HYDROGEOLOGIC DATA FOR EXISTING EXCAVATIONS
AT THE AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE,
NEVADA TEST SITE, NYE COUNTY, NEVADA

By

Special Projects Section

Environmental Restoration & Technology Development Department

Environmental Management Division

Reynolds Electrical & Engineering Co., Inc.

December 1993

Work performed under contract

No. DE-AC08-94-NV11432

Prepared for

Department of Energy

Nevada Operations Office

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

for

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
FIGURES	v
TABLES	vi
ACRONYMS	viii
EXECUTIVE SUMMARY	ix
1.0 INTRODUCTION	1
1.1 Purpose and Justification	1
1.2 Scope of Report	2
1.3 Overview of Activities	2
1.4 Literature Review	3
1.5 Objectives	5
1.6 Site Description	6
1.7 Site Climate and Meteorology	7
2.0 IN SITU TESTING AND FIELD SAMPLING METHODS	7
2.1 Description of Sampling Scheme	7
2.2 In Situ Testing Methods	15
2.2.1 Water Content and Bulk Density Measurements	15
2.2.2 Infiltration Measurements	15
2.3 Core and Bulk Sample Collection Methods	16
2.4 Laboratory Testing Methods	17
3.0 RESULTS OF TESTING	18
3.1 In Situ Testing Results	18
3.2 Laboratory Testing Results	20
3.2.1 Chloride and Bromide Concentrations	20
3.2.2 Physical and Hydraulic Parameters	22
4.0 ANALYSIS AND INTERPRETATION OF RESULTS	37
4.1 Methods of Data Analysis	37
4.1.1 Water Characteristic Curve Fitting	37
4.1.2 Statistical Analyses	37
4.2 Water Characteristic Curves	39
4.3 Sample Distributions	41
4.4 Comparison of Testing Methods and Sample Sizes for Determining Particle Size Distributions	44
4.5 Correlations Between In Situ and Laboratory Measurements	46

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
4.6 Sample Size Calculations	48
4.7 Comparisons for Coring Direction, Transect Orientation, and LayType . . .	48
4.8 Dependencies Among Hydrogeologic Variables	53
4.9 Analysis of Spatial Variability	54
4.10 Implications for Site Characterization at the RWMS	58
5.0 SUMMARY	60
6.0 REFERENCES	62
DISTRIBUTION LIST	67
7.0 APPENDICES	68
Appendix A	69
A.1 Field Testing Data From the Fine Layer in Trench 8	70
A.2. Field Testing Data From the Upper Coarse Layer in Trench 8	72
A.3. Field Testing Data From the Lower Coarse Layer in Trench 8	74
A.4. Field Testing Data From the Fine Layer in Pit 3	76
Appendix B	78
B.1. Laboratory Chloride and Bromide Measurements From the Fine Layer of Trench 8	79
B.2. Laboratory Chloride and Bromide Measurements From the Upper Coarse Layer of Trench 8	81
Appendix C	83
C.1. Physical and Hydraulic Parameter Data for Vertical Cores From the Fine Layer of Trench 8	84
C.2. Physical and Hydraulic Parameter Data for Horizontal Cores From the Fine Layer of Trench 8	87
C.3. Physical and Hydraulic Parameter Data for Bulk Samples From the Upper Coarse Layer of Trench 8	90
C.4. Physical and Hydraulic Parameter Data for Vertical Cores From the Lower Coarse Layer of Trench 8	93
C.5. Physical and Hydraulic Parameter Data for Horizontal Cores From the Lower Coarse Layer of Trench 8	96

TABLE OF CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
C.6. Physical and Hydraulic Parameter Data for Vertical Cores From the Fine Layer of Pit 3	99
C.7. Physical and Hydraulic Parameter Data for Horizontal Cores From the Fine Layer of Pit 3	102
C.8. Physical and Hydraulic Parameter Data for Vertical Cores From the Coarse Layer of Pit 3	105
C.9. Physical and Hydraulic Parameter Data for Horizontal Cores From the Coarse Layer of Pit 3	108
Appendix D	111
D.1. Water Characteristic Curve Data for Vertical Cores From the Fine Layer of Trench 8	112
D.2. Water Characteristic Curve Data for Horizontal Cores From the Fine Layer of Trench 8	115
D.3. Water Characteristic Curve Data for Vertical Cores From the Lower Coarse Layer of Trench 8	118
D.4. Water Characteristic Curve Data for Horizontal Cores From the Coarse Layer of Trench 8	120
D.5. Water Characteristic Curve Data for Vertical Cores From the Fine Layer of Pit 3	122
D.6. Water Characteristic Curve Data for Horizontal Cores From the Fine Layer of Pit 3	124
D.7. Water Characteristic Curve Data for Vertical Cores From the Coarse Layer of Pit 3	126
D.8. Water Characteristic Curve Data for Horizontal Cores From the Coarse Layer of Pit 3	128
Appendix E	130
E.1. Hydrometer Data for Vertical Cores From the Fine Layer of Trench 8	131
E.2. Hydrometer Data for Horizontal Cores From the Fine Layer of Trench 8	135
E.3. Hydrometer Data for Vertical Cores From the Lower Coarse Layer of Trench 8	138
E.4. Hydrometer Data for Horizontal Cores From the Lower Coarse Layer of Trench 8	142
E.5. Hydrometer Data for Vertical Cores From the Fine Layer of Pit 3	146
E.6. Hydrometer Data for Horizontal Cores From the Fine Layer of Pit 3	147
E.7. Hydrometer Data for Horizontal Cores From the Coarse Layer of Pit 3 ..	148

FIGURES

<u>Number</u>		<u>Page</u>
1A	Typical Fine- and Coarse-Grained Layers (Scale Increment is 1 ft)	11
1B	Typical Fine- and Coarse-Grained Layers (Scale Increment is 1 ft)	12
1C	Alternating Fine- and Coarse-Grained Layers on Excavation (15 ft High Wall) . . .	13
2	Location of Sampling Transects in Existing Excavations (Trench 8 and Pit 3) at the RWMS	14
3	Chloride and Bromide Data for Fine Layer in Trench 8	23
4	Chloride and Bromide Data for Upper Coarse Layer in Trench 8	25
5	Composite Particle Size Distributions for Fine and Coarse Layer Cores From Trench 8. The Symbol is the Mean and the Lines are Drawn One Sample Standard Deviation Above and Below the Mean	33
6	Bulk Density Data for Trench 8 Sampling Transect	35
7	Bulk Density Data for Pit 3 Sampling Transect	36
8	Composite Water Characteristic Curves (Vertical and Horizontal Cores Combined) for Sampling Transects. Fitted Line is Equation 1 With Mean Parameter Values From Table 10. The Dashed Lines Define the Upper and Lower Limits of all Fitted Curves	42
9	Comparison of In Situ and Laboratory Measurements for Gravimetric Water Content (Upper Figure) and Dry Bulk Density (Lower Figure)	47
10	Dependence of $\log(K_s)$ on Effective Particle Diameter d_{10} for Coarse Layer in Trench 8 and Fine and Coarse Layers in Pit 3. "*" and "***" Indicate Regression is Significant at 0.05 and 0.01 Level, Respectively	53
11	$\log(K_s)$ vs. Distance Along Sampling Transect (Left) and Corresponding Sample Variograms (Right) for Pooled Data (Vertical and Horizontal Cores Combined) for Pit 3 Fine and Coarse Layers	55
12	$\log(K_s)$ vs. Distance Along Sampling Transect (Left) and Corresponding Sample Variograms (Right) for Pooled Data (Vertical and Horizontal Cores Combined) for Trench 8 Fine and Coarse Layers	56

TABLES

<u>Number</u>		<u>Page</u>
1	Summary of Numbers of In Situ and Laboratory Tests for Core Samples	8
2	Summary of Numbers of Laboratory Tests for Bulk Samples	9
3	Descriptive Statistics for Surface Moisture-Density Gage Measurements; "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size	19
4	Descriptive Statistics for In Situ Infiltration Measurements: "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size	21
5	Descriptive Statistics for Chloride and Bromide Measurements; "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size	27
6	Descriptive Statistics for Fine Layer in Trench 8; "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size . . .	28
7	Descriptive Statistics for Upper and Lower Coarse Layers in Trench 8; "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size	29
8	Descriptive Statistics for Fine Layer in Pit 3; "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size	31
9	Descriptive Statistics for Coarse Layer in Pit 3; "min" and "max" are Minimum and Maximum, "mean" and "s" are the Sample Mean and Standard Deviation, "CV" is Coefficient of Variation and "n" is Sample Size	32
10	Summary of Fitted Parameters for Water Characteristic Curves, Combined Vertical and Horizontal Cores (n is number of cores)	40

TABLES (Continued)

<u>Number</u>		<u>Page</u>
11	Results of Distributional Tests for Selected Properties. Entries are Value of the Shapiro-Wilk Test Statistic as Implemented in MINITAB (MINITAB Inc., 1991) for the Assumption that the Distribution is Normal (Upper Number) or Lognormal (Lower Number). Asterisk Marks Rejection of Distribution at $p = 0.05$ Significance Level	43
12	Comparison of Particle Size Distribution Data Obtained by Wet and Dry Sieving for Bulk Samples From East Wall, Trench 8. The mean" and "s" are Sample Mean and Standard Deviation	45
13	Sample Size Calculations Based on Equation 2 with $(1-\alpha) = (1-\beta) = 0.95$, $d = 10$ Percent of Sample Mean, s and n From Tables 6 to 9	49
14	Results of Three-Way ANOVA for Selected Properties. "F" is Test Statistic; "p" is Significance Level. Large Values of F (Small Values of p) Indicate Factor or Interaction is Significant	49
15	Summary of One-Way ANOVA for Selected Properties. "DF" = Degrees-of-Freedom. Figure on Right Shows 95 Percent Confidence Intervals for the Mean (Read Upper Scale)	50
15B	Summary of One-Way ANOVA for Selected Properties. "DF" = Degrees-of-Freedom. Figure on Right Shows 95 Percent Confidence Intervals for the Mean (Read Upper Scale)	50
15C	Summary of One-way ANOVA for Selected Properties. "DF" = Degrees-of-Freedom. Figure on Right Shows 95 Percent Confidence Intervals for the Mean (Read Upper Scale)	51
16	Summary of Fitted Variogram Models; " C_0 " is the Nugget (semivariance at $h = 0$) and "a" is the Range (Correlation Length)	57

ACRONYMS

ASTM	American Society for Testing & Materials
CFR	Code of Federal Regulations
DBS&A	Daniel B. Stephens & Associates
DOE	Department of Energy
ERWM	Environmental Restoration and Waste Management
HGC	HydroGeo Chem
LDR	Land Disposal Restricted
LLW	Low-level Waste
LLWMU	Low-level Waste Management Unit
MW	Mixed Waste
NTS	Nevada Test Site
NV	Nevada Operations Office
RCRA	Resource Conservation and Recovery Act
REEC_o	Reynolds Electrical & Engineering Co., Inc.
RSN	Raytheon Services Nevada
RWMS	Radioactive Waste Management Site
SPS	Special Projects Section
TRU	Transuranic Waste
WMD	Waste Management Division

EXECUTIVE SUMMARY

The primary purpose of the Existing Excavation Project is two-fold: first, to characterize important hydrologic properties of the near-surface alluvium, thought to play an important role in the infiltration and redistribution of water and solutes through the upper unsaturated (vadose) zone at the Area 5 RWMS; and second, to provide guidance for the design of future sampling and testing programs. Geological and statistical models for the spatial variability of soil properties are needed to predict field scale water flow and solute transport at the RWMS. Unfortunately, only limited information is currently available on unsaturated soils in the near surface. Properties of these materials are needed because of the effect of upper unsaturated zone hydrologic processes (primarily infiltration and evapotranspiration) on net recharge to the buried waste.

Spatial variability of selected physical and hydrologic properties was quantified for representative fine- and coarse-grained layers at the Area 5 RWMS. Gravimetric water content (w), bulk density (ρ_b), saturated hydraulic conductivity (K_s), and particle size distribution were determined for vertical and horizontal core specimens and bulk samples collected from 600-ft-long, horizontal transects in two existing waste disposal trenches located on a single alluvial fan. The transects were aligned approximately parallel (Trench 8) and perpendicular (Pit 3) to the principal direction of sediment transport. Properties were modeled as either normally or lognormally distributed random variables. A weak correlation was identified between $\log(K_s)$ and the effective grain diameter d_{10} (ten percent of the particles in an alluvium sample have a diameter smaller than d_{10}). Sample coefficients of variation were smallest for (ρ_b) and largest for $\log(K_s)$. Particle size distributions for the two materials were different, and significant differences in the natural logarithm of saturated hydraulic conductivity, $\log(K_s)$, existed between coarse and fine layers in transects aligned with the principal direction of alluvium deposition (but not for layers aligned in a perpendicular direction). Differences in $\log(K_s)$ for vertical and horizontal cores were not significant. Sample variograms were described by combinations of pure nugget and spherical model structures with correlation lengths ranging from less than 5 to 200 ft.

The data and analyses contained in this report provide a detailed description of the properties of representative fine and coarse layers at the RWMS and of the horizontal variability of these properties over the site. The data and analyses for the four sampling transects can also be used to assist in the design of future sampling programs at the RWMS. A summary of the implications for future site characterization activities for selected properties (ρ_b , $\log(K_s)$, and d_{10}) is shown below:

<u>Property</u>	<u>Pool data from fine and coarse layers ?</u>	<u>Number of cores to estimate mean value for layer</u>	<u>Optimum core spacing within horizontal layers (ft)</u>	<u>Within-layer anisotropy ?</u>	<u>Site-scale anisotropy ?</u>
ρ_b	Yes	8 (pooled data)	150 (pooled data)	No	No
$\log(K_s)$	No	16 (fine layers) 24 (course layers)	150 (fine layers) 200 (course layers)	No	No
d_{10}	No	37 (fine layers) 43 (course layers)	100 (fine layers) 40 (course layers)	Yes*	Yes

*Probably a sampling artifact resulting from loss of fines during horizontal coring.

Sampling transects were located in individual fine and coarse layers. Properties of the two materials are compared in the second column. ANOVA results indicated that ρ_b data from the fine and coarse layers can be combined (pooled). However, there were significant differences in $\log(K_s)$ and d_{10} between the two types of materials, indicating that these properties for the two materials should be analyzed separately. It should be noted that although the differences were statistically significant, the absolute magnitudes were relatively small and may not have practical importance. This is currently being tested by ongoing sensitivity analyses using numerical water flow codes.

The third column lists the number of core specimens required to estimate the mean value of a property for individual fine or coarse layers at the 95 percent confidence level. If at least

these numbers of core specimens are analyzed, the computed sample means for these layers will be within 10 percent of the true (population) mean.

The sample size calculations in column three are based on the assumption of statistical independence of measurements for all cores within a layer. However, analysis of sample variograms indicated that correlation lengths (the distance beyond which a pair of cores becomes statistically independent) ranged from 40 to 200 ft. Property values for samples placed horizontally closer together than the correlation length contain partially redundant information because the measured property values will be correlated. To avoid the collection of redundant information, cores should be collected a horizontal distance apart equal to or greater than the largest fitted correlation lengths, as listed in column four. This information can be used as one criteria to guide the placement of future boreholes.

Vertical and horizontal cores were collected at each sampling location along each transect, providing the opportunity to test for the presence of small-scale anisotropy, e.g., due to small-scale sedimentary structures such as cross- or planar-bedding. The absence of vertical and horizontal anisotropy, except for d_{10} which is probably an artifact created by the loss of fines during horizontal coring, indicates that vertical core specimens (e.g., from boreholes), can be used to characterize these materials.

Sampling transects were aligned parallel and perpendicular to the principal sediment transport direction for the alluvium at the site. Comparisons of property values can be used to test for the existence of horizontal site-scale anisotropy caused by large-scale geologic processes. A greater degree of variability in one direction, for example, would imply that future boreholes be more closely spaced in that direction. The results in column five show that such anisotropy existed only for d_{10} .

1.0 INTRODUCTION

The Special Projects Section (SPS) of Reynolds Electrical & Engineering Co., Inc. (REECo) is responsible for characterizing the subsurface geology and hydrology of the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada Test Site (NTS) for the U.S. Department of Energy, Nevada Operations Office (DOE/NV), Office of Environmental Restoration and Waste Management (ERWM), Waste Management Division (WMD). Geologic description, in situ testing, and laboratory analyses of alluvium exposed in existing excavations are important subparts to the Area 5 Site Characterization Program designed to determine the suitability of the RWMS for disposal of low level waste (LLW), mixed waste (MW), and transuranic waste (TRU).

1.1 Purpose and Justification

The primary purpose of the Existing Excavation Project is two-fold: first, to characterize important hydrologic properties of the near surface alluvium, thought to play an important role in the infiltration and redistribution of water and solutes through the upper unsaturated zone at the Area 5 RWMS; and second, to provide guidance for the design of future sampling and testing programs. The justification for this work comes from the state of Nevada review of the original DOE/NV Part B Permit application submitted in 1988 for disposal of mixed wastes at the RWMS. The state of Nevada determined that the permit was deficient in characterization data concerning the hydrogeology of the unsaturated zone. DOE/NV agreed with the state and proposed the study of alluvium exposed in existing excavations as one step toward satisfying these important site characterization data requirements. Other components of the site characterization process include the Science Trench Borehole and Pilot Well Projects.

A number of other federal regulations and DOE Orders provide additional justification for the site characterization activities incorporated in the Existing Excavation Project. These regulations include specific Resource Conservation and Recovery Act (RCRA) requirements

for the land disposal of hazardous waste as well as DOE Order 5820.2A, "Radioactive Waste Management" and 40 Code of Federal Regulations (CFR) 191 requirements for land disposal of radioactive waste.

1.2 Scope of Report

This report provides a complete description of in situ testing, field sampling, and laboratory analyses conducted in the Existing Excavation Project up to January 1, 1993. In addition, preliminary interpretations of these data based on detailed statistical analyses are presented.

1.3 Overview of Activities

A sampling scheme was designed to obtain information about important physical and hydrologic properties for representative fine- and coarse-grained layers at the Area 5 RWMS. Laboratory measurements of gravimetric water content, bulk density, particle size distribution (sieve method), and saturated hydraulic conductivity were conducted on each vertical and horizontal core specimen collected from four 600-ft-long transects established along the exposed face of two existing excavations (Trench 8 and Pit 3). One transect in each excavation was located within a clearly identified fine-grained layer; the other transect was in an underlying coarse-grained layer. In addition, water characteristic curves and particle size distributions measured by the hydrometer method were measured on selected core specimens.

Forty-nine sampling locations were established along each transect. At each sampling location, in situ measurements of water content and bulk density were made with a surface moisture-density gage and measurements of infiltration rates were determined with a constant head infiltrometer. Vertical and horizontal cores were then collected using a "California sampler" (split spoon) attached to a hand-held air-percussion hammer. These cores were then subjected to the above-mentioned laboratory analyses.

The testing and sampling activities described above were preceded by in situ measurements of bulk density and water content at several locations along a separate 600-ft-long transect in an overlying coarse layer in Trench 8, and at several locations in coarse and fine layers on the opposite (east) wall of this trench. Large bulk samples (20 to 30 kg) were also collected from these locations to determine the effects of sample size and testing methods on particle size distribution data.

In addition, two smaller bulk samples (about 0.5 kg) were collected from selected layers in Trench 8 for onsite measurement of gravimetric water content and laboratory measurement of chloride and bromide concentrations.

1.4 Literature Review

Numerical models are commonly used to predict infiltration and redistribution of water and solutes in unsaturated soils. Requirements for their use include accurate information about the size and shape of subsurface layers (e.g., soil horizons) and the spatial variability of physical and hydrologic properties within each layer. Previous studies have demonstrated that soil properties vary vertically and laterally (Nielsen et al., 1973; Healy and Mills, 1991) and that this variability can be modeled as a stochastic process (Russo and Bresler, 1981). In this approach, soil properties are considered to be regionalized (spatially distributed) variables with specified distribution and spatial correlation functions. Geostatistical methods (Journel and Huijbregts, 1987) have been widely used to quantify the spatial variability displayed by regionalized variables. Mathematical models fit to sample variograms form the basis for a number of estimation (kriging) and simulation methods. For example, kriging has been used to develop maps of soil property estimates on the field scale from measured values on a limited number of soil samples (Burgess et al., 1981; Russo, 1984a). Several studies have demonstrated that water flow and solute transport predictions obtained from numerical models are improved by incorporating information on the spatial variability of soil properties (Peck et al., 1977; Gelhar and Axness, 1983; Russo, 1984a; van der Zee et al., 1987).

Alluvial sedimentary deposits exist at a number of contaminated sites and existing and proposed waste storage and disposal facilities. Mapped soil units in these materials frequently contain lenses and layers of contrasting mineralogies, particle sizes, and hydrologic properties. Individual units are frequently laterally discontinuous and may display lateral anisotropy, i.e., spatial structure may change with direction relative to the depositional axis (Nilsen, 1982). Vertical vs. horizontal anisotropy is also common due to the frequent occurrence of small-scale sedimentary structures (e.g., planar- and cross-bedding [Harms et al., 1965]); in many deposits hydraulic conductivity is larger in the horizontal direction than in the vertical direction (Johnson and Dreiss, 1989).

The development of realistic site-scale models requires information on the (three-dimensional) spatial variability of soil properties over distances of tens to hundreds of meters. The related problem of optimizing the number and locations of boreholes to maximize information can also be addressed if quantitative information on lateral spatial variability is available (Russo, 1984b). However, at most sites, the only available information on subsurface materials is obtained from a limited number of boreholes; this information alone is often insufficient to describe the continuity of subsurface layers and/or to interpolate properties between core specimens within and between boreholes. In addition, core specimens obtained from boreholes, because of their vertical orientation, provide no information on vertical vs. horizontal anisotropy in hydrologic properties.

The most previous work in quantifying the spatial variability of unsaturated porous media has emphasized the near-surface soil materials. Particular emphasis has been placed on quantifying the spatial variability of hydrologic properties of soils used in irrigated agriculture, motivated by the need to improve water use efficiency, to reduce soil salinity, or to reduce the impact of leachate on groundwater quality (Guma, 1978; Gajem et al., 1981; Viera et al., 1981). Only two previous studies, Wierenga (1988) and Healy and Mills (1991), have presented information on the spatial variability of alluvial deposits below the root zone. However, data in both studies were collected over relatively short (less than 20 m) lateral

distances; there appears to be no published information on the lateral spatial variability of these materials over longer distances.

The present study was motivated by the need to predict water flow and solute transport at the Area 5 RWMS on the NTS, Nye County, Nevada. At this site, trenches excavated in alluvium are currently used for the storage of low-level radioactive waste. Unsaturated water flow occurs through thick sequences of alluvium derived primarily from Tertiary volcanic sediments with minor amounts of Paleozoic clastic and carbonate sediments. A good example of the stratigraphy of these deposits is given by Dixon et al. (1967). The alluvium beneath the RWMS consists of alternating sequences of fine- and coarse-grained materials, with occasional lenses of very coarse stream channel deposits (Dozier and Rawlinson, 1991). Core specimens have been analyzed to obtain generalized properties for these materials (Dixon, 1965; RSN, 1991), but the small number of available boreholes provides little information on the lateral (horizontal) spatial variability of the properties of these materials or the existence of vertical vs. horizontal anisotropy within layers. This information is needed because previous research suggests that flow and transport processes in these types of materials are truly three-dimensional (Wierenga, 1988). The soil deposits were exposed on the sidewalls of existing 600-ft-long trenches; this made it possible to conduct detailed sampling, in situ testing, and laboratory analyses on a scale not previously reported in the literature.

1.5 Objectives

The overall objective of current site characterization activities at the RWMS is to develop a comprehensive three-dimensional model for the important physical and hydrologic properties of the alluvial deposits. The specific objectives of this study were to:

- (1) Characterize the hydrologic properties of representative fine-grained and coarse-grained deposits, including vertical vs. horizontal anisotropy.
- (2) Determine the range of spatial correlation of hydrologic properties for directions parallel and perpendicular to the direction of sediment transport.
- (3) Develop a preliminary statistical model for hydrologic properties for use in numerical water flow and solute transport modeling at the site.

1.6 Site Description

The study area is located within the RWMS in northern Frenchman Flat in Area 5 of the NTS, in southern Nevada. The NTS is a DOE facility occupying approximately 1,350 mi² approximately 65 miles northwest of Las Vegas. The NTS is bordered to the north, south, and east by the Nellis Air Force Range, a government-owned restricted access area. Activities at the NTS include a variety of nuclear and non-nuclear projects and experiments.

The Area 5 RWMS encompasses 732 acres north of Frenchman Flat. Frenchman Flat is a closed basin; the RWMS is at an elevation of 3,200 ft on a bajada of the Massachusetts Mountains at the intersection of three alluvial fans on a slope of about 1°; the sampling transects utilized in this study (described below) are located entirely within the boundaries of the Scarp Canyon Fan. Source rocks for the alluvium are primarily tuffs with lesser amounts of lava flows, limestone, dolomite, and quartzite (RSN, 1991). Alluvial deposits consist of combinations fine- and coarse-grained sediments that are differentiated by the degree of sorting, grain size distribution, clast abundance, and presence or absence of bedding.

The Low-level Waste Management Unit is a 92-acre facility located in the southeast section of the RWMS. It was established in 1978 for the purpose of disposing of low-level waste generated at the NTS and DOE facilities. Current waste disposal operations at the RWMS include disposal of contact-handled low-specific-activity waste in shallow trenches and pits. Waste buried at the RWMS may be containerized in metal drums, plywood boxes, cardboard boxes, metal boxes, and nonstandard containers.

DOE/NV has in the recent past accepted low-level mixed waste containing hazardous constituents that are not land disposal restricted (LDR), and plans are being made to resume accepting this type of mixed waste in the near future. Moreover, high-specific activity waste was buried at the RWMS in boreholes measuring approximately 10 ft in diameter and 120 ft in depth. Long-term DOE/NV waste management goals include obtaining regulatory approval

to resume disposing high specific yield waste as well as developing the capability to dispose of low-level mixed LDR waste that does not meet treatment standards.

1.7 Site Climate and Meteorology

The climate and meteorology of the region is typical of the upper Mojave Desert province. Two major air movement patterns affect this area. Pacific air flowing over the Sierra Nevada exerts its influence from fall through spring. As the Pacific high-pressure area dissipates in summer, the warm moist air mass in the Gulf of Mexico exerts its influence. Average daily temperatures range from 2°C in January to 24°C in August. Precipitation is highly variable in the desert. The summer months are typified by intense, isolated thunderstorms, and the winter storms are of long duration and low intensity. The average precipitation is approximately 10 cm per year. The estimated evapotranspiration rate is 220 cm per year.

2.0 IN SITU TESTING AND FIELD SAMPLING METHODS

Tables 1 and 2 summarize all in situ and laboratory testing conducted in this study. The following sections describe approaches and methods used to conduct this testing. Section 3 will discuss results of these tests, and Section 4 describes analyses and interpretations made on these data.

2.1 Description of Sampling Scheme

Previous research at the RWMS identified two types of layers that were repeated throughout the walls of the existing excavations. RSN (1991) tentatively classified these layers in terms of depositional mechanisms as debris flow (fine-grained and well-graded) and sheet flood (coarse-grained and poorly-graded). Ongoing research (Snyder et al., 1992) suggests that post-depositional, soil-forming processes have acted to remove depositional structure, thus obscuring purely depositional classifications such as debris flow and sheet flood. Because the interpretation of the origin and formation of these materials is beyond the scope of this report,

Table 1. Summary of numbers of in situ and laboratory tests for core samples.

Existing excavation site	Layer	Sample orientation	<u>Moisture-density gage</u>				<u>Particle size distribution</u>					Water characteristic curves	Grain density
			Volumetric water content	Bulk density	Infiltrometer rates	Saturated hydraulic conductivity	Volumetric water content	Bulk density	wet sieve	dry sieve	Hydrometer		
∞	Trench 8	Upper Coarse Layer	None ¹	49	49	-	-	-	-	-	-	-	-
			Vertical	-	-	-	-	-	-	-	-	-	-
			Horizontal	-	-	-	-	-	-	-	-	-	-
		Fine Layer	None	49	49	-	-	-	-	-	-	-	-
			Vertical	-	-	50	25	25	25	-	23	25	6
			Horizontal	-	-	52	26	26	25	-	16	26	-
		Lower Coarse Layer	None	49	26	-	-	-	-	-	-	-	-
			Vertical	-	-	25	19	25	25	-	25	27	2
			Horizontal	-	-	22	18	22	22	-	22	13	1
	Pit 3	Fine Layer	None	49	49	47	-	-	-	-	-	-	-
			Vertical	-	-	47	47	47	-	47	4	16	-
			Horizontal	-	-	47	42	42	-	42	3	14	-
		Coarse Layer	None	-	-	2	-	-	-	-	-	-	-
			Vertical	-	-	41	41	41	-	41	-	12	-
			Horizontal	-	-	31	31	31	-	31	2	11	-

¹ Refers to bulk samples, "vertical" and "horizontal" refer to core specimens.

Table 2. Summary of numbers of laboratory tests for bulk samples.

Existing excavation site	Layer	Particle size distribution by wet sieve	Grain density	<u>Gravimetric water content</u> ¹			Chloride	Bromide
				REEC0	DBS&A	HGC		
Trench 8	Upper coarse layer	49	6	49	49	48	48	48
	Fine layer	-	-	49	-	49	49	49

¹ Measurements made at different laboratories

a simple classification based on texture ("fine-grained" and "coarse-grained") was adopted. Fine-grained materials consist of a mixture of silty, fine-to-medium sand, and display only weak sedimentary structure on scales of 10 to 20 cm (Figure 1A). Coarse-grained materials consist of layered deposits of sand and gravel with numerous small-scale sedimentary structures, especially planar- and cross-bedding (Figure 1B) that is anticipated to cause hydrologic properties to display vertical vs. horizontal anisotropy. These materials occur in alternating layers throughout the depth of existing excavations; layers are often laterally continuous over many hundreds of feet (Figure 1C). Stream channel deposits, consisting of sand and coarse gravel that filled the bottom of channels eroded in previously deposited material, are laterally discontinuous and were not sampled in this study.

The sampling scheme was designed to obtain information about important physical and hydrologic properties for representative fine- and coarse-grained layers at the site. It was expected that particle size distribution would be different for fine and coarse layers and that particle sizes would decrease in the direction of alluvium transport. Saturated hydraulic conductivity was expected to be anisotropic, especially in the coarse-grained layers, and dependent to some degree on particle size distribution. An additional hypothesis was that hydrogeological properties would have longer correlation lengths in the direction of alluvial transport. To test these hypotheses, gravimetric and volumetric water contents, bulk density, particle size distribution, and saturated hydraulic conductivity were measured on vertical and horizontal core specimens from four 600-ft-long transects established along the exposed face of two existing excavations: Trench 8 and Pit 3 (Figure 2). One transect in each excavation was located within a clearly identified fine-grained layer (defined in earlier site investigations as the "datum debris flow"); the other transect was in an underlying coarse-grained layer. The transects on the western wall of Trench 8 are aligned approximately parallel to the principal sediment transport direction of the Scarp Canyon Fan; the transects on the southwestern wall of Pit 3 are aligned approximately perpendicular to the principal transport direction. Finally, bulk samples were collected from selected transects and locations on both walls (west and east) of Trench 8 to examine the effects of sample size and testing methods on particle size distributions and to determine water content and chloride and bromide concentrations.

Figure 1A. Typical fine- and coarse-grained layers (scale increment is 1 ft).

Figure 1B. Typical fine- and coarse-grained layers (scale increment is 1 ft).

Figure 1C. Alternating fine- and coarse-grained layers on excavation wall (wall height is 15 ft).

Figure 2. Location of sampling transects in existing excavations (Trench 8 and Pit 3) at the RWMS.

Forty-nine sampling locations were established along each transect using a clustered line approach (Russo, 1984b) to ensure an adequate number of sample pairs (greater than 30) to permit the calculation of informative sample variograms for separations up to about 300 ft. Sample locations were 0, 5, 10, 15, 20, 40, 60, 80, 100, 105, 110, 115, 120, 140, 160, 180, 200, 205, 210, 215, 220, 240, 260, 280, 300, 305, 310, 315, 320, 340, 360, 380, 400, 405, 410, 415, 420, 440, 460, 480, 500, 505, 510, 515, 520, 540, 560, 580, and 600 ft from the transect origin. At approximately 15 percent of the sampling locations, trench wall instabilities and/or access problems prevented sample collection.

2.2 In Situ Testing Methods

2.2.1 Water Content and Bulk Density Measurements

At each sampling location, a front-end loader was used to excavate a working bench in the wall of the excavation. In situ volumetric water content and bulk density were measured on the surface of the horizontal working bench using a surface moisture-density gage at sampling locations in each transect except the coarse layer in Pit 3. Cost and scheduling constraints precluded making in situ measurements along this sampling transect.

2.2.2 Infiltration Measurements

Following in situ measurements with the surface moisture-density gage, ponded and tension infiltration measurements were made at the same locations on the working bench.

Infiltrometer equipment and measurement methods were equivalent to those used by Ankeny et al. (1988). Infiltration measurements were made at tensions of 0, -3, -6, and -15 cm of water. Infiltration measurements at each tension were continued until a steady flow rate was achieved. Matric potentials were controlled by a series of Mariotte bubbler tubes connected to a water supply reservoir. Water was transmitted to the soil through an 8.2-cm-diameter, 400 mesh nylon membrane.

The equations used by Ankeny et al. (1988) to convert infiltration rates to hydraulic conductivity values (Wooding, 1968) assumed infiltration is occurring beneath a shallow pond of infinite diameter to minimize capillarity effects around the edge of the infiltrometer. This assumption is clearly not appropriate for the 8.2 cm diameter "pond" used in the infiltration tests. Numerical and analytical solutions are currently being developed in an attempt to quantify the magnitude of the capillarity effects on the 8.2 cm diameter infiltration surface. At the same time, field tests are being conducted to compare infiltration rates obtained with the 8.2 cm tension infiltrometer to those obtained with a much larger (20-cm diameter) disk infiltrometer developed by Perroux and White (1988).

2.3 Core and Bulk Sample Collection Methods

Vertical and horizontal cores were collected with a "California sampler" consisting of an impact "jackhammer" with an attached 2.5-in diameter split-spoon core barrel; core specimens were collected in 2.5-in by 2.5-in long stainless steel liners. This coring method is generally considered to yield cores that are representative of in situ deposits. However, it might be expected that the impact coring method will slightly compact core specimens. Attempts were made to quantify these effects by comparing measured bulk densities obtained from cores with in situ density measurements obtained with a surface moisture-density meter (see Section 4.5). No significant correlations between these densities were found, suggesting that coring did not systematically affect the density of the cores.

Although soils were allowed to dry following infiltration tests, visual inspection indicated that vertical cores were noticeably wetter than horizontal cores at some sampling locations. Horizontal cores were collected approximately one foot below the horizontal surface of the sampling bench, directly below the bottom of the vertical core. Difficulties encountered during horizontal coring may have resulted in greater sample disturbance (primarily loss of fines) in the horizontal cores compared to the vertical cores.

Bulk samples (20 to 30 kg) were collected in Trench 8 from sampling locations in the upper coarse layer on the western wall and from selected locations in both coarse and fine layers on the eastern wall to determine the effects of sample size and measurement method on particle size distribution data. In addition, small (approximately 0.5 kg) bulk samples were collected in moisture tins for onsite gravimetric water content determinations at these sampling locations as well as from the fine layer in Trench 8. These onsite measurements of water content were made to rapidly obtain data which could be used to check the performance of the surface moisture meter. Finally, an additional small bulk sample was collected from all upper coarse and fine layer sampling locations to determine soluble chloride and bromide concentrations.

2.4 Laboratory Testing Methods

Gravimetric and volumetric water contents, w and θ , respectively (ASTM D 2216-80), bulk density, ρ_b (Klute et al., 1986, pp. 363-367), saturated hydraulic conductivity, K_s (ASTM D 2434-68), water characteristic curves (Klute et al., 1986; ASTM D 2325-68), and particle size distribution by sieve (ASTM D 422-63 [72]) and hydrometer (ASTM D 422-63 [72]) were measured on each core using methods in the cited references. The grain size parameter, d_{10} was computed from the particle size distributions using linear interpolation; ten percent of a sample's weight has a particle size smaller than d_{10} . Onsite gravimetric water content determinations were made by REECo, all other laboratory tests were conducted by commercial testing laboratories. To be consistent with onsite water content determinations, analyses of laboratory gravimetric water content data are presented. If desired, volumetric water contents can be computed using the values for gravimetric water content and bulk density contained in Appendix C. Chloride and bromide analyses were performed by Hydro Geochem Inc. (HGC) of Tucson, Arizona. All other laboratory tests were performed by Daniel B. Stephens & Associates (DBS&A) of Albuquerque, New Mexico. All analyses were conducted under quality assurance programs that have been previously approved by REECo.

3.0 RESULTS OF TESTING

Data obtained from in situ and laboratory testing are summarized in tabular form in appendices; in situ testing results are in Appendix A and the results of laboratory testing are in Appendices B, C, D, and E. In most cases data within these appendices are grouped by layer (i.e., coarse or fine) and sample orientation (none for bulk samples, vertical or horizontal for core specimens) if appropriate. The following sections briefly describe testing results as well as any limitations or potential problems with the data. Data will be discussed by reference to tabular data in appendices, graphical representations of selected portions of the data, and summary statistics for the tabular data where appropriate. Additional detailed analyses and interpretations of the data are presented in Section 4.0.

3.1 In Situ Testing Results

Appendix A contains the following in situ testing results: infiltration data at tensions of 0, -3, -6, and -15 cm of water for all sampling transects; volumetric water content and dry bulk density measurements made with a surface moisture-density gage for all sampling transects except the coarse layer in Pit 3; gravimetric water contents measured on small bulk samples from the upper coarse and fine layers in Trench 8.

It was not possible to obtain surface moisture-density gage data from the lower coarse layer in Pit 3 within the time frame available for the sampling/testing program. Scheduling constraints arose when DOE/NV personnel became concerned that the construction of benches on the side walls of Trench 8 and Pit 3 constituted an enlargement of the capacity of these existing excavations and potentially violated previous agreements with the state of Nevada. To alleviate these concerns, the schedule for in situ testing and sampling was accelerated so that benches could be backfilled and the excavation capacities restored to the original volumes prior to formal inspection by the state of Nevada. Descriptive statistics for surface moisture-density gage measurements are presented in Table 3. Both density and moisture data are remarkably consistent within and between transects. However, it should be emphasized that

Table 3. Descriptive statistics for surface moisture-density gage measurements; "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Trench 8 Fine Layer

	ρ_b	w	θ
min	1.48	2.17	4.40
max	1.65	5.34	8.30
mean	1.565	3.654	5.190
s	0.041	0.537	0.667
CV%	2.6	14.7	12.9
n	49	49	49

Trench 8 Upper Coarse Layer

	ρ_b	w	θ
min	1.48	2.17	4.40
max	1.65	5.34	8.30
mean	1.565	3.654	5.190
s	0.041	0.537	0.667
CV%	2.6	14.7	12.9
n	49	49	49

Trench 8 Lower Coarse Layer

	ρ_b	θ
min	1.42	3.4
max	1.70	8.0
mean	1.558	5.24
s	0.059	0.92
CV%	3.8	17.5
n	49	49

Trench 8 Lower Coarse Layer

	ρ_b	θ
min	1.43	4.7
max	1.59	11.2
mean	1.513	7.37
s	0.042	2.02
CV%	2.8	27.4
n	49	49

there are still unanswered questions regarding the representativeness of these data. The results of a statistical analysis (Section 4.5) show that in situ measurements of bulk density are approximately correlated with laboratory measurements. However, data scatter suggest that there may be calibration problems with the surface moisture-density gage and/or differences in sample size and volume investigated by in situ and laboratory testing. Additional work is required to understand these factors. Descriptive statistics for infiltration data are presented in Table 4. The variability (as measured by the standard deviation and coefficient of variation) of these data decreases dramatically from 0 to -3 cm of tension. As mentioned previously, it is not known the degree to which the capillarity of the surrounding dry soil affects the infiltration rates measured with the small diameter source. Because of the uncertainty concerning the magnitude of these effects, the data will not be converted to hydraulic conductivity values and compared with laboratory measurements made on core samples. Numerical and analytical mathematical solutions are currently being developed to quantify the effects of capillarity on infiltration from such a small-diameter source.

3.2 Laboratory Testing Results

3.2.1 Chloride and Bromide Concentrations

Precipitation which falls on the soil surface contains relatively low and constant concentrations of chloride and bromide ions (Cl^- and Br^-), respectively. As precipitation infiltrates the soil, the concentrations of these ions increase as a result of ion exchange with soil mineral surfaces and evapotranspiration (pure water evaporates leaving chloride and bromide in the soil). Because these data are dependent on infiltration and evapotranspiration processes, they can provide an indication of the variability in historical evapotranspiration and infiltration which have occurred along the length of the sampling transects. This approach assumes other factors affecting chloride and bromide concentrations, such as rate of sediment aggradation, have been constant along the length of the sampling transects.

Table 4. Descriptive statistics for in situ infiltration measurements: "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Trench 8 Fine Layer

	Infiltration rates (mm/s) at indicated tension (cm)			
	0	-3	-6	-15
min	0.072	0.042	0.044	0.016
max	1.019	0.476	0.342	0.180
mean	0.236	0.167	0.138	0.078
s	0.154	0.085	0.060	0.031
CV%	65.1	51.1	43.3	39.8
n	49	49	49	49

Trench 8 Lower Coarse Layer

	Infiltration rates (mm/s) at indicated tension (cm)			
	0	-3	-6	-15
min	0.249	0.156	0.129	0.016
max	1.766	0.683	0.674	0.150
mean	0.8138	0.3814	0.2938	0.0702
s	0.4398	0.1630	0.1382	0.0349
CV%	54.0	42.7	47.0	49.8
n	26	26	26	26

Pit 3 Fine Layer

	Infiltration rates (mm/s) at indicated tension (cm)			
	0	-3	-6	-15
min	0.136	0.009	0.072	0.004
max	1.223	0.698	0.539	0.36
mean	0.4124	0.2777	0.2146	0.0992
s	0.2523	0.1423	0.1026	0.0797
CV%	61.2	51.3	47.8	80.3
n	47	47	47	40

Measured chloride and bromide concentrations for the upper coarse and fine layers in Trench 8 are presented in Appendix B. Summary plots of these data (Figures 3 and 4) as well as descriptive statistics (Table 5), indicate relatively low variability in chloride and bromide concentrations along both transects. This suggests that evapotranspiration and infiltration processes along the entire lengths of these transects have been relatively constant.

3.2.2 Physical and Hydraulic Parameters

Physical and hydraulic parameter measurements made on samples collected from each sampling transect are tabulated in Appendix C and descriptive statistics for these data are given in Tables 6 to 9. Particle size distribution data indicate that the overall character of the deposits is that of a well-graded, medium sand with small amounts of silty clay and gravel (Tables 6 to 9). The soils were very dry at the time and depth of sampling, with gravimetric water content (w) generally below 15 percent even though some vertical cores were pre-wetted by prior infiltration tests. Bulk density (ρ_b), was extremely uniform with mean values for all specimens in the range of 1.5 to 1.7 g/cm³ and coefficients of variation smaller than 5 percent. By contrast, saturated hydraulic conductivity, K_s , varied by as much as two orders of magnitude within a transect; coefficients of variation ranged from 69.6 to 205.0 percent. The materials are generally coarse-grained with a mean fine fraction (200 mesh) between 2 percent and 16 percent. Values for the effective grain diameter, d_{10} , ranged from 0.01 to 0.25 mm. Hydrometer analyses (Appendix E) were performed on selected samples and indicated that the fine fraction consisted primarily of silt for all transects. Particle density, ρ_s , analyses on a few samples from each transect gave a mean particle density for these materials of 2.55 g/cm³. Measured values of particle density are tabulated in Appendix C.

Differences in particle size distributions between the coarse and fine layers are illustrated with composite (pooled vertical and horizontal cores) particle size distributions for the two transects in Trench 8 (Figure 5). Both materials consisted primarily of sand with some silty clay and gravel; the coarse layer had a higher percentage of particles larger than 5 mm in diameter and a smaller percentage of particles smaller than 0.07 mm the fine layer. The

Figure 3. Chloride and bromide data for fine layer in Trench 8.

Figure 3. (Continued).

Figure 4. Chloride and bromide data for upper coarse layer in Trench 8.

Figure 4. (Continued).

Table 5. Descriptive statistics for chloride and bromide measurements; "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Trench 8 Fine Layer

	Dry Soil [Cl ⁻]	Dry Soil [Br ⁻]	Dry Soil [Cl ⁻]	Dry Soil [Br ⁻]
min	197.47	1.51	4980	38
max	461.61	3.48	11947	91
mean	287.432	2.134	7423.5	55.0
s	64.983	0.471	1441.7	9.8
CV%	22.6	22.1	19.4	17.8
n	39	39	39	39

Trench 8 Upper Coarse Layer

	Dry Soil [Cl ⁻]	Dry Soil [Br ⁻]	Dry Soil [Cl ⁻]	Dry Soil [Br ⁻]
min	176.60	1.37	2524	15
max	409.53	2.69	15326	93
mean	273.245	1.852	8596.9	58.4
s	58.541	0.329	2636.2	15.6
CV%	21.4	17.8	30.7	26.7
n	48	48	47	47

Table 6. Descriptive statistics for fine layer in Trench 8; "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Vertical cores

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	4.0	1.53	1.0×10^{-4}	100	95.1	88.2	84.0	78.3	72.0	46.9	24.5	12.3	9.2	0.01
max	10.3	1.70	4.7×10^{-3}	100	100	96.6	93.2	88.3	82.7	70.3	64.3	58.1	56.3	0.08
mean	6.84	1.61	8.9×10^{-4}	100	97.9	92.6	87.9	82.3	76.0	56.4	35.2	19.7	16.2	0.053
s	1.71	0.04	8.5×10^{-4}	0	1.57	2.13	2.25	2.54	2.81	4.90	7.55	8.80	8.90	0.016
CV(%)	25.1	2.7	94.9	0	1.6	2.3	2.6	3.1	3.7	8.7	21.4	44.8	55.2	29.4
n	25	25	49	23	23	23	23	23	23	23	23	23	23	23

Horizontal cores

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	2.1	1.52	8.8×10^{-5}	86.6	81.0	74.7	71.3	67.2	62.3	44.6	21.4	9.2	6.8	0.05
max	5.8	1.85	3.7×10^{-3}	100	99.7	97.0	94.1	89.8	83.8	60.2	37.0	23.1	20.5	0.11
mean	3.38	1.64	6.3×10^{-4}	98.9	95.5	90.9	86.0	80.7	74.3	52.6	29.6	14.4	11.1	0.076
s	0.97	0.07	6.7×10^{-4}	3.52	4.54	5.06	4.90	4.94	4.89	4.74	4.08	3.24	3.03	0.016
CV(%)	28.7	4.4	105.8	3.6	4.8	5.6	5.7	6.1	6.6	9.0	13.8	22.5	27.3	19.1
n	25	25	47	25	25	25	25	25	25	25	25	25	25	25

Table 7. Descriptive statistics for upper and lower coarse layers in Trench 8; "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Bulk samples (upper coarse layer)

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	0.4					41.4	38.8	35.2	28.9	16.0	8.3	4.2	3.3	0.08
max	2.7					90.6	88.3	83.8	77.3	61.2	38.4	19.1	14.4	0.27
mean	4.7					74.1	70.4	65.4	59.2	40.5	23.6	11.9	8.7	0.123
s	1.14					12.0	12.4	12.9	13.1	12.0	8.45	4.22	2.85	0.047
CV(%)	42.2					16.2	17.7	19.8	22.1	29.7	35.8	35.5	32.9	38.2
n	49					49	49	49	49	49	49	49	49	35

Vertical cores (lower coarse layer)

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	3.1	1.49	5.2×10^{-4}	79.2	64.9	55.9	44.3	37.7	33.5	18.2	8.1	3.8	2.9	0.07
max	11.1	1.74	1.9×10^{-2}	100.0	100.0	96.3	93.0	88.5	82.4	61.1	31.5	16.6	13.0	0.25
mean	5.31	1.60	4.5×10^{-3}	98.8	94.5	87.9	81.5	74.4	66.7	40.9	17.8	7.8	6.0	0.148
s	1.67	0.07	4.2×10^{-3}	4.21	6.98	8.52	10.49	11.26	11.60	10.89	6.89	3.62	2.84	0.048
CV(%)	31.5	4.5	94.5	4.3	7.4	9.7	12.9	15.1	17.4	26.6	38.7	47.9	47.7	32.5
n	18	23	24	24	24	24	24	24	24	24	24	24	24	24

Table 7. (Continued).

Horizontal cores (lower coarse layer)

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	3.9	1.42	1.2×10^{-3}	92.3	82.8	67.6	60.1	50.5	39.8	19.2	6.6	2.7	2.2	0.09
max	8.6	1.66	2.2×10^{-2}	100.0	99.0	94.1	90.3	85.6	79.3	52.8	28.3	15.1	11.9	0.26
mean	6.4	1.57	7.5×10^{-3}	98.6	93.0	84.2	76.9	68.2	59.7	34.6	14.9	6.3	5.0	0.177
s	1.13	0.06	5.2×10^{-3}	2.44	4.67	8.02	9.12	10.48	11.32	11.21	6.98	3.45	2.63	0.057
CV(%)	17.8	4.0	69.6	2.5	5.0	9.5	11.9	15.4	19.0	32.4	46.9	54.4	52.4	32.4
n	17	22	22	21	21	21	21	21	21	21	21	21	21	21

Table 8. Descriptive statistics for fine layer in Pit 3; "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Vertical cores

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	3.2	1.41	1.9×10^{-4}	89.1	86.9	76.9	70.2	63.1	56.2	35.1	16.5	5.9	3.3	0.02
max	14.3	1.68	5.6×10^{-3}	100	99.3	96.8	92.3	93.9	83.4	63.2	42.7	20.4	12.0	0.15
mean	7.4	1.52	1.9×10^{-3}	98.1	94.9	89.2	84.4	79.2	73.2	54.7	31.9	12.6	7.8	0.091
s	2.75	0.06	1.4×10^{-3}	2.16	3.55	4.76	5.53	6.45	6.37	6.60	4.60	2.43	1.56	0.018
CV(%)	37.3	4.2	72.8	2.2	3.7	5.3	6.6	8.1	8.7	12.1	14.4	19.2	20.0	19.7
n	38	38	47	46	46	46	46	46	46	46	46	46	46	46

Horizontal cores

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	3.3	1.43	3.4×10^{-4}	96.1	89.0	83.1	76.3	71.0	63.7	39.6	17.5	5.4	2.9	0.05
max	6.5	1.60	8.3×10^{-3}	100	99.8	98.0	94.2	89.7	84.4	65.6	40.4	18.2	14.2	0.15
mean	4.5	1.51	1.9×10^{-3}	99.8	96.5	91.4	87.0	82.1	76.5	57.5	32.2	11.4	6.89	0.099
s	0.76	0.04	1.6×10^{-3}	0.91	2.80	3.58	4.29	4.37	4.75	5.52	4.56	2.37	1.91	0.017
CV(%)	17.0	2.5	85.5	0.9	2.9	3.9	4.9	5.3	6.2	9.6	14.2	20.7	27.7	16.9
n	31	31	41	41	41	41	41	41	41	41	41	41	41	41

Table 9. Descriptive statistics for coarse layer in Pit 3; "min" and "max" are minimum and maximum, "mean" and "s" are the sample mean and standard deviation, "CV" is coefficient of variation and "n" is sample size.

Vertical cores

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	2.2	1.39	1.7×10^{-4}	92.0	77.4	56.9	48.4	40.5	34.6	23.7	6.7	0.9	0.4	0.08
max	8.3	1.68	3.8×10^{-2}	100	100	98.8	96.6	92.3	86.0	73.9	45.0	15.5	10.0	0.24
mean	4.2	1.55	3.0×10^{-3}	98.6	94.6	87.5	83.2	77.3	71.1	50.2	23.9	7.6	4.2	0.131
s	1.32	0.07	6.1×10^{-3}	2.59	5.17	8.08	9.28	9.91	10.22	11.15	8.98	3.79	2.34	0.038
CV(%)	31.7	4.3	205.0	2.6	5.5	9.2	11.2	12.9	14.4	22.2	37.6	50.1	5.5	28.0
n	40	41	40	40	40	40	40	40	40	40	40	40	40	40

Horizontal cores

	w	ρ_b	K_s	----- % passing indicated sieve size -----										
	(%)	(g/cm ³)	(cm/s)	3/4	3/8	4	6	10	16	40	70	140	200	d ₁₀
min	1.6	1.42	3.2×10^{-4}	72.1	68.6	64.0	59.8	50.2	42.6	30.2	13.3	2.5	1.2	0.07
max	4.1	1.69	2.1×10^{-2}	100	99.5	97.6	94.9	93.9	92.6	79.8	56.0	19.3	11.2	0.17
mean	3.2	1.55	3.5×10^{-3}	97.2	92.8	85.6	80.8	75.2	69.8	49.8	25.4	7.5	4.0	0.132
s	0.70	0.07	5.0×10^{-3}	5.83	6.96	8.73	9.94	10.81	11.29	10.40	9.71	3.68	2.26	0.025
CV(%)	21.6	4.3	140.9	6.0	7.5	10.2	12.3	14.4	16.2	20.9	38.2	49.3	56.8	19.2
n	30	30	31	30	30	30	30	30	30	30	30	30	30	30

Figure 5. Composite particle size distributions for fine and coarse layer cores from Trench 8. The symbol is the mean and the lines are drawn one sample standard deviation above and below the mean.

variability in particle sizes for each diameter (as measured by the standard deviation) was generally smaller for the fine layer than for the coarse layer (except at the smallest particle diameters), supporting field observations (Figure 5). However, differences between the two distributions decreased with increasing particle diameter up to about 4 mm. Although the core barrel could not sample particles larger than 64 mm, visual examination of the deposits in the field indicates that the distributions in Figure 5 would diverge for particle diameters larger than about 10 mm because the coarse layers contain large cobbles (not sampled) that are not found in fine deposits (Figure 1b).

The coarse layers display small-scale sedimentary structures, especially cross-bedding and planar-bedding and imbricate structure that are not apparent in the fine layers (Figure 1b). A detailed discussion of the relationship between transport and soil-forming processes responsible for the formation of these structures is in Harms and Fahnestock (1965). For our purposes it is sufficient to note that the occurrence of these sedimentary structures in the coarse layers is consistent with observed differences in particle size distributions.

Plots of dry bulk density for all transects (Figures 6 and 7) and descriptive statistics (Tables 6 to 9) indicate extremely low variability in this parameter. However, descriptive statistics for saturated hydraulic conductivity (Tables 6 to 9) indicate a greater degree of variability. More detailed analyses of the spatial variability of these parameters and plots of the natural logarithm (log) of saturated hydraulic conductivity vs. distance along each transect are presented in Section 4.

Finally, it should be noted that water content data have been affected by several factors that may cause them to be nonrepresentative of in situ conditions. The working benches used for sampling were excavated variable distances from the original trench walls, depending on the stability of the materials being excavated. Also, working benches were exposed to ambient atmospheric conditions for variable amounts of time prior to sampling. Most importantly, infiltration measurements were made on the benches prior to collecting vertical core specimens, and the time between the end of infiltration measurements and core collection

Fine Layer

Lower Coarse Layer

Figure 6. Bulk density data for Trench 8 sampling transect.

Fine Layer

Coarse Layer

Figure 7. Bulk density data for Pit 3 sampling transect.

varied from a few hours to several days. Nearly all vertical core specimens showed some visible evidence of added moisture from the preceding infiltration tests. Horizontal cores, which were collected approximately one foot below the bench surface, showed no visible evidence of added moisture.

4.0 ANALYSIS AND INTERPRETATION OF RESULTS

4.1 Methods of Data Analysis

4.1.1 Water Characteristic Curve Fitting

Preliminary examination of water characteristic curves indicated that they could be described well by the van Genuchten equation (van Genuchten, 1980). The equation was fit to each water characteristic curve to obtain values for residual water content and the shape parameters α and n using the program RETC (van Genuchten, 1980). The van Genuchten equation is:

$$\theta = \theta_r + (\theta_s - \theta_r) \left[\frac{1}{1 + (\alpha h)^n} \right]^m \quad (1)$$

where θ is volumetric water content, θ_r is the residual volumetric water content, θ_s is the saturated volumetric water, h is matric potential expressed as a pressure head (cm), and $m = 1/n$. For the purpose of fitting equation 1, the value of θ at $h = -0.1$ cm was used for θ_s .

4.1.2 Statistical Analyses

Sample distributions were tested for normality and lognormality using the Shapiro-Wilk test (Shapiro and Wilk, 1965) as implemented in MINITAB (1991). Differences among drilling orientation (vertical vs. horizontal), layer type (fine vs. coarse), and transect orientation (parallel to depositional axis in Trench 8 vs. perpendicular to depositional axis in Pit 3) were assessed through a three-way ANOVA for each normally or lognormally distributed variable.

Dependencies among the variables were assessed using the Blum, Kiefer, and Rosenblatt test (Blum et al., 1961) which is designed to detect any departure (linear or nonlinear) from the assumption of independence. In general, problems can arise when performing multiple comparisons. For n tests, each with a Type I error of α , the approximate probability of at least one Type I error is $n\alpha$ leading to inflated Type I error rates. In the test of independence used here, Bonferonni's inequality is used to control overall error rates (Bickel and Doksum, 1977). Significance of observed dependency is not reported unless the overall significance value was very small.

Least squares linear regression models were fit in scatter plots for selected pairs of variables that displayed linear dependency. Emphasis was on the analysis of regression models for saturated hydraulic conductivity and bulk density as a function of grain size distribution parameters, including d_{10} .

The number of samples required to estimate the mean value for each normally distributed variable, n , was determined using the method in Zar (1984, p.109). $\hat{n}$ is the smallest integer that satisfies the inequality:

$$\hat{n} \geq \frac{s^2 t^2_{\alpha(2), (\hat{n} - 1)} F_{\beta(1), (\hat{n} - 1, \nu)}}{d^2} \quad (2)$$

where s^2 is the sample variance (estimated with ν degrees of freedom) d is the half-width of the desired confidence interval, $(1 - \alpha(2))$ is the confidence level for the two-sided confidence interval, and $(1 - \beta(1))$ is the assurance that the one-sided confidence interval will be no larger than specified. Equation 2 was solved iteratively.

Spatial continuity was examined and correlation lengths were estimated using sample variograms. Sample cross-variograms were not computed because of the absence of strong intervariable correlations. Sample variograms were computed using the computer program VARIO (Istok et al., 1988) based on the traditional Matheron estimator (Journel and Huijbregts, 1987):

$$\gamma(h) = \frac{1}{n_i} \sum_{i=1}^{n_i} [z(x_i + h) - z(x_i)]^2 \quad (3)$$

where $\gamma(h)$ is the value of the sample variogram for a separation distance h , $z(x_i)$ is the measured value of parameter z at sampling location x_i , and n_i is the number of sample pairs separated by h . The advantage of the clustered line sampling plan described above is that it maximizes the number of sample pairs at each value of h , thus improving the utility of the sample variogram as an estimator of the true variogram (Russo, 1984b). Sample variograms were computed for each parameter and transect; selection of variogram models and values of model parameters was initially performed graphically (Journel and Huijbregts, 1987). Sample variograms were fit with combinations of pure nugget and spherical models (Journel and Huijbregts, 1987). Model variograms are defined by:

$$\begin{aligned} \gamma(h) &= C_o + (s^2 - C_o) \left[\frac{3h}{2a} - \frac{h^3}{2a^3} \right], & h \leq a \\ &= s^2, & h > a \end{aligned} \quad (4)$$

where C_o is the nugget (semivariance at $h = 0$), s^2 is the sample variance, h is the distance between a pair of points, and a is the range (correlation length). Initial estimates of model parameters were improved and verified using the cross-validation procedure described in Hevesi et al. (1992).

4.2 Water Characteristic Curves

Fitted water characteristic curve parameters for all sampling transects were similar (Table 10). There were no significant differences between fitted parameters for vertical and horizontal cores for any transect. Fitted residual water contents ranged from 0 to 0.10 cm³/cm³. These values are close to volumetric water contents computed using measured gravimetric water contents and bulk densities (Tables 6 to 9). For these data and units $\theta = (w/100)\rho_b$. For example, using mean values for w and ρ_b for the fine layer in Trench 8, $\theta = 0.11$ (vertical cores) and 0.06 cm³/cm³ (horizontal cores); for the coarse layer in Pit 3, $\theta = 0.07$ (vertical cores) and 0.05 cm³/cm³ (horizontal cores). As mentioned previously, differences in water

Table 10. Summary of fitted parameters for water characteristic curves, combined vertical and horizontal cores (n is number of cores).

<u>Trench 8</u>		θ_r	θ_s	α	n
Fine layer		(cm ³ /cm ³)	(cm ³ /cm ³)	(cm ⁻¹)	
(n = 50)	minimum	0.00	0.30	0.014	1.30
	maximum	0.09	0.37	0.052	2.12
	mean	0.063	0.335	0.029	1.54
	standard deviation	0.053	0.017	7.21x10 ⁻³	0.16
 Coarse layer					
(n = 33)	minimum	0.06	0.30	0.017	1.33
	maximum	0.11	0.39	0.157	3.41
	mean	0.079	0.338	0.056	2.15
	standard deviation	0.014	0.024	0.036	0.54
 <u>Pit 3</u>					
Fine layer					
(n = 30)	minimum	0.05	0.30	0.018	1.37
	maximum	0.09	0.38	0.069	2.28
	mean	0.071	0.340	0.029	1.69
	standard deviation	0.010	0.018	0.011	0.23
 Coarse layer					
(n = 23)	minimum	0.00	0.31	0.016	1.23
	maximum	0.10	0.42	0.089	4.96
	mean	0.066	0.354	0.032	2.39
	standard deviation	0.024	0.025	0.015	0.98

content between vertical and horizontal cores are probably an artifact from the sampling procedure. These results suggest that soils were close to residual saturation at the time of sampling.

Composite water characteristic curves (vertical and horizontal curves combined) are plotted in Figure 8. The solid line is computed using (eq.) 1 and the mean parameter values from Table 10; the dashed lines define the upper and lower limits of all fitted curves. The range in observed volumetric water contents for each value of head (Figure 8) was larger for cores from the coarse layers than for cores from the fine layers, reflecting the wider range of grain (and pore) sizes in the coarser materials (compare upper and lower plots in Figure 8). Greater variability in fitted parameters for coarse layers is also seen in the larger computed ranges and sample variances for these materials (Table 10). In spite of these differences, the curves are remarkably similar and this is consistent with the very similar particle size distributions measured for these materials.

4.3 Sample Distributions

Most of the statistical methods used in subsequent data analyses require that variables be normally (or lognormally) distributed. Knowledge of sample distributions is also required for the development of statistical models for soil properties. Results of distributional tests for ρ_b , K_s , and d_{10} for samples from all transects are in Table 11. K_s was accepted as lognormally distributed while ρ_b and d_{10} were generally accepted as both normally and lognormally distributed; for simplicity ρ_b and d_{10} were accepted as normally distributed in subsequent analyses.

Figure 8. Composite water characteristic curves (vertical and horizontal cores combined) for sampling transects. Fitted line is Equation 1 with mean parameter values from Table 10. The dashed lines define the upper and lower limits of all fitted curves.

Table 11. Results of distributional tests for selected properties. Entries are value of the Shapiro-Wilk test statistic as implemented in MINITAB (MINITAB Inc., 1991) for the assumption that the distribution is normal (upper number) or lognormal (lower number). Asterisk marks rejection of distribution at $p = 0.05$ significance level.

<u>Trench 8 Fine layer</u>	ρ_b	K_s	d_{10}
Vertical cores	0.99	0.87*	0.95
	0.99	1.00	0.75*
Horizontal cores	0.97	0.84*	0.99
	0.98	0.99	1.00
<u>Trench 8 Coarse layer</u>			
Vertical cores	0.99	0.43*	0.99
	0.99	0.75*	0.99
Horizontal cores	0.97	0.95	0.98
	0.97	0.99	0.98
<u>Pit 3 Fine layer</u>			
Vertical cores	0.98	0.95*	0.94*
	0.98	0.98	0.95*
Horizontal cores	0.99	0.85*	0.93*
	0.99	0.99	0.92*
<u>Pit 3 Coarse layer</u>			
Vertical cores	0.46*	0.63*	0.97
	0.55*	0.99	0.99
Horizontal cores	0.99	0.75*	0.98
	0.99	0.97	0.95*

4.4 Comparison of Testing Methods and Sample Sizes for Determining Particle Size Distributions

A pilot study was performed using large bulk samples collected from fine and coarse layers on the east wall of Trench 8 to determine the method of laboratory testing (wet sieving vs. dry sieving) on particle size distributions. Replicate bulk samples were collected from two locations in fine and coarse layers on the east wall of Trench 8. One set of replicate samples (Dry 1, 2, and 3) was analyzed by dry sieving. Another set of replicate samples (Wet 1, 2, and 3) was analyzed by wet sieving. The resulting particle size distributions are given in Table 12 and indicate that wet sieving recovered a greater portion of the fine fraction than dry sieving, especially for the fine layers. However, the absolute magnitudes of the differences are small and may not be significant for site-scale flow and transport modeling. Sensitivity analyses are being conducted to evaluate the potential significance of these differences.

Large bulk samples were also collected from the upper coarse layer in Trench 8 to determine the effect of sample size on resulting particle size distributions, and to further examine the effect of laboratory testing methods discussed above. These analyses were not completed in time to be included in this report.

4.5 Correlations Between In Situ and Laboratory Measurements

The representativeness of in situ measurements of volumetric water content and bulk density with the surface moisture-density gage was evaluated by comparing in situ water content and bulk density data with laboratory measurements on small bulk samples and vertical cores from the fine layer in Trench 8. Two comparisons were performed. In the first, measured gravimetric water content data obtained from small bulk samples were compared with computed gravimetric water content data from the surface moisture-density gage data. The results showed generally good agreement (Figure 9). In the second, measured dry bulk density data from the core were compared with measured dry bulk density data from the surface moisture-density gage. The results indicate generally good agreement, although the

Table 12. Comparison of particle size distribution data obtained by wet and dry sieving for bulk samples from east wall, Trench 8. The "mean" and "s" are sample mean and standard deviation.

Coarse Layer Location No. 1

Sieve No.	<u>% passing indicated sieve</u>					<u>% passing indicated sieve</u>				
	Dry 1	Dry 2	Dry 3	Mean	s ²	Wet 1	Wet 2	Wet 3	Mean	s ²
3/4	90.5	96.7	99.3	95.49	20.15	86.2	95.1	67.7	83.00	196.44
3/8	84.8	90.1	94.1	89.66	21.88	79.8	89.7	62.2	77.26	193.78
4	80.3	84.5	88.1	84.31	15.00	73.7	83.0	57.3	71.32	168.39
6	74.7	77.4	80.4	77.50	8.02	67.1	75.9	52.3	65.08	142.31
10	68.5	70.3	72.6	70.44	4.14	61.1	69.0	47.4	59.15	118.97
16	60.1	60.8	62.6	61.17	1.63	53.8	60.4	41.4	51.88	93.47
40	32.9	33.0	33.6	33.16	0.17	31.8	35.0	23.6	30.14	34.92
70	13.9	14.1	14.2	14.08	0.03	15.2	17.0	11.0	14.41	9.26
140	4.8	4.9	5.0	4.89	0.01	7.0	8.1	4.8	6.62	2.77
200	2.9	3.1	3.1	3.00	0.01		6.2	3.6	4.86	3.43

Fine Layer Location No. 1

Sieve No.	<u>% passing indicated sieve</u>					<u>% passing indicated sieve</u>				
	Dry 1	Dry 2	Dry 3	Mean	s ²	Wet 1	Wet 2	Wet 3	Mean	s ²
3/4	96.5	93.5	98.6	96.21	6.76	96.2	94.6	99.0	96.60	5.15
3/8	93.0	90.9	94.5	92.81	3.33	92.7	92.4	95.0	93.35	2.03
4	88.9	86.9	90.3	88.71	2.97	87.9	88.6	89.4	88.61	0.53
6	83.9	82.0	85.4	83.76	2.87	83.7	83.3	85.1	84.02	0.89
10	78.9	77.2	79.9	78.66	1.90	78.7	78.4	80.2	79.10	0.89
16	72.9	71.4	73.7	72.69	1.37	72.8	72.5	74.3	73.18	0.89
40	52.0	51.0	52.4	51.81	0.50	52.3	52.1	53.5	52.62	0.56
70	26.6	26.0	26.5	26.36	0.10	28.6	28.0	28.7	28.42	0.13
140	9.7	9.3	9.5	9.52	0.04	13.1	12.9	13.3	13.09	0.03
200	6.1	6.0	6.2	6.11	0.01	10.0	9.9	10.0	9.98	0.00

Table 12. (Continued)

Coarse Layer Location No. 2

Sieve No.	<u>% passing indicated sieve</u>					<u>% passing indicated sieve</u>				
	Dry 1	Dry 2	Dry 3	Mean	s ²	Wet 1	Wet 2	Wet 3	Mean	s ²
3/4	86.5	89.3	88.2	87.99	2.08	85.3	89.5	91.3	88.70	9.63
3/8	72.4	80.5	75.4	76.10	16.81	73.1	78.2	79.8	77.03	12.31
4	61.3	71.5	64.2	65.69	27.57	60.9	66.1	64.7	63.89	7.34
6	51.2	61.9	53.3	55.45	32.34	53.8	58.3	57.1	56.43	5.37
10	43.2	53.6	44.8	47.16	31.38	45.8	49.8	47.9	47.80	4.05
16	35.8	45.0	36.8	39.17	25.38	38.2	41.5	39.8	39.84	2.66
40	17.9	23.0	18.3	19.76	7.91	19.7	21.2	20.4	20.44	0.61
70	8.1	10.4	8.4	8.96	1.62	9.2	9.3	9.8	9.58	0.11
140	3.1	4.0	3.3	3.49	0.21	4.3	4.4	5.0	4.56	0.14
200	1.8	2.6	2.2	2.18	0.15	3.2	3.1	3.7	3.33	0.12

Fine Layer Location No. 2

Sieve No.	<u>% passing indicated sieve</u>					<u>% passing indicated sieve</u>				
	Dry 1	Dry 2	Dry 3	Mean	s ²	Wet 1	Wet 2	Wet 3	Mean	s ²
3/4	99.1	92.3	94.8	95.41	12.09	92.8		98.0	95.41	13.68
3/8	94.4	89.8	92.0	92.05	5.37	89.2		94.0	91.60	11.57
4	89.4	85.9	87.3	87.55	2.99	86.7		89.7	88.18	4.59
6	86.6	83.6	84.4	84.84	2.41	82.7		85.1	83.91	2.98
10	82.5	79.9	79.8	80.76	2.36	79.0		80.7	79.85	1.57
16	77.7	75.5	74.9	75.99	2.15	74.4		75.6	75.00	0.77
40	59.2	56.9	56.2	57.43	2.44	56.5		57.7	57.10	0.78
70	32.2	28.2	27.7	29.34	6.27	31.9		33.6	32.76	1.45
140	10.8	8.3	9.4	9.50	1.66	13.9		14.8	14.38	0.40
200	6.0	4.9	5.6	5.51	0.28	10.2		10.8	10.52	0.20

Figure 9. Comparison of in situ and laboratory measurements for gravimetric water content (upper figure) and dry bulk density (lower figure).

scatter of the data is fairly large (Figure 9). Additional analysis and testing are in progress to verify these findings and to develop more reliable in situ calibrations for the surface moisture-density gage.

4.6 Sample Size Calculations

Sample size estimates are useful for planning future site characterization work at the RWMS and at other sites with similar materials. The sample sizes required to estimate the mean for ρ_b , d_{10} , and $\log(K_s)$ for each layer and transect were computed using Equation 2 with $(1-\alpha) = (1-\beta) = 0.95$ and $d = 10$ percent of the sample mean (Table 13). For example, the sample size (number of cores), n , required to estimate ρ_b within 10 percent of the mean for the fine layer in Trench 8 using vertical core data is 5 (computed with $n = 25$, $v = 24$ and $d = 0.16$). Generally, the smallest required sample sizes were for ρ_b , with values for n ranging from 3 to 8. The largest computed sample sizes were for d_{10} with a maximum required sample size of 43.

4.7 Comparisons for Coring Direction, Transect Orientation, and Layer Type

Results of three-way ANOVAs indicated no significant differences among measured values of ρ_b for either coring direction (vertical vs. horizontal), transect orientation (perpendicular to alluvial deposition for Trench 8 and parallel for Pit 3), and layer type (coarse vs. fine layers [Table 14]). The relatively narrow range of values of ρ_b for all transects suggests a high degree of uniformity for this property (Table 15A). However, the results of three-way ANOVAs showed significant differences for $\log(K_s)$ existed between coarse and fine layers, with significant interactions between layer type and coring and transect orientation in some transects (Table 14). Differences between layer type and coring direction were not significant for Pit 3 (Table 15B); layer type, but not coring orientation, were significantly different in Trench 8. The lack of vertical vs. horizontal anisotropy for $\log(K_s)$ in the coarse layers was unexpected given the presence of cross-bedding in these materials (Figure 1). Also, the lack of significant differences in $\log(K_s)$ between coarse and fine layers was unexpected given

Table 13. Sample size calculations based on Equation 2 with $(1-\alpha) = (1-\beta) = 0.95$, $d = 10$ percent of sample mean, s and n from Tables 6 to 9.

<u>Trench 8 Fine layer</u>	ρ_b	$\log(K_s)$	d_{10}
Vertical cores	3	14	37
Horizontal cores	5	16	23
<u>Trench 8 Coarse layer</u>			
Vertical cores	5	24	43
Horizontal cores	5	21	40
<u>Pit 3 Fine layer</u>			
Vertical cores	8	16	18
Horizontal cores	5	14	16
<u>Pit 3 Coarse layer</u>			
Vertical cores	5	23	32
Horizontal cores	3	22	18

Table 14. Results of three-way ANOVA for selected properties. "F" is test statistic; "p" is significance level. Large values of F (small values of p) indicate factor or interaction is significant.

	ρ_b		$\log(K_s)$		d_{10}	
Factor or interaction	F	p	F	p	F	p
1. Coring orientation	0.66	0.42	1.48	0.22	24.99	0.00
2. Layer type	0.40	0.53	105.69	0.00	185.26	0.00
3. Transect orientation	1.75	0.19	0.21	0.65	3.87	0.05
4. 1 x 2	1.35	0.25	9.77	0.00	7.47	0.01
5. 1 x 3	0.48	0.49	0.54	0.46	0.50	0.48
6. 2 x 3	2.96	0.09	78.97	0.00	70.61	0.00
Error DF	227		295		231	
Total DF	233		301		237	

Table 15A. Summary of one-way ANOVA for selected properties. "DF" = degrees-of-freedom. Figure on right shows 95 percent confidence intervals for the mean (read upper scale).

ρ_b : F = 1.25, p = 0.28, Error DF = 226, Total DF = 233						$\rho_b(\text{g/cm}^3)$								
	Layer	Drilling orientation	n	mean	Standard deviation	1.5			1.6				1.7	
Trench 8	Fine	Vertical	25	1.61	0.044									
		Horizontal	25	1.64	0.074				-----					
	Coarse	Vertical	23	1.60	0.074				-----					
		Horizontal	22	1.57	0.065				-----					
Pit 3	Fine	Vertical	38	1.52	0.064	-----								
		Horizontal	31	1.51	0.039	--								
	Coarse	Vertical	40	1.65	0.623	-----								
		Horizontal	30	1.55	0.067	-----								

Table 15B. Summary of one-way ANOVA for selected properties. "DF" = degrees-of-freedom. Figure on right shows 95 percent confidence intervals for the mean (read upper scale).

$\log(K_s)$: F = 27.46, p = 0.00, Error DF = 294, Total DF = 301						$\log(K_s)$								
	Layer	Drilling orientation	n	mean	Standard deviation	-4			-6				-8	
Trench 8	Fine	Vertical	49	-7.38	0.85							---		
		Horizontal	47	-7.78	0.91							--		
	Coarse	Vertical	24	-5.80	0.93				---					
		Horizontal	22	-5.16	0.78				---					
Pit 3	Fine	Vertical	47	-6.55	0.87				---					
		Horizontal	41	-6.55	0.73				---					
	Coarse	Vertical	41	-6.61	1.14				-----					
		Horizontal	31	-6.22	0.99				-----					

Table 15C. Summary of one-way ANOVA for selected properties. "DF" = degrees-of-freedom. Figure on rights shows 95 percent confidence intervals for the mean (read upper scale.)

d_{10} : $F = 38.54$, $p = 0.00$, Error DF = 217, Total DF = 223						d_{10} (mm)									
	Layer	Drilling orientation	n	mean	Standard deviation	0.0					0.1				0.2
Trench 8	Fine	Vertical	23	0.053	0.016										
		Horizontal	24	0.076	0.018										
	Coarse	Vertical	24	0.148	0.049										
		Horizontal	21	0.177	0.059										
Pit 3	Fine	Vertical	46	0.091	0.018										
		Horizontal	30	0.131	0.026										
	Coarse	Vertical	40	0.134	0.038										
		Horizontal	30	0.131	0.026										

apparent differences in particle size distributions for these materials (Tables 6 to 9). However, this is consistent with the results of one-way ANOVA for d_{10} and the weak correlation between $\log(K_s)$ and d_{10} discussed in the next section.

For d_{10} , differences between coring and transect orientation, layer type, and the layer type/transect orientation interaction were significant at $p = 0.05$ (Table 14). For Pit 3, the only significant differences in d_{10} were for vertical cores in the fine layer; in Trench 8, the only significant differences were for layer type (Table 15C).

4.8 Dependencies Among Hydrogeologic Variables

The existence of dependencies among variables (intervariable correlations) is of interest for two reasons. First, dependencies may have predictive values permitting, for example, the estimation (using regression models) of a variable that is difficult or expensive to measure by another variable that is simpler or less expensive to measure. Second, knowledge of correlations among variables allows the use of a large amount of qualitative information in the interpretation of sample data. For example, as discussed previously, knowledge of site geology provides a conceptual framework for interpreting particle size distribution data on alluvial fans. If the data can be correlated to other physical properties, this conceptual framework can aid the interpretation of observed spatial variability in these additional variables.

Using the transect data, all selected pairs of variables were tested for dependency. Based on the results of three-way ANOVA presented earlier, data for vertical and horizontal cores were pooled for this analysis. The coarse layers, $\log(K_s)$ was weakly related to the effective grain size d_{10} (Figure 10). No other dependencies among variables were significant for this layer. Also, the fine layer in Pit 3, $\log(K_s)$ was weakly related to d_{10} . Based on apparent linear correlations among these variables in scatter plots (Figure 10), regression models of the form $y = mx + b$ were fit, where x and y are the independent and dependent variable, b is the intercept, and m is the slope. Model parameters for significant fits are in Figure 10.

Figure 10. Dependence of $\log(K_s)$ on effective particle diameter d_{10} for coarse layer in Trench 8 and fine and coarse layers in Pit 3. "*" and "**" indicate regression is significant at 0.05 and 0.01 level, respectively.

Although the correlations are significant, computed coefficients of determination, r^2 , ranged from 0.20 to 0.39, indicating that only a relatively small percentage of the observed variance for $\log(K_s)$ can be explained by variations in effective grain diameter and bulk density.

4.9 Analysis of Spatial Variability

Plots of property values vs. distance were used to identify trends in properties along the length of each sampling transect. Plots for $\log(K_s)$ are in Figures 11 and 12. In general, no trends were apparent. A linear regression was used to test for the presence of significant linear trends in property values along the length of each sampling transect. The independent variable in the regression analysis was the distance from transect origin; dependent variables were $\log(w)$, $\log(K_s)$, ρ_b , and d_{10} . The ANOVA for the regression results indicated no significant trends (significance level $p > 0.20$ for all tests) for any variable along the length of any transect. For distances of up to 600 ft, then, these properties of the coarse and fine layers can be considered stationary regionalized variables.

Variations of $\log(K_s)$ with distance and resulting sample variograms for vertical and horizontal cores from sampling transects in Trench 8 are in Figure 11; similar plots for Pit 3 are in Figure 12. Recall that the transect length, $\max(h)$, was 600 ft and that sample variograms are generally not useful for identifying spatial structures for values of h larger than $\max(h)/2 = 300$ ft (Journel and Huijbregts, 1987; Russo, 1984a). The use of a clustered line approach for placing sampling locations along each transect ensured that the number of sample pairs, n_i (Equation 3), exceeded 30 for distances up to 300 ft. The minimum value of h was 5 ft.

For $\log(K_s)$, correlation lengths were larger for Trench 8 than for Pit 3, indicating a higher degree of spatial continuity for $\log(K_s)$ in the direction of alluvium transport than in the direction perpendicular to alluvium transport (Table 16). In Trench 8, correlation lengths

Figure 11. $\log(K_s)$ vs. distance along sampling transect (left) and corresponding sample variograms (right) for pooled data (vertical and horizontal cores combined) for Pit 3 fine and coarse layers.

Figure 12. $\log(K_s)$ vs. distance along sampling transect (left) and corresponding sample variograms (right) for pooled data (vertical and horizontal cores combined) for Trench 8 fine and coarse layers.

Table 16. Summary of fitted variogram models; "C_o" is the nugget (semivariance at h = 0) and "a" is the range (correlation length).

	log(K _s)		ρ _b		d ₁₀	
<u>Trench 8</u>	C _o	a (ft)	C _o	a (ft)	C _o	a (ft)
Fine layer	0.40	150	3.72x10 ⁻³	< 5	3.91x10 ⁻⁴	75
Coarse layer	0.42	200	2.50x10 ⁻³	75	3.02x10 ⁻³	< 5
<u>Pit 3</u>						
Fine layer	0.40	80	1.00x10 ⁻³	150	3.19x10 ⁻⁴	100
Coarse layer	1.13	< 5	4.43x10 ⁻³	< 5	8.00x10 ⁻⁴	40

for $\log(K_s)$ for fine and coarse layers were approximately equal, while in Pit 3, correlation lengths were larger in the fine layer than in the coarse layer which was fit with a pure nugget model ($C_0 = s^2$). For bulk density, however, the highest correlation length was obtained for the fine layer in Pit 3,

followed by the coarse layer in Trench 8. The sample variograms for bulk density in the coarse layer in Pit 3 and the fine layer in Trench 8 were fit with pure nugget models. For d_{10} , the largest correlation lengths were in the coarse layer in Pit 3; the coarse layer in Trench 8 was fit with a pure nugget model.

4.10 Implications for Site Characterization at the RWMS

The data and analyses for the four sampling transects can be used to guide the design of future sampling programs at the RWMS and, potentially, at other sites in similar materials. A summary of these implications for ρ_b , $\log(K_s)$, and d_{10} is shown below:

<u>Property</u>	<u>Pool data from fine and coarse layers ?</u>	<u>Number of cores to estimate mean value for layer</u>	<u>Optimum core spacing within horizontal layers (ft)</u>	<u>Within-layer anisotropy ?</u>	<u>Site-scale anisotropy ?</u>
ρ_b	Yes	8 (pooled data)	150 (pooled data)	No	No
$\log(K_s)$	No	16 (fine layers) 24 (course layers)	150 (fine layers) 200 (course layers)	No	No
d_{10}	No	37 (fine layers) 43 (course layers)	100 (fine layers) 40 (course layers)	Yes*	Yes

*Probably a sampling artifact resulting from loss of fines during horizontal coring.

Sampling transects were located in individual fine and coarse layers. Properties of the two materials are compared in the second column. ANOVA results indicated that ρ_b data for the two types of materials were not significantly different and that ρ_b data from the fine and coarse layers can be combined (pooled). However, there were significant

differences in $\log(K_s)$ and d_{10} between the two types of materials, indicating that these properties for the two materials should be analyzed separately. It should be noted that although the differences were statistically significant, the absolute magnitudes were relatively small and may not have practical importance. This is currently being tested by ongoing sensitivity analyses using numerical water flow codes.

The third column lists the number of core specimens required to estimate the mean value of a property for individual fine or coarse layers at the 95 percent confidence level. If at least this number of core specimens are analyzed, computed sample means will be within 10 percent of the population mean.

The sample size calculations in column three are based on the assumption of statistical independence of measurements for all cores within a layer. However, analysis of sample variograms indicated correlation lengths (the distance beyond which a pair of cores becomes statistically independent) ranged from less than 5 to 200 ft (Table 16). Samples placed horizontally closer together than the correlation length are partially redundant because the measured property values will be correlated. To avoid the collection of redundant information, cores should be collected a horizontal distance apart equal to or greater than the fitted correlation length. The fitted correlation length was different for each property, layer, and sampling transect (Table 16). The maximum correlation length for each property (all layers and sampling transects combined) provides a conservative indication of horizontal core spacing required to ensure independent samples. These core spacings are listed above in column four. It should be noted that the use of the term "optimum" to describe the core spacings applies only in the context of fitted correlation lengths in Table 16.

Vertical and horizontal cores were collected at each sampling location along each transect, providing the opportunity to test for the presence of small-scale anisotropy, e.g., due to small-scale sedimentary structures such as cross- or planar-bedding. The absence of vertical and horizontal anisotropy, except for d_{10} which is probably an artifact created by

loss of fines during horizontal coring, indicates that vertical core specimens (e.g., from boreholes) can be used to characterize these materials.

Sampling transects were aligned parallel and perpendicular to the principal sediment transport direction for the alluvium at the site. Comparisons of property values can be used to test for the existence of horizontal site-scale anisotropy caused by large-scale geologic processes. A greater degree of variability in one direction, for example, would imply that future boreholes be more closely spaced in that direction. The results in column five show that such anisotropy existed only for d_{10} .

5.0 SUMMARY

Statistical analyses of selected physical and hydrologic properties were performed for representative fine and coarse layers at a low-level waste disposal site on the NTS in southern Nevada. This study has provided the first information on the statistical properties of desert soils (below the root zone) for distances of 600 ft. This information will be used as input for numerical water, air, and solute transport modeling and to guide future sampling efforts at the RWMS. These analyses also supply preliminary information for use in designing unsaturated zone sampling programs at other sites in similar materials. Properties were modeled as either normally or lognormally distributed random variables. Intervariable correlations, although statistically significant, were weak. Sample coefficients of variation were smallest for bulk density and largest for saturated hydraulic conductivity. Differences in $\log(K_s)$ for vertical and horizontal cores were not significant. Sample variograms were described by combinations of pure nugget and spherical model structures with correlation lengths ranging from less than 5 to 200 ft.

An important consideration for the development of site scale models in these materials is the need to separately characterize fine- and coarse-grained materials. In this study, particle size distributions for the two materials were different, and significant differences in the natural logarithm of saturated hydraulic conductivity, $\log(K_s)$, existed between

coarse and fine layers in an excavation aligned with the principal direction of alluvium deposition but not in a perpendicular direction. Although these differences are expected given the different origins of the two materials, the implications for flow and transport modeling are unknown. Sensitivity analyses are being conducted to determine if observed differences in hydrologic properties between the two materials result in important differences in water flow for expected infiltration events.

6.0 REFERENCES

- Ankeny, M. D., T. C. Kaspar, and R. Horton. 1988. Design for an automated tension infiltrometer. *Soil Sci. Soc. Am. J.* 52:893-896.
- ASTM D 422-63. 1972. Method for particle-size analysis of soils. In 1987 Annual book of ASTM standards, Vol. 04.08, American Society for Testing & Materials, Philadelphia, PA.
- ASTM D 2216-80. 1980. Method for laboratory determination of water (moisture) content of soil, rock, and soil-aggregate mixtures. In 1987 Annual book of ASTM standards, Vol. 04.08, American Society for Testing & Materials, Philadelphia, PA.
- ASTM D 2325-68. 1981. Test method for capillary-moisture relationships for coarse- and medium-textured soils by porous-plate apparatus. In 1987 Annual book of ASTM standards, Vol. 04.08, American Society for Testing & Materials, Philadelphia, PA.
- ASTM D 2434-68. 1974. Test method for permeability of granular soils (constant head). In 1987 Annual book of ASTM standards, Vol. 04.08, American Society for Testing & Materials, Philadelphia, PA.
- Bickel, P. and K. Doksum. 1977. *Mathematical statistics: Basic ideas and selected topics*, Holden Day, San Francisco, CA.
- Blum, J. R., J. Kiefer, and M. Rosenblatt. 1961. Distribution-free tests of independence based on the sample distribution function. *Annals of Mathematical Statistics*, 32: 485-498.

- Burgess, T. M., R. Webster, and A. B. McBratney. 1981. Optimal interpolation and isarithmic mapping of soil properties. IV. Sampling strategy. *J. Soil Sci.* 32: 643-659.
- Dixon, G. L. 1965. Geologic report on drill hole UE11b, Nevada Test Site. U.S. Geological Survey Technical Letter NTS-157.
- Filliben, J. J. 1975. The probability plot correlation coefficient test for normality. *Technometrics* 17: 11-117.
- Gajem, Y. M., A. W. Warrick, and D. E. Myers. 1981. Spatial structure of physical properties of a Typic Torrifluvent soil. *Soil Sci. Soc. Am. J.* 45:709-715.
- Gelhar, L. W. and C. L. Axness. 1983. Three-dimensional stochastic analysis of macrodispersion in aquifers. *Water Resour. Res.* 19:161-180.
- Guma, G. S. 1978. Spatial variability of in situ available water. Ph.D. dissertation, The University of Arizona, Tucson, AZ.
- Harms, J. C. and R. K. Fahnestock. 1965. Stratification, bed forms, and flow phenomena (with an example for the Rio Grande). In G.V. Middleton (ed.), *Primary sedimentary structures and their hydrodynamic interpretation*. Soc. of Economic Paleontologists and Mineralogists Special Publication 12:84-115.
- Healy, R. W. and P. C. Mills. 1991. Variability of an unsaturated sand unit underlying a radioactive-waste trench. *Soil Sci. Soc. Am. J.* 55(4): 899-907.
- Hevesi, J. A., J. D. Istok, and A. L. Flint. 1992. Precipitation estimation in mountainous terrain using multivariate geostatistics. Part I: Structural analysis. *J. Applied Meteorology*, 31(7): 661-676.

- Istok, J. D., R. M. Cooper, and A. L. Flint. 1988. Three-dimensional, cross-semivariogram calculations for hydrogeological data. *Ground Water* 26:638-646.
- Johnson, N. M. and S. J. Dreiss. 1989. Hydrostratigraphic interpretation using indicator geostatistics. *Water Resour. Res.* 25(12): 2501-2510.
- Journel, A. G. and Ch. J. Huijbregts. 1987. *Mining geostatistics*, Academic Press, New York, NY.
- Klute, A. (ed.). 1986. *Methods of soil analysis, Part 1, Physical and mineralogical methods*, 2nd Ed. American Society of Agronomy, Madison WI.
- MINITAB Inc. 1991. *MINITAB reference manual, release 8*. MINITAB Inc., State College, PA.
- Nielsen, D. R., J. W. Biggar, and K. T. Erh. 1973. Spatial variability of field-measured soil-water properties. *Hilgardia* 42: 215-259.
- Nilsen, T. H. 1982. Alluvial fan deposits. P. A. Scholle and D. Spearing (eds.) *Sandstone depositional environments*. American Society of Petroleum Engineers Memoir 31, pp. 49-86.
- Peck, A. J., R. J. Luxmoore, and J. T. Stolzy. 1977. Effects of spatial variability of soil hydrologic properties in water budget modeling. *Water Resour. Res.* 13:348-354.
- Perroux, K. M. and I. White. 1988. Designs for disc permeameters. *Soil Sci. Soc. Am. J.* 52:1205-1215.

- Raytheon Services Nevada. 1991. Surficial geology of the Area 5 Radioactive Waste Management Site. Environmental Operations Department, Raytheon Services Nevada, Las Vegas, NV.
- Russo, D. 1984a. A geostatistical approach to solute transport in heterogeneous fields and its application to salinity management. *Water Resour. Res.* 20:1260-1270.
- Russo, D. 1984b. Design of an optimal sampling network for estimating the variogram. *Soil Sci. Soc. Am. J* 48:708-716.
- Russo, D. and E. Bresler. 1981. Soil hydraulic properties as stochastic processes: I. An analysis of field spatial variability. *Soil Sci. Soc. Am. J.* 45:682-687.
- Shapiro, S. S. and M. B. Wilk. 1965. An analysis of variance test for normality (complete samples). *Biometrika* 52:591-611.
- Snyder, K. E., S. M. Parsons, and D. L. Gustafson. 1993. Field results of subsurface geologic mapping at the Area 5 Radioactive Waste Management Site, DOE/Nevada Test Site, Nye County. Raytheon Services Nevada. Las Vegas, NV.
- van der Zee, S.E.A.T.M., and W. H. van Riemsdijk. 1987. Transport of reactive solute in spatially variable soil systems. *Water Resour. Res.* 23:2059-2069.
- van Genuchten, M. T. 1980. A closed-form equation for predicting the hydraulic conductivity of unsaturated soils. *Soil Sci. Soc. Am. J.*, 45:892-898.
- Viera, S. R., D. R. Nielsen, and J. W. Biggar. 1981. Spatial variability in field measured infiltration rate. *Soil Sci. Soc. Am. J* 45: 1040-1048.

Wierenga, P. J. 1988. Validation of flow and transport models at the Jornada test facility. P. 525-530. In P.J. Wierenga and D. Bachelet (ed.) Int. Conf. Worksh. validation of flow and transport models for the unsaturated zone, Ruidoso, N.M. 22-25 May 1988. College of Agriculture and Home Economics, New Mexico State University, Las Cruces, NM.

Wooding, R. A. 1968. Steady infiltration from a shallow circular pond. Water Resour. Res. 4:1259-1273.

Zar, J. H. 1984. Biostatistical analysis. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.

Distribution List

**Layton O'Neill (5)
U.S. Department of Energy
Waste Management Division
Nevada Field Office
P.O. Box 98518, MS 505
Las Vegas, NV 89193-8518**

**Stuart Rawlinson
Raytheon Services Nevada
Environmental Operations
P.O. Box 95487, MS 424
Las Vegas, NV 89193-5487**

**David P. Gallegos
Sandia National Laboratories
Department 6331
P.O. Box 5800
Albuquerque, NM 87185**

**Dr. Scott Tyler
Desert Research Institute
Water Resources Center
7010 Dandini Blvd.
Reno, NV 89512**

**Dr. Jack Istok (3)
Oregon State University
Department of Civil Engineering
Environmental and Water Resources
Engineering Program
Corvallis, OR 97331**

**Gayle Pawlowski
Lawrence Livermore National Laboratory
P.O. Box 808, MS L-221
Livermore, CA 94551**

**Jacob Rubin
U.S. Geological Survey
345 Middlefield Road, MS 421
Menlo Park, CA 94025**

**David Stonestrum
U.S. Geological Survey
345 Middlefield Road, MS 421
Menlo Park, CA 94025**

7.0 APPENDICES

APPENDIX A

Table A.1. Field testing data from the fine layer in Trench 8.

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)	Infiltration rates (mm/s) at indicated tension (cm)			
				0	-3	-6	-15
0	1.59	3.66	4.5	0.255	0.192	0.144	0.111
5	1.65	3.22	4.5	0.232	0.354	0.258	0.153
10	1.60	3.36	4.4	0.164	0.207	0.186	0.108
15	1.61	3.30	4.7	0.294	0.195	0.156	0.090
20	1.53	3.52	6.1	0.264	0.171	0.132	0.086
40	1.63	3.43	5.0	0.272	0.168	0.132	0.085
60	1.60	3.59	4.8	0.204	0.132	0.108	0.084
80	1.59	3.08	4.7	0.290	0.216	0.173	0.108
100	1.52	3.73	5.7	0.272	0.168	0.163	0.108
105	1.48	3.72	6.9	0.190	0.153	0.127	0.084
110	1.58	3.50	4.9	0.226	0.156	0.132	0.078
115	1.57	3.41	5.0	0.245	0.125	0.108	0.058
120	1.55	3.62	6.0	0.215	0.180	0.153	0.063
140	1.64	3.38	4.4	0.204	0.132	0.120	0.076
160	1.59	2.89	4.8	0.181	0.115	0.096	0.030
180	1.61	3.49	4.7	0.204	0.153	0.135	0.048
200	1.61	3.67	4.8	0.219	0.144	0.125	0.077
205	1.57	3.62	5.2	0.199	0.187	0.156	0.128
210	1.56	4.06	5.4	0.181	0.177	0.144	0.105
215	1.62	2.98	4.8	0.362	0.252	0.191	0.084
220	1.56	3.95	5.1	0.243	0.180	0.162	0.110
240	1.56	3.67	5.0	0.091	0.054	0.048	0.036
260	1.54	4.44	5.0	0.136	0.120	0.108	0.084
280	1.56	3.81	5.2	0.159	0.139	0.120	0.093
300	1.52	2.17	4.7	0.181	0.146	0.123	0.084
305	1.56	3.79	5.1	0.136	0.102	0.084	0.062
310	1.54	4.27	5.1	0.181	0.171	0.138	0.098
315	1.55	2.23	5.1	0.113	0.078	0.072	0.053
320	1.48	3.40	6.3	0.176	0.152	0.127	0.090
340	1.58	3.63	4.9	0.091	0.093	0.085	0.016
360	1.50	4.10	5.8	0.072	0.042	0.044	0.034
380	1.58	3.18	4.9	0.153	0.144	0.117	0.086
400	1.52	4.26	5.0	0.528	0.256	0.186	0.076
405	1.52	4.12	5.0	0.272	0.141	0.120	0.046
410	1.57	3.60	4.9	0.445	0.312	0.255	0.070
415	1.52	3.77	5.2	0.211	0.136	0.114	0.073
420	1.52	4.08	5.0	1.019	0.476	0.324	0.096
440	1.56	3.02	5.1	0.159	0.112	0.117	0.070
460	1.58	3.89	5.2	0.226	0.156	0.135	0.072
480	1.55	3.87	5.5	0.113	0.096	0.087	0.050
500	1.60	3.90	5.2	0.136	0.102	0.090	0.052
505	1.65	3.77	4.8	0.109	0.067	0.056	0.043
510	1.55	3.70	5.2	0.267	0.088	0.069	0.043

Table A.1. (Continued).

Distance (ft)	P _b (g/cm ³)	w (%)	θ (%)	Infiltration rates (mm/s) at indicated tension (cm)			
				0	-3	-6	-15
515	1.56	3.61	5.0	0.221	0.136	0.108	0.054
520	1.58	3.95	4.9	0.166	0.108	0.097	0.072
540	1.56	4.08	5.5	0.181	0.144	0.144	0.090
560	1.54	3.45	5.1	0.272	0.205	0.171	0.108
580	1.60	4.78	5.9	0.634	0.449	0.342	0.180
600	1.49	5.34	8.3	0.204	0.180	0.156	0.033

Table A.2. Field testing data from the upper coarse layer in Trench 8.

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)
0	1.70	3.57	4.1
5	1.63	3.95	4.4
10	1.72	3.42	4.3
15	1.69	3.11	3.7
20	1.56	4.66	5.2
40	1.58	3.02	6.8
60	1.65	3.11	5.6
80	1.68	3.15	4.7
100	1.65	3.65	4.2
105	1.71	2.73	3.9
110	1.74	3.12	3.8
115	1.69	3.40	4.0
120	1.63	3.35	4.9
140	1.71	3.44	4.0
160	1.61	3.54	5.4
180	1.63	3.53	5.8
200	1.63	3.28	4.5
205	1.68	3.35	4.0
210	1.60	3.54	4.0
215	1.61	3.70	4.6
220	1.53	3.76	4.7
240	1.56	3.50	4.3
260	1.64	3.31	4.2
280	1.61	3.72	3.7
300	1.51	4.02	5.1
305	1.56	4.78	5.1
310	1.54	4.39	5.1
315	1.60	2.96	5.2
320	1.55	4.75	5.9
340	1.52	3.49	5.8
360	1.53	3.98	4.7
380	1.66	4.00	5.0
400	1.44	4.62	5.6
405	1.58	4.22	4.9
410	1.48	3.69	5.4
415	1.61	3.79	5.0
420	1.59	3.52	4.8
440	1.62	3.99	3.6
460	1.53	3.66	5.0
480	1.56	2.95	5.6
500	1.56	4.05	5.7
505	1.52	4.01	5.3
510	1.48	4.11	5.7

Table A.2. (Continued).

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)
515	1.48	3.69	6.0
520	1.55	4.05	5.3
540	1.50	3.43	5.1
560	1.50	4.27	4.5
580	1.48	4.02	5.8
600	1.49	6.61	8.5

Table A.3. Field testing data from the lower coarse layer in Trench 8.

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)	Infiltration rates (mm/s) at indicated tension (cm)			
				0	-3	-6	-15
0	1.51		5.9				
5	1.58		4.7				
10	1.48		5.0				
15	1.66		5.3				
20	1.55		5.6				
40	1.61		4.6	0.611	0.291	0.230	0.030
60	1.65		3.4	1.203	0.407	0.288	0.064
80	1.58		5.8	0.849	0.455	0.324	0.150
100	1.58		4.7	0.249	0.156	0.132	0.066
105	1.45		7.9	1.145	0.503	0.390	0.023
110	1.42		7.2	1.359	0.683	0.539	0.120
115	1.59		4.4	0.362	0.225	0.148	0.049
120	1.55		4.7	1.631	0.564	0.496	0.048
140	1.51		5.3	0.444	0.176	0.176	0.053
160	1.52		5.5	0.390	0.173	0.129	0.016
180	1.58		4.8	1.291	0.614	0.674	0.070
200	1.48		5.4	0.516	0.342	0.249	0.066
205	1.55		4.7	0.423	0.225	0.180	0.063
210	1.57		4.4	1.336	0.548	0.372	0.082
215	1.50		4.7	0.992	0.453	0.345	
220	1.56		5.7	0.747	0.409	0.313	0.071
240	1.59		4.8	0.317	0.216	0.165	0.097
260	1.56		5.8				
280	1.56		4.9				
300	1.56		5.4				
305	1.57		5.7				
310	1.59		5.3				
315	1.62		4.3				
320	1.53		5.7				
340	1.59		5.4				
360	1.57		5.3	0.362	0.216	0.207	0.117
380	1.54		5.5	1.009	0.581	0.216	0.119
400	1.56		5.3				
405	1.65		4.5	0.734	0.360	0.266	0.043
410	1.62		4.3	0.815	0.342	0.270	0.064
415	1.56		5.0	0.272	0.180	0.153	0.099
420	1.56		5.7				
440	1.49		5.4	0.815	0.333	0.204	0.029
460	1.57		6.0	1.114	0.602	0.457	0.095
480	1.70		3.8	1.766	0.578	0.431	0.097
500	1.56		5.2				
505	1.58		5.3				
510	1.58		4.9				
515	1.63		4.3				
520	1.58		4.9				

Table A.3. (Continued).

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)	Infiltration rates (mm/s) at indicated tension (cm)			
				0	-3	-6	-15
540	1.58		4.9	0.408	0.285	0.285	0.023
560	1.49		4.1				
580	1.45		8.0				
600	1.42		7.4				

Table A.4. Field testing data from the fine layer in Pit 3.

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)	Infiltration rates (mm/s) at indicated tension (cm)			
				0	-3	-6	-15
0	1.54		5.5	0.362	0.252	0.198	
5	1.52		6.2	0.408	0.270	0.234	0.042
10	1.59		4.9	0.317	0.196	0.180	0.036
15	1.56		5.1	0.317	0.234	0.180	0.048
20	1.56		4.9	0.181	0.144	0.126	0.030
40	1.54		5.3	0.453	0.351	0.288	
60	1.55		5.4	0.400	0.306	0.234	0.360
80	1.48		6.4	0.317	0.162	0.144	0.042
100	1.51		5.4	0.226	0.144	0.126	0.030
105	1.52		6.0	0.347	0.285	0.216	0.030
110	1.54		4.9	0.226	0.216	0.180	0.030
115	1.53		4.9	0.408	0.360	0.252	0.018
120	1.56		4.7	0.408	0.306	0.234	0.030
140	1.53		5.4	0.317	0.252	0.216	
160	1.53		5.6	0.272	0.234	0.180	0.024
180	1.51		4.8	1.087	0.342	0.220	0.042
200	1.50	10.5		1.087	0.698	0.539	0.180
205	1.54		8.9	0.951	0.431	0.324	0.198
210	1.52		9.2	1.223	0.640	0.485	0.270
215	1.47		10.9	0.815	0.485	0.342	0.189
220	1.47		10.2	0.453	0.521	0.360	0.180
240	1.52		8.9	0.544	0.378	0.270	0.062
260	1.58		8.7	0.544	0.449	0.324	0.072
280	1.50	10.2		0.679	0.419	0.252	0.096
300	1.49		9.9	0.408	0.342	0.261	0.144
305	1.44		9.2	0.498	0.413	0.360	0.216
310	1.49		9.6	0.317	0.252	0.234	0.162
315	1.48		6.9	0.362	0.270	0.234	0.162
320	1.43		9.3	0.317	0.330	0.270	0.180
340	1.52		8.9	0.317	0.243	0.186	0.126
360	1.46	11.2		0.453	0.431	0.369	0.198
380	1.51		9.0	0.226	0.103	0.072	0.033
400	1.45		8.6	0.317	0.198	0.162	
405	1.48		9.0	0.408	0.180	0.076	
410	1.44	10.3		0.340	0.162	0.126	
415	1.46		7.8	0.226	0.171	0.108	0.004
420	1.49		8.6	0.340	0.270	0.162	
440	1.57		7.6	0.136	0.009	0.072	0.036
460	1.56		9.3	0.136	0.102	0.090	0.084
480	1.59		4.8	0.272	0.162	0.126	0.063
500	1.47		6.7				
505	1.45		5.8				
510	1.50		6.3	0.181	0.180	0.144	0.096
515	1.50		5.7	0.226	0.132	0.120	0.072

Table A.4. (Continued).

Distance (ft)	ρ_b (g/cm ³)	w (%)	θ (%)	Infiltration rates (mm/s) at indicated tension (cm)			
				0	-3	-6	-15
520	1.59		5.7	0.226	0.162	0.144	0.108
540	1.54		8.2	0.272	0.126	0.126	0.072
560	1.55		7.5	0.226	0.216	0.180	0.066
580	1.51		6.7	0.679	0.413	0.270	0.090
600	1.49		5.6	0.159	0.108	0.090	0.048

APPENDIX B

Table B.1. Laboratory chloride and bromide measurements from the fine layer of Trench 8.

Distance (ft)	Leachate [Cl ⁻] (ppm)	Dry Soil [Cl ⁻] (ppm)	Leachate [Br ⁻] (ppm)	Dry Soil [Br ⁻] (ppm)	Soil Water [Cl ⁻] (ppm)	Soil Water [Br ⁻] (ppm)
0						
5	130.00	198.96	1.00	1.53	4980	38
10						
15						
20	157.00	286.25	1.03	1.88	8541	56
40	146.00	229.31	1.12	1.76	5970	46
60						
80						
100						
105	133.00	214.31	1.02	1.64	7392	57
110	131.00	197.47	1.00	1.51	7181	55
115	122.00	203.46	0.95	1.58	6459	50
120	134.00	219.85	1.04	1.71	6581	51
140	126.00	209.62	0.98	1.63	6145	48
160	192.00	305.09	1.26	2.00	10979	72
180	135.00	209.69	0.99	1.54	6873	50
200	143.00	246.76	1.02	1.76	7787	56
205	169.00	277.69	1.25	2.05	8267	61
210	173.00	284.99	1.26	2.08	6946	51
215	163.00	307.22	1.18	2.22	8968	65
220						
240	193.00	284.83	1.39	2.05	8430	61
260	265.00	415.33	1.94	3.04	8470	62
280	166.00	250.47	1.27	1.92	6437	49
300	191.00	279.31	1.45	2.12	11947	91
305	135.00	201.73	1.03	1.54	5626	43
310	124.00	231.33	0.96	1.79	5929	46
315						
320						
340						
360	247.00	371.00	1.84	2.76	9500	71
380	156.00	237.17	1.20	1.82	5503	42
400	204.00	293.22	1.50	2.16	9173	67
405	225.00	340.79	1.65	2.50	7692	56
410	208.00	298.34	1.57	2.25	6709	51
415	236.00	362.21	1.72	2.64	6909	50
420	220.00	308.75	1.60	2.25	6760	49
440	245.00	360.55	1.76	2.59	8116	58
460	193.00	280.56	1.41	2.05	6528	48
480	196.00	303.95	1.45	2.25	8116	60
500	181.00	270.04	1.35	2.01	5897	44
505	202.00	287.72	1.50	2.14	7112	53
510	187.00	274.27	1.43	2.10	6177	47

Table B.1. (Continued).

Distance	Leachate	Dry Soil	Leachate	Dry Soil	Soil Water	Soil Water
(ft)	[Cl⁻]	[Cl⁻]	[Br⁻]	[Br⁻]	[Cl⁻]	[Br⁻]
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
515	217.00	317.01	1.64	2.40	6469	49
520	279.00	426.87	2.10	3.21	8114	61
540	209.00	311.49	1.57	2.34	7376	55
560	198.00	289.59	1.48	2.16	8327	62
580	230.00	361.02	1.75	2.75	7031	54
600	317.00	461.61	2.39	3.48	8099	61

Table B.2. Laboratory chloride and bromide measurements from the upper coarse layer of Trench 8.

Distance (ft)	Leachate [Cl ⁻] (ppm)	Dry Soil [Cl ⁻] (ppm)	Leachate [Br ⁻] (ppm)	Dry Soil [Br ⁻] (ppm)	Soil Water [Cl ⁻] (ppm)	Soil Water [Br ⁻] (ppm)
0	215.00	272.39	1.29	1.63	2524	15
5	245.00	307.68	1.50	1.88	4335	27
10	119.00	287.38	0.70	1.69	7660	45
15	116.00	265.18	0.70	1.60	7960	48
20	169.00	315.96	0.97	1.81	7788	45
40	141.00	214.51	0.94	1.43		
60	103.00	206.45	0.77	1.54	7514	56
80	173.00	314.13	1.02	1.85	13702	81
100	137.00	250.38	0.80	1.46	4624	27
105	179.00	273.82	0.99	1.51	10487	58
110	181.00	289.43	1.04	1.66	9938	57
115	108.00	176.60	0.84	1.37	8136	63
120	232.00	362.43	1.46	2.28	11883	74
140	193.00	291.19	1.22	1.84	10150	64
160	211.00	353.39	1.28	2.14	15326	93
180	178.00	345.87	0.99	1.92	9795	54
200	257.00	333.33	1.41	1.83	8341	46
205	120.00	235.02	0.88	1.72	8292	61
210	165.00	230.06	1.20	1.67	11373	83
215	147.00	242.91	1.07	1.77	8688	63
220	261.00	409.53	1.50	2.35	12903	74
240	249.00	382.89	1.39	2.14	14660	82
260	185.00	362.57	1.09	2.14	12895	76
280	133.00	276.62	1.00	2.08	9581	72
300	178.00	271.11	1.31	2.00	8760	64
305	141.00	209.05	1.07	1.59	5776	44
310	132.00	187.11	1.01	1.43	6427	49
315	135.00	202.07	1.04	1.56	5561	43
320	152.00	215.46	1.14	1.62	5832	44
340	139.00	202.78	1.03	1.50	6349	47
360	167.00	261.10	1.27	1.99	7567	58
380	148.00	219.26	1.12	1.66	5836	44
400	193.00	273.22	1.42	2.01	7975	59
405	149.00	213.04	1.11	1.59	8144	61
410	188.00	267.78	1.38	1.97	8400	62
415	188.00	272.04	1.38	2.00	7842	58
420	246.00	370.08	1.74	2.62	11509	81
440	150.00	221.25	1.06	1.56	7354	52
460	189.00	263.47	1.36	1.90	7547	54
480	145.00	209.54	1.10	1.59	9952	75
500	157.00	213.78	1.14	1.55	6520	47
505	157.00	239.86	1.16	1.77	6457	48
510	272.00	373.98	1.96	2.69	9443	68

Table B.2. (Continued).

Distance (ft)	Leachate [Cl ⁻] (ppm)	Dry Soil [Cl ⁻] (ppm)	Leachate [Br ⁻] (ppm)	Dry Soil [Br ⁻] (ppm)	Soil Water [Cl ⁻] (ppm)	Soil Water [Br ⁻] (ppm)
515	169.00	237.41	1.28	1.80	8168	62
520	198.00	283.46	1.52	2.18	10225	78
540	177.00	245.68	1.37	1.90	7906	61
560	241.00	333.57	1.79	2.48	7524	56
580	232.00	329.95	1.84	2.61	8424	67
600						

APPENDIX C

Table C.1. Physical and hydraulic parameter data for vertical cores from the fine layer of Trench 8.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	-----			% passing indicated seive size -----											ρ_s (g/cm ³)
				d_{10}	d_{50}	d_{60}	3/4	3/8	4	6	10	16	40	70	140	200		
0	8.1	1.66	9.1x10-4	0.08	0.43	0.67	100	97.1	91.55	85.91	80.01	72.97	49.9	27.15	12.44	9.21		
5			8.6x10-4															
10	10.3	1.53	4.7x10-3	0.07	0.39	0.6	100	100	93.51	89.03	82.72	75.27	52.85	29.72	15.07	11.84		
15			1.7x10-3															
20	9.2	1.56	1.5x10-3	0.05	0.34	0.49	100	97.64	92.02	88.62	83.74	77.87	57.68	33.97	17.32	16.65	2.55	
40			2.4x10-3															
60	6.2	1.65	7.7x10-4	0.075	0.4	0.6	100	96.56	92.94	86.59	80.76	74.69	52.5	28.11	12.71	10.11		
80			2.4x10-3															
100	7.5	1.57	9.0x10-4	0.06	0.36	0.55	100	98.27	91.45	87.19	80.87	74.42	55.26	33.43	16.91	13.48		
105			1.1x10-3															
110	5.7	1.63	5.8x10-4	0.055	0.33	0.46	100	98.91	94.15	90.64	85.57	79.59	58.71	34.58	17.94	14.65		
115			1.7x10-3															
120	6.7	1.62	6.7x10-4														2.53	
140			2.0x10-3															
160	6.6	1.65	6.4x10-4	0.06	0.39	0.6	100	98.61	95.04	88.4	82.35	74.91	52.69	31.68	16.54	12.6		
180			4.2x10-4															

Table C.1. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated scive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
200	8.7	1.62	2.0x10 ⁻⁴	0.063	0.42	0.61	100	98.16	94.45	90.02	83.21	75.26	50.66	27.71	14.44	11.99	
205			3.3x10 ⁻⁴														
210	4	1.7	1.0x10 ⁻⁴	0.047	0.37	0.55	100	98.96	92.42	88.26	82.22	75.64	54.96	33.86	18.39	14.9	
215			1.3x10 ⁻⁴														
220	5.9	1.64	2.7x10 ⁻⁴	0.04	0.38	0.6	100	96.07	92.78	86.98	81.01	73.82	53.45	34.34	19.64	15.98	2.6
240			2.3x10 ⁻⁴														
260	4.7	1.67	2.8x10 ⁻⁴	0.045	0.32	0.45	100	97.49	93.51	88.24	82.46	76.8	58.74	37.73	20.7	16.35	
280			4.2x10 ⁻⁴														
300	4.4	1.64	5.7x10 ⁻⁴	0.053	0.32	0.49	100	95.07	90.32	85.84	80.61	75.12	57.85	36.64	19.88	15.86	
305			4.6x10 ⁻⁴														
310	5.7	1.62	4.1x10 ⁻⁴	0.005	0.09	0.13	100	97.6	91.96	87.74	82.33	77.57	70.31	64.29	58.14	56.28	
315			3.5x10 ⁻⁴														
320	6	1.62	4.9x10 ⁻⁴														2.6
340			2.7x10 ⁻⁴														
360	5.2	1.58	3.2x10 ⁻⁴	0.06	0.3	0.4	100	99.04	96.29	92.37	87.89	82.68	62.88	37.58	18.21	13.51	
380			4.6x10 ⁻⁴														

Table C.1. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
400	4.6	1.65	2.2x10 ⁻⁴	0.05	0.33	0.51	100	96.52	91.05	84.71	79.33	73.89	56.85	36.72	19.94	14.86	
405			1.7x10 ⁻⁴														
410	6	1.63	2.2x10 ⁻⁴	0.041	0.3	1.2	100	95.12	88.43	85.19	80.49	75.89	60.69	41.03	23.86	18.71	
415			2.3x10 ⁻⁴														
420	5.8	1.61	6.1x10 ⁻⁴	0.046	0.37	0.6	100	95.66	88.16	83.98	78.28	72.15	54.31	32.56	16.41	14.27	2.55
440			8.0x10 ⁻⁴														
460	9.5	1.54	9.5x10 ⁻⁴	0.042	0.29	0.4	100	100	94.77	90.24	85.98	80.73	62.18	40.03	21.67	15.95	
480			1.6x10 ⁻³														
500	7.3	1.54	5.8x10 ⁻⁴	0.044	0.34	0.5	100	96.67	91.5	87.51	80.76	74.47	56.53	37.45	21.84	19.2	
505			7.0x10 ⁻⁴														
510	9.6	1.6	5.9x10 ⁻⁴	0.04	0.3	0.41	100	99.33	96.58	93.15	88.26	81.94	61.21	39.63	23.31	18.58	
515			4.9x10 ⁻⁴														
520	8	1.59	8.3x10 ⁻⁴	0.049	0.35	0.51	100	100	94.09	87.34	81.45	75.1	55.93	36.89	21.1	15.62	2.61
540			1.3x10 ⁻³														
560	7.4	1.59	2.0x10 ⁻³	0.07	0.49	0.7	100	100	90.37	85.78	79.37	72	46.91	24.52	12.3	10.73	
580			2.6x10 ⁻³														
600	8	1.56	1.2x10 ⁻³	0.07	0.39	0.59	100	99.58	92.7	88.55	82.5	75.37	53.9	30.43	14.33	11.44	

Table C.2. Physical and hydraulic parameter data for horizontal cores from the fine layer of Trench 8.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
0	4.1	1.54	8.9x10-4	0.095	0.37	0.5	100	97.89	96.56	92.74	88.03	81.8	55.93	26.46	11.06	8.19		
5			8.9x10-4															
10	2.8	1.64	3.1x10-4	0.06	0.32	0.43	100	98.23	94.79	90.99	86.47	81.05	58.81	33.08	16.08	12.39		
15			1.1x10-3															
20	3.1	1.58	7.1x10-4	0.075	0.38	0.57	100	96.44	90.5	86.84	81.54	75.68	54.32	30.29	13.69	9.74	2.55	
40	4.5	1.61	7.2x10-4	0.1	0.47	0.72	100	94.9	88.65	83.67	77.4	70.51	47.97	24.59	10.49	8.02		
60			6.7x10-4															
80	3.3	1.72	8.2x10-4	0.11	0.58	1	86.58	81.36	74.66	71.25	67.19	62.7	44.75	23.53	9.61	6.81		
100	4.4	1.55	6.2x10-4	0.07	0.38	0.6	100	98.29	93.6	86.76	80.1	73.68	54.09	31.35	14.58	10.99		
105			7.8x10-4															
110	3.5	1.52	1.5x10-3	0.05	0.32	0.42	100	99.21	96.96	94.06	89.81	83.8	60.15	33.91	22.48	19		
115			5.0x10-4															
120	2.4	1.59	8.1x10-4	0.09	0.49	0.7	100	95.77	91.21	84.78	78.43	71.46	47.3	23.35	11.26	8.74	2.53	
140			2.1x10-3															
160	5.6	1.59	7.8x10-4	0.07	0.42	0.62	100	97.43	94	88.56	82.48	75.02	50.52	27.16	12.81	10.2		
180			1.2x10-3															

Table C.2. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
200	3.1	1.63	6.3x10-4	0.075	0.4	0.6	100	98.03	93.46	87.82	82.57	75.53	52.34	28.78	13.6	10.73		
205			2.9x10-4															
210	4.7	1.54	2.4x10-3	0.085	0.55	0.81	100	93.4	88.43	82.15	75.87	68.22	44.57	23.95	11.73	9.19		
215			4.2x10-4															
220	3.3	1.7	8.8x10-5		0.59	1	87.5	80.95	76.67	73.01	67.96	62.34	44.92	27.9	14.37	10.55	2.6	
240			3.7x10-3															
260	2.5	1.64	1.4x10-4	0.065	0.32	0.49	100	95.66	91.9	87.07	82.09	76.35	57.63	34.19	16.35	12.47		
280			3.6x10-4															
300	3.2	1.7	2.7x10-4	0.075	0.35	0.5	100	96.96	91.92	88.27	82.83	77.01	56.4	32.58	14.62	10.23		
305			1.8x10-4															
310	2.1	1.69	1.7x10-4	0.07	0.36	0.53	100	95.91	90.42	84.62	79.75	74.39	55.67	32.56	15.07	11.09		
315			1.3x10-4															
320	3.8	1.67	2.0x10-4	0.08	0.35	0.5	100	95.91	91.88	86.4	81.5	75.85	56.69	33.56	16.28	12.34	2.6	
340			2.1x10-4															
360	2.6	1.69	2.1x10-4	0.06	0.32	0.43	100	93.84	89.85	85.29	81.22	76.37	59	34.88	16.43	12.25		
380			2.3x10-4															

∞

Table C.2. (Continued).

Table C.2. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
400	3.8	1.66	2.4x10-4	0.075	0.38	0.57	100	97.31	92.76	86.5	81.26	74.88	54.43	30.69	13.53	9.85		
405			1.3x10-4															
410																		
415			3.2x10-4															
420	2.7	1.69	2.5x10-4	0.088	0.38	0.56	100	94.2	89.93	86.42	81.23	74.96	54.47	30.25	13.65	10.58	2.55	
440			1.1x10-4															
460			2.6x10-4															
480			3.6x10-4															
500	2.8	1.6	3.4x10-4	0.055	0.42	0.65	100	99.06	93.4	87.21	80.79	73.27	50.91	30.79	16.57	13.07		
505	3.1	1.59	5.6x10-4	0.055	0.4	0.62	100	99.68	93.74	89.22	83.66	76.63	52.35	37.04	23.07	20.47		
510	2.6	1.72	8.8x10-5	0.065	0.49	0.79	100	97.42	88.17	82.84	76.68	69.06	47.09	25.71	12.87	10.49		
515			1.4x10-4															
520	2.2	1.85	1.2x10-4	0.061	0.4	0.6	100	98.37	95.62	89.26	82.97	75.44	52.17	29.77	15.42	12.23	2.61	
540			8.3x10-4															
560	2.7	1.64	1.2x10-3	0.11	0.5	0.7	100	96.2	92.24	87.11	82.11	74.93	45.8	21.4	9.2	7.03		
580																		
600	5.8	1.61	7.5x10-4	0.088	0.36	0.5	100	94.95	90.88	87.9	83.38	77.27	56.68	32.15	14.97	11.85		

Table C.3. Physical and hydraulic parameter data for bulk samples from the upper coarse layer of Trench 8.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size									ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	
				----- (mm) -----												
0	1.7			0.23	3.9		56.61	54.15	48.67	41.18	33.66	17.85	9.5	4.84	3.93	
5	3.4			0.27	4.5		52.6	50.37	44.39	36.58	28.94	15.96	8.74	4.88	4.14	
10	4			0.25			42.99	41.98	39.26	35.21	30.16	16.2	8.3	4.24	3.26	
15	2.6			0.19	1.7	3	69.93	68.09	61.74	52.87	43.4	21.09	11.16	6.34	5.39	
20	3.4			0.12	0.9	1.8	75.32	75.32	69.54	62.66	54.98	33.84	16.91	8.52	6.84	2.54
40	2.6			0.15	1.8	4.3	62.94	61.32	57.38	51.17	44.33	25.85	13.97	7.2	5.28	
60	3.9			0.13	1.8	4.7	61.79	60.47	57.03	51.75	45.79	27.77	15.16	7.71	5.84	
80	1.7			0.15	1.8	3.35	67.14	64.89	59.25	52.12	44.48	26.11	14.22	7.62	6.12	
100	3.3			0.14	1.2	2.8	69.64	67.96	63.3	56.42	49.06	29.68	15.11	7.53	5.71	
105	2.4			0.09	0.54	0.89	79.65	79.65	76.34	72	66.12	44.99	25.08	12.33	8.75	
110	0.4			0.095	0.69	1.18	72.6	71.97	69.9	65.87	60.36	40.8	22.89	11.26	8.11	
115	1.1			0.095	0.8	1.7	71.53	71.53	67.48	62.71	57.19	38.65	21.71	11.08	8.12	
120	3.2				0.43	0.75	79.9	79.12	76.4	74.28	68.66	49.17	29.71	16.23	12.2	2.6
140	3.1			0.11	1.18	3.4	62.65	62.63	58.73	54.77	50.13	34.12	18.77	9.14	6.26	
160	3.6				0.51	0.9	84.56	82.68	78.47	71.95	65.36	46.37	28.62	15.43	11.45	
180	1.8			0.09	0.9	2.2	69.11	69.06	64.05	59.07	53.8	38.66	23.28	11.67	8.41	

Table C.3. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	----- d ₁₀ d ₅₀ d ₆₀ ----- (mm)			----- % passing indicated seive size -----										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
200	3.5			0.11	1.8	3.9	63.79	63.72	58.29	52.24	45.49	29	16.66	9.11	6.85		
205	3			0.11	1.4	2.6	71.51	69.83	64.14	56.57	48.84	30.82	18.27	10.06	7.87		
210	1.1			0.09	0.43	0.62	92.13	90.62	88.25	83.83	77.23	49.75	24.76	11.63	8.56		
215	1.8			0.085	0.45	0.69	88.51	88.48	84.65	79.62	73.24	48.78	25.16	12.1	8.92		
220	3.8			0.12	0.72	1.2	83.83	82.23	78.52	71.92	63.57	36.46	17.91	9.18	7.28	2.52	
240	0.9			0.08	0.51	0.8	87.21	87.21	81.95	76.04	68.15	45.1	25.51	12.74	9.31		
260	3.4			0.095	0.7	1.2	76.97	76.9	72.46	66.42	59.35	38.77	22.2	10.81	7.81		
280	2.6			0.11	0.9	1.7	77.31	75.36	70.35	64.07	56.91	36.04	19.63	9.5	7.33		
300	2.9			0.095	0.52	0.8	87.51	86.69	83.31	77.71	70.07	45.26	22.47	10.5	8.05		
305	4.1			0.09	0.63	1.1	80.77	78.34	73.91	68.32	61.91	41.71	23.08	10.79	7.88		
310	3			0.081	0.42	0.67	84.2	84.2	80.95	77.06	71.95	50.95	27.76	13.15	9.15		
315	3.3			0.08	0.6	0.9	86.12	86.05	81.07	74.89	67.3	44.48	23.87	12.33	9.55		
320	1.7			0.12	0.71	1.2	82.8	81.44	77.52	71.66	63.93	37.88	19.71	9.92	8.04	2.53	
340	3.7				0.55	0.95	76.85	75.81	73.16	69.29	64.28	45.25	26.86	13.62	10.16		
360	3.7			0.14	1.9	4	63.04	62.93	57.25	51.27	45.11	27.53	14.02	7.12	5.41		
380	4.3			0.095	0.89	1.9	71.61	70.25	66.37	61.21	55.23	37.55	21.54	10.89	8.59		

Table C.3. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_z (cm/s)	----- d ₁₀ d ₅₀ d ₆₀ ----- (mm)			----- % passing indicated seive size -----										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
400	0.5				0.39	0.61		81.95	81.9	78.61	74.84	70.15	53.63	32.86	17.14	12.96	
405	4.2				0.08	0.49	1.3	69.66	68.75	66.84	64.23	61.07	48.56	29.63	13.41	9.49	
410	1.4					0.3	0.41	86.68	86.04	83.79	80.9	77.3	61.23	38.35	18.76	13.22	
415	1.7					0.33	0.5	81.48	81.43	79.96	77.73	74.03	57.62	35.95	17.95	12.56	
420	1.5				0.13			41.43	41.41	38.82	36.39	33.65	24.98	15.67	8.36	6.33	2.57
440	3.3				0.09	0.71	1.3	77.45	75.3	71.8	66.93	61.41	40.17	21.54	13.75	7.4	
460	3.9					0.67	1.1	85.3	85.27	81.27	77.6	61.73	40.61	36.52	17.84	12.47	
480	0.7				0.14	0.6	0.85	88.9	87.84	84.1	77.64	69.28	41.45	20.27	9.18	6.97	
500	3.6				0.09	1.8		56.32	55.57	53.51	51.02	48.05	37.83	24.69	12.6	8.74	
505	3.7					0.51	1.2	67.67	67.63	64.95	62.24	58.96	47.35	31.14	15.8	10.32	
510	1					0.32	0.44	84.06	84.06	81.46	78.43	74.28	58.59	37.7	18.96	13.61	
515	1.6					0.35	0.57	78.25	77.71	76.05	73.68	70.3	56.3	36.68	18.64	12.6	
520	1.7					0.3	0.43	86.04	85.52	83.96	80.82	76.66	60.28	37.96	18.59	13.16	2.47
540	3.5					0.31	0.43	88.5	87.15	84.52	80.96	76.4	59.34	36.93	18.24	12.38	
560	2.2					0.34	0.49	89.91	89.41	86.86	82.33	76.13	57.42	36.4	19.06	14.4	
580	3.7					0.34	0.51	85.25	84.7	82.49	78.78	73.63	56.33	35.9	18.28	12.91	
600	4.7				0.16	1.3	2.6	71.88	70.25	64.79	56.46	47.99	27.75	14.18	6.22	4.21	

Table C.4. Physical and hydraulic parameter data for vertical cores from the lower coarse layer of Trench 8.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
0																	
5																	
10																	
15																	
20																	
40	4.5	1.49	3.1x10-3	0.084	0.39	0.55	100	97.33	93.88	91.21	86.35	80.29	53.39	24.06	11.54	9.35	
60	4.6	1.52	7.1x10-3	0.14	0.46	0.61	100	98.4	96.25	92.96	88.52	82.44	47.66	17.36	6.74	5.65	
80	3.9	1.62	1.1x10-2	0.24	0.9	1.3	100	94.89	86.35	80.82	71.64	59.18	22.85	8.23	4.13	3.54	
100	5.1	1.58	1.5x10-3	0.085	0.38	0.54	100	96.49	92.19	88.89	82.85	76.49	55.09	30.95	14.5	11.51	
105	5.9	1.49	1.6x10-3	0.21	1.1	1.9	100	88.96	80.01	70.27	61.4	51.91	28.9	10.44	3.84	3.09	2.53
110			1.4x10-3	0.18	0.65	0.95	100	98.65	89.3	82.89	74.36	66.16	38.65	12.72	4.01	3.05	
115		1.68	2.7x10-3	0.13	0.7	1.1	100	94.01	84.46	78.73	69.74	61.36	38.71	17.94	7.79	6.03	
120	5	1.56	8.9x10-3	0.15	0.45	0.67	100	97.13	93.69	88.69	82.61	75.87	48.64	17.16	5.5	3.92	
140	6.5	1.62	6.3x10-3	0.25	4	6.7	79.22	64.93	55.91	44.29	37.69	33.45	18.16	8.08	3.85	3.13	
160	4.6	1.59	4.5x10-3	0.15	0.61	0.81	100	98.51	92.64	88.45	80.67	72.21	37.34	14.91	6.84	5.93	
180	5	1.53	1.9x10-2	0.19	0.69	0.94	100	96.98	90.35	82.85	75.52	66.99	35.51	11.11	4.03	3.19	

Table C.4. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
200	5	1.56	3.8x10-3	0.12	0.4	0.59	100	96.91	93.47	88.44	82.36	75.79	52.93	23.14	8.9	6.95	
205	5.6	1.58	5.5x10-4	0.065	0.37	0.5	100	97.49	93.86	90.75	85.59	80.76	56.34	31.5	16.64	13.01	2.55
210		1.62	3.5x10-3	0.14	0.66	0.95	100	98.69	89.6	83.9	75.38	66.13	38.23	15.91	6.81	5.51	
215		1.74	2.5x10-3	0.18	0.65	0.95	100	98.22	92.45	83.18	74.9	66.22	37.97	12.58	3.93	2.87	
220	11.1	1.56	1.1x10-3	0.13	0.52	0.75	100	100	94.82	89.38	81.98	72.64	44.03	17.88	7.3	5.74	
240	3.1	1.68	2.9x10-3	0.17	0.85	1.5	100	92.6	82.75	72.73	64.54	56.64	35.74	14.38	5.64	4.48	
260																	
280																	
300																	
305																	
310																	
315																	
320																	
340																	
360	5.4	1.52	2.1x10-3	0.09	0.33	0.42	100	99.1	94.57	91.52	87.41	81.86	61.1	31.09	13.75	10.56	
380	6.5	1.61	5.1x10-3	0.16	1.1	2.3	96.31	86.13	73.74	66.23	58.13	51.28	31.04	13.93	5.63	4.5	

95

[illegible]

Table C.5. Physical and hydraulic parameter data for horizontal cores from the lower coarse layer of Trench 8.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	----- % passing indicated seive size -----										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
0																	
5																	
10																	
15																	
20																	
40	8.6	1.42	9.2x10-3	0.19	1.4	2	100	93.77	84.06	71.05	59.86	48.14	24.71	11.1	5.5	4.77	
60	3.9	1.63	1.0x10-2	0.25	0.92	1.4	100	96.39	89.42	84	72.9	58.75	20.72	7.28	3.98	3.61	
80	6.9	1.51	3.7x10-3	0.11	0.43	0.69	100	97.4	90.63	82.33	75.23	71.21	49.91	24.03	10.5	7.79	
100	6.8	1.51	1.5x10-3	0.098	0.41	0.61	100	99.04	94.1	89.56	82.68	74.71	51.08	27.34	13.34	10.18	
105		1.64	5.6x10-3	0.14	0.61	0.86	100	95.19	91.11	84.61	78.02	69.72	39.1	16.65	6.67	5.25	
110		1.6	7.8x10-3	0.12	0.41	0.58	100	98.04	93.16	90.27	85.6	79.3	52.75	22.51	7.75	5.91	
115	5.5	1.62	2.2x10-2	0.26	1.8	2.6	100	92.56	77.22	67.5	53.4	41.5	19.16	7.61	2.85	2.16	
120	8	1.5	4.7x10-3	0.19	1.3	2.6	100	88.06	71.07	64.51	56.37	49.25	28.69	11.69	4.46	3.39	
140	6.9	1.58	1.8x10-3	0.26	1.9	2.9	100	96.82	76.03	64.2	50.52	39.79	19.25	7.14	2.95	2.39	
160	6.5	1.61	5.4x10-3	0.18	1.7	3.1	94.47	82.76	68.9	61.21	52.06	45.87	28.39	12.59	4.84	3.6	
180	6.7	1.53	7.9x10-3	0.13	0.51	0.8	100	95.81	89.07	81.09	75.02	69.24	44.98	17.49	7.21	5.92	

97

[illegible]

Table C.6. Physical and hydraulic parameter data for vertical cores from the fine layer of Pit 3.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	----- % passing indicated seive size -----										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
0	7.17	1.46	5.5x10-3	0.089	0.31	0.41	100	99.27	92.55	89.01	84.02	78.51	61.52	36.01	13.5	7.68	
5			3.4x10-3														
10			2.8x10-3	0.095	0.35	0.51	100	93.57	89.65	85.24	80.48	74.81	56.7	32.53	11.9	7.01	
15			1.1x10-3	0.095	0.35	0.48	100	97.44	93.7	88.49	83.14	77.38	57.9	32.64	11.57	6.75	
20	6.08	1.47	1.1x10-3	0.09	0.32	0.45	100	98.39	94.05	89.1	83.93	78.06	59.08	33.45	12.35	7.33	
40	6.28	1.54	8.9x10-4	0.09	0.38	0.6	100	93.07	86.97	82.85	77.42	72.7	53.8	31.21	12.43	7.86	
60	5.77	1.53	1.3x10-3	0.093	0.35	0.5	100	97.62	91.59	87.3	81.22	75.24	56.93	32.52	11.59	7.73	
80	7.88	1.48	1.3x10-3	0.072	0.32	0.43	100	96.66	94.13	88.4	83.56	78.19	60.4	37.32	16.43	11.16	
100	6.21	1.5	1.2x10-3	0.087	0.31	0.42	100	98.78	94.3	89.01	84.25	78.5	60.26	35.23	13.3	7.96	
105	5.6	1.53	1.3x10-3	0.089	0.36	0.54	100	98.03	90.97	85.85	79.65	73.54	55.78	32.62	12.22	8.3	
110			2.5x10-4	0.084	0.38	0.61	100	89.3	85.78	81.16	75.52	70.19	53.74	32.52	13.29	8.14	
115			3.0x10-4	0.085	0.37	0.59	100	93.09	88.69	82.15	76.7	71.03	55.14	33.37	13.29	8.3	
120	5.36	1.59	8.3x10-4	0.09	0.41	0.78	97.61	90.36	81.94	77.79	71.86	66.96	50.75	30.67	12.63	7.73	
140	6.01	1.53	1.8x10-3	0.087	0.33	0.45	100	97.26	93.68	88.63	83.38	77.38	59	34.24	12.92	7.94	
160	7.1	1.48	1.0x10-3	0.088	0.35	0.5	100	95.78	89.32	85.08	79.09	74.3	57.13	33.72	13.02	7.88	
180	5.4	1.53	7.2x10-4	0.09	0.33	0.42	100	97.01	90.67	87.05	82.2	77.25	59.34	33.84	11.86	7.68	

Table C.6. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_p (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
200	7.06	1.52	2.5x10-3	0.15	0.75	1.2	100	91.5	83.28	78.53	71.45	61.95	35.07	16.53	5.94	3.33		
205	4.62	1.63	1.3x10-3	0.12	0.42	0.65	100	96.76	91.13	87.02	81.54	74.87	50.1	25.8	9.09	5.85		
210	5.21	1.56	1.7x10-3	0.12	0.41	0.6	100	98.49	94.56	91.72	86.93	79.13	50.04	24.54	8.8	5.68		
215	5.62	1.52	1.2x10-3	0.095	0.3	0.39	100	97.28	94.07	91.97	88.13	83.41	63.23	34.93	11.77	7.33		
220	5.19	1.55	1.4x10-3	0.12	0.39	0.61	100	96.5	88.66	81.45	76.14	70.59	53.65	28.85	9.27	4.97		
240	6.9	1.53	1.1x10-3	0.098	0.38	0.59	100	94.66	89.79	84.37	78.31	72.34	54.51	31.67	11.28	7.27		
260	8.31	1.53	2.1x10-3	0.12	0.41	0.65	100	96.61	90.88	86.17	79.74	72.69	51.44	27.55	9.67	6.07		
280	10.7	1.5	2.6x10-3	0.095	0.4	0.69	89.1	86.89	82.42	78.94	73.97	69.37	51.66	30.42	12	6.98		
300			1.5x10-3	0.08	0.31	0.41	100	98.52	94.93	89.21	84.25	78.72	60.56	36.65	14.87	9.19		
305	10.8	1.48	2.1x10-3	0.09	0.32	0.48	100	97.46	93.67	88.3	83.07	76.96	58.39	33.72	12.71	7.76		
310	5.94	1.48	2.7x10-3	0.095	0.34	0.49	94.51	90.98	87.73	83.58	79.4	74.43	57.68	33.93	11.99	6.93		
315	9.35	1.49	2.1x10-3	0.092	0.34	0.48	100	96.7	91.52	87.39	82.39	76.46	57.94	33.18	11.68	7.6		
320	9.16	1.5	2.2x10-3	0.092	0.32	0.42	100	97.95	92.63	89.31	84.31	79.53	60.5	34.85	12.54	7.36		
340			4.4x10-3	0.095	0.35	0.49	100	97.66	92	88.36	83.24	77.11	57.47	32.06	11.29	7.36		
360	10.7	1.49	2.7x10-3	0.092	0.32	0.42	96.03	93.55	89.6	86.6	82.21	77.3	60.44	35.04	12.61	6.74		
380	5.7	1.45	1.1x10-3	0.093	0.35	0.51	100	94.64	88.86	84.38	79.29	74.11	56.69	32.28	12.01	7.25		

Table C.6. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
				----- (mm)	----- (mm)	----- (mm)	3/4	3/8	4	6	10	16	40	70	140	200	
400	8.92	1.44	2.7x10 ⁻³	0.09	0.31	0.4	100	98.68	96.78	91.85	87.3	81.97	62.73	35.39	12.2	7.89	
405	10.4	1.48	2.8x10 ⁻³	0.095	0.35	0.49	100	94.82	89.21	85.82	81.48	76.28	57.43	31.78	11.43	7.66	
410			5.5x10 ⁻³	0.08	0.32	0.43	100	99.1	92.8	88.48	83.55	78.13	59.73	33.73	13.5	9.14	
415	10.1	1.41	4.5x10 ⁻³	0.082	0.3	0.39	100	98.96	96.04	92.32	87.6	81.99	63.15	35.79	13.94	8.56	
420	10.2	1.44	5.6x10 ⁻³	0.087	0.31	0.41	97.09	94.52	91.62	88.04	84.21	79.19	60.84	34.59	13.01	8.1	
440	14.2	1.45	3.2x10 ⁻³	0.07	0.57	1.2	94.13	88.04	81.57	72.85	66.38	60.67	46.16	32.52	16.73	11.65	
460	5.44	1.6	6.6x10 ⁻⁴	0.091	0.81	1.7	96.07	87.9	79.35	70.17	63.05	56.17	38.26	23.56	11.87	7.61	
480	12.2	1.5	3.6x10 ⁻³	0.09	0.51	0.88	100	97.66	87.53	81.24	73.65	66.28	46.45	27.16	12.88	7.73	
500																	
505																	
510			2.6x10 ⁻⁴	0.079	0.42	0.9	100	88.7	81.18	73.66	68.52	63.25	49.75	34.64	15.85	9.15	
515	4.7	1.58	1.9x10 ⁻⁴	0.017	0.37	0.7	96.09	91.97	85.62	78.36	72.82	66.98	53.53	39.04	18.25	10.8	
520	14.3	1.44	1.3x10 ⁻³	0.074	0.29	0.45	100	98.13	90.58	85.91	79.91	73.83	59.45	42.7	20.35	10.06	
540	4.59	1.63	2.4x10 ⁻⁴	0.068	0.49	0.84	100	92.53	83.58	78.55	72.5	66.55	47.24	30.49	16.62	12.04	
560	4.81	1.68	7.1x10 ⁻⁴	0.093	0.55	0.9	100	90.53	82.61	77.62	71.42	65.15	45.31	25.6	12.16	7.35	
580	3.22	1.63	1.9x10 ⁻³	0.1	0.45	0.73	97.09	91.02	83.9	80.55	75.25	69.61	48.94	26.16	10.33	6.6	
600	3.66	1.64	3.2x10 ⁻⁴	0.097	0.8	1.5	100	89.96	76.88	71	63.67	57.5	37.94	22.11	11.15	7.39	

Table C.7. Physical and hydraulic parameter data for horizontal cores from the fine layer of Pit 3.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
0	6.53	1.43	1.3x10-3	0.078	0.28	0.38	100	98.6	95.9	91.12	86.95	81.94	64.69	40.36	16.65	9.47	
5			2.7x10-3	0.097	0.31	0.4	100	99.59	95.62	93.11	88.62	83.78	62.92	34.22	11.22	7.03	
10			8.3x10-3	0.12	0.39	0.55	100	99.08	92.6	89.6	84.55	78.22	54.11	26.47	8.33	5.08	
15			9.6x10-4	0.095	0.37	0.51	100	99.09	93.32	88.35	82.37	76.3	56.25	31.4	11.47	7.55	
20			1.9x10-3	0.091	0.33	0.44	100	95.93	90.38	86.88	82.46	77.41	59.25	33.93	11.88	7.49	
40	5.28	1.47	3.3x10-3	0.094	0.32	0.42	100	98.09	93.6	90.06	84.53	79.82	60.87	34.45	12.23	6.77	
60	5.08	1.53	1.8x10-3	0.097	0.38	0.6	100	89.11	84.5	81.24	76.75	71.46	54.05	30.75	11.11	7.31	
80	5.15	1.5	2.9x10-3	0.099	0.31	0.4	100	98.02	94.37	89.77	84.89	79.97	61.8	35.34	11.64	5.81	
100	4.65	1.46	2.1x10-3	0.095	0.31	0.41	100	98.8	95.89	91.58	85.95	80.02	61.61	35.37	12.03	6.74	
105	4.45	1.53	7.4x10-4	0.091	0.31	0.41	100	96.96	92.97	89.45	84.53	79.19	61.18	35.21	12.08	7.57	
110			7.4x10-4	0.095	0.34	0.47	100	97.54	90.71	86.9	81.74	76.22	57.94	32.92	11.5	7.49	
115			7.4x10-4	0.096	0.38	0.61	100	93.96	88.75	81.55	75.78	70.21	53.62	30.97	11.33	6.77	
120	4.97	1.54	8.6x10-4	0.094	0.33	0.44	100	96.79	89.84	86.6	81.39	77.17	59.65	34.68	12.08	6.91	
140			2.0x10-3	0.085	0.32	0.42	100	96.93	93.13	89.59	84.79	79.5	60.31	34.46	12.67	8.5	
160	4.79	1.51	7.8x10-4	0.094	0.3	0.4	100	96.89	91.21	86.26	82.61	78.18	62.07	36.78	12.46	6.33	
180			1.5x10-3	0.097	0.32	0.42	100	99.62	94.61	89.47	84.54	78.77	60.03	33.89	11.48	6.46	

Table C.7. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
200	3.71	1.51	7.4x10-3	0.15	0.67	1	100	97	85.26	79.15	71.04	63.69	39.66	17.5	5.44	2.89		
205	3.69	1.57	3.1x10-3	0.14	0.49	0.69	100	98.96	97.95	93.72	87.24	77.7	45.44	20.14	6.08	3.35		
210	4.04	1.48	1.2x10-3	0.099	0.33	0.44	100	96.74	91.86	87.49	83.41	78.21	59.33	32.31	11.14	6.36		
215	4.26	1.54	6.4x10-4	0.095	0.33	0.45	100	97.39	89.36	85.79	81.72	76.79	59.98	33.21	11.63	7.73		
220	3.34	1.54	1.4x10-3	0.12	0.36	0.53	100	95.08	90.83	85.33	80	74.43	55.92	27.69	8.49	4.62		
240	4.04	1.54	1.9x10-3	0.12	0.49	0.79	100	94.13	87.43	80.59	74.38	68.15	47.49	24.57	8.08	4.02		
260	3.92	1.48	1.1x10-3	0.09	0.3	0.4	100	97.05	92.88	87.34	83.13	78.07	61.99	36.61	12.85	7.17		
280	5.78	1.45	1.8x10-3	0.099	0.35	0.47	100	98.79	93.07	89.3	84.33	78.62	58.34	32.61	11.23	7.06		
300	5.11	1.52	2.8x10-3	0.095	0.33	0.45	100	95.33	91.76	86.14	81.47	76.07	58.67	33.83	11.71	6.73		
305	5.71	1.47	2.7x10-3	0.09	0.29	0.38	100	99.78	97.66	94.22	89.73	84.41	65.61	38.25	13.17	7.37		
310	4.83	1.51	1.6x10-3	0.095	0.31	0.4	100	97.3	94.25	90.31	85.9	80.42	61.72	34.89	11.86	6.73		
315	5.09	1.51	1.1x10-3	0.095	0.32	0.43	100	99.7	94.6	90.65	85.34	79.34	59.52	33.55	11.45	7.24		
320	5.28	1.52	7.3x10-4	0.092	0.32	0.42	100	96.69	91.28	88.12	83.7	78.82	60.61	35.59	12.14	7.55		
340	4.22	1.51	1.5x10-3	0.1	0.34	0.45	100	96.22	91.49	87.98	83.38	78.17	58.98	32.12	10.78	6.69		
360	4.93	1.51	1.0x10-3	0.09	0.3	0.4	100	98.26	92.21	89.52	84.93	80.8	62.89	36.17	12.74	7.12		
380			9.0x10-4	0.1	0.31	0.41	100	97.81	93.85	88.72	83.62	78.57	61.1	34.23	10.81	5.93		

104

[illegible]

Table C.8. Physical and hydraulic parameter data for vertical cores from the coarse layer of Pit 3.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
0	3.4	1.51	5.1x10-3	0.15	0.38	0.49	100	100	97.76	95.88	92.28	85.98	55.92	20.08	4.29	1.8		
5	4.47	1.5	4.7x10-3	0.16	0.52	0.72	100	98.88	95.98	92.47	84.18	74.83	43.58	15.39	3.69	1.98		
10	4.71	1.48	1.2x10-3	0.22	0.69	0.88	100	100	97.15	94.25	86.33	72.95	29.68	10.04	3.79	2.22		
15	4.01	1.53	1.0x10-3	0.11	0.35	0.44	100	98.59	93.88	91.02	86.63	81.42	59.1	29.73	9.4	4.58		
20	4.23	1.58	6.8x10-4	0.11	0.36	0.48	100	98.42	93.06	89.63	84.47	78.88	57.58	29.87	9.9	5.14		
40	3.34	5.47	9.2x10-4	0.16	0.7	1	100	92.4	82.94	78.23	71.51	64.04	36.67	14.89	4.74	3.18		
60	3.42	1.58	6.7x10-4	0.13	0.42	0.71	100	93.78	85.74	81.57	75.32	69.9	49.75	24.65	7.35	3.34		
80	3.49	1.48	1.4x10-3	0.09	0.28	0.36	100	97.49	91.69	88.68	84.9	81.34	66.51	39.27	12.67	7.53		
100	8.29	1.43	1.6x10-3	0.08	0.31	0.41	100	96.32	89.98	84.47	80.19	75.45	60.45	36.41	13.76	9.13		
105	4.33	1.5	1.1x10-3	0.089	0.29	0.37	100	98.21	93.19	90.48	85.23	80.66	65.09	38.98	14.02	7.56		
110	4.19	1.6	4.7x10-4	0.14	0.69	1.8	92.03	84.93	71.59	66.41	60.74	56.93	73.88	23.64	6.95	3.52		
115	3.58	1.6	8.5x10-4	0.14	0.63	1	92.8	89.11	81.1	76.91	70.18	63.12	42.38	19.14	5.66	3.24		
120	3.54	1.56	2.8x10-3	0.12	0.34	0.41	100	98.63	96.23	91.73	86.93	81.62	61.03	29.67	8.32	3.95		
140	3.35	1.66	8.2x10-4	0.16	0.75	1.4	93.93	86.68	79.07	71.89	65.9	59.1	38.3	15.25	4.14	2.59		
160	2.99	1.59	6.8x10-4	0.14	0.51	0.73	100	97.96	91.53	87.39	80.94	73.14	44.94	20.02	6.43	3.25		
180	4.46	1.53	2.3x10-4	0.09	0.46	0.95	93.79	81.87	75.4	69.6	66.27	62.57	49.31	29.63	12	8.23		

Table C.8. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
200	7.17	1.43	8.3x10-3	0.16	0.59	0.85	100	98.96	92.62	87.03	77.41	69.19	41.49	14.93	3.43	2.04	
205	6.47	1.48	2.0x10-3	0.14	0.58	0.95	100	90.61	83.85	77.03	71.39	64.48	44.42	22.8	7	4.33	
210	4.81	1.68	4.1x10-3	0.16	3.6	5.3	94.96	77.41	56.92	48.42	40.45	34.55	23.72	14.08	5.31	2.92	
215	6.83	1.39	2.1x10-3	0.084	0.25	0.34	100	94.22	88.58	86.36	83.33	80.6	68.92	44.98	15.48	8.02	
220	5.44	1.49	1.5x10-3	0.11	0.31	0.4	100	97.11	91.1	88.3	84.23	79.56	62.17	33.42	10.53	4.84	
240	3.69	1.59	6.4x10-4	0.14	0.43	0.62	100	98.16	94	89.9	83.36	77.21	49.81	19.31	5.41	3.5	
260	3.74	1.52	2.9x10-3														
280	4.88	1.46	3.4x10-3	0.14	0.48	0.73	100	97.14	88.22	83.4	77.54	70.73	47.92	19.72	4.48	2.15	
300	5.03	1.52	4.6x10-4	0.094	0.35	0.52	94.89	91.35	85.28	81.65	77.09	73.13	56.84	33.8	12.34	6.35	
305	2.61	1.56	3.1x10-4	0.11	0.4	0.72	92.2	88.13	79.85	76.28	71.89	66.78	52.13	30.04	9.73	5.46	
310	4.37	1.57	8.9x10-4	0.12	0.41	0.7	100	96.13	88.06	82.93	75.71	69.86	50.52	27.18	8.9	4.37	
315	6.52	1.57	1.3x10-3	0.17	1.5	2.4	100	91.67	77.24	67.78	56.58	46.84	27.94	13.81	5.03	3.04	
320	3.79	1.58	5.0x10-4	0.13	0.45	0.78	97.97	93.28	83.22	79.01	73.85	68.5	48.82	24.25	7.42	4.17	
340	2.95	1.59	1.9x10-3	0.14	0.45	0.63	100	98.29	93.25	89.32	83.46	77.1	48.9	19.49	5.43	2.77	
360	4.03	1.58	3.0x10-4	0.09	0.35	0.51	100	98.32	90.56	86.27	80.67	75.02	56.6	32.93	12.38	8.22	
380	3.76	1.49	3.8x10-2	0.24	0.47	0.61	100	99.64	98.84	96.64	90.53	82.57	46.63	6.66	0.86	0.4	

Table C.8. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
400	3.83	1.64	1.3x10-2	0.22	0.85	1.3	100	96.29	84.8	78.51	69.19	59.4	30.51	9.22	1.79	0.84	
405	2.23	1.65	6.0x10-3	0.17	0.7	1.2	97.49	93.16	82.31	78.59	68.29	60.91	39.71	13.58	2.65	1.25	
410	2.62	1.66	2.5x10-3	0.16	0.48	0.76	94.45	90.97	85	80.25	75.12	69.88	47.6	16.61	3.99	2.16	
415	2.78	1.59	1.3x10-3	0.14	0.38	0.54	100	97.85	91.86	88.44	83.22	77.27	55.08	21.94	5.51	3.12	
420	2.49	1.59	3.7x10-3	0.15	0.4	0.56	100	99.57	94.06	90.41	85	79.94	53.7	18.42	3.99	1.94	
440	2.89	1.59	9.4x10-4	0.11	0.31	0.39	100	96.71	93.61	91.32	87.5	82.64	63.44	32.21	9.11	4.71	
460	4.36	1.57	4.1x10-4	0.1	0.39	0.69	100	93.41	84.16	79.42	73.92	68.66	52.85	30.97	11.23	5.38	
480																	
500																	
505																	
510																	
515																	
520																	
540																	
560	3.99	1.59	3.6x10-4	0.12	0.41	0.69	100	92.65	84.39	80.78	75.38	70.39	50.87	26.58	8.77	5.83	
580			1.7x10-4	0.075	0.37	0.55	100	99.21	93.43	89.65	82.91	76.2	54.65	31.85	14.88	9.96	
600																	

Table C.9. Physical and hydraulic parameter data for horizontal cores from the coarse layer of Pit 3.

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	----- % passing indicated seive size -----											ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200		
0	2.43	1.49	1.9x10-2	0.14	0.39	0.5	100	98.77	95.13	93.04	89.39	83.8	54.88	21.72	4.78	1.47		
5	2.63	1.53	3.5x10-3	0.14	0.45	0.7	100	95.72	90.5	84.18	77.71	71.21	49.2	22.6	5.59	3.06		
10	2.18	1.53	1.2x10-3	0.14	0.57	1	100	92.31	82.21	76.58	68.88	63.12	44.42	21.79	6.27	3.25		
15	3.5	1.5	1.8x10-3	0.14	0.46	0.69	100	96.88	89.25	84.9	78.56	72.96	48.73	21.87	6.59	3.68		
20	3.62	1.42	1.8x10-3	0.12	0.35	0.47	100	95.13	89.39	86.11	81.01	76.45	58.67	30.59	8.91	3.93		
40	3.53	1.45	1.8x10-3	0.12	0.33	0.4	100	98.52	95.75	93.39	89.16	84.77	62.81	29.47	8.46	4.28		
60	3.79	1.58	2.0x10-3	0.17	0.79	1.3	100	88.4	78.47	72.79	66.54	59.51	36.32	13.26	3.65	1.89		
80	2.82	1.63	7.6x10-4	0.14	0.48	0.86	94.95	88.67	80.75	74.77	70.51	65.59	48.15	21.9	5.33	2.25		
100	3.61	1.56	1.7x10-3	0.13	0.5	0.91	93.12	88.71	80.6	75.58	69.88	64.03	47.16	23.96	8.05	4.14		
105	4.14	1.49	4.6x10-4	0.07	0.33	0.45	98.63	96.58	89.42	86.39	81.45	76.67	59.3	36.39	16.36	10.24		
110	3.2	1.54	2.0x10-3	0.099	0.31	0.4	100	97.85	93.55	90.3	84.49	78.84	62.77	35.6	11.55	5.78		
115	2.89	1.57	8.0x10-4	0.12	0.37	0.49	100	97.07	89.74	86.36	81.56	77.28	57.1	26.67	8.04	4.39		
120	2.28	1.68	1.2x10-3	0.16	0.9	2.1	86.98	78.78	69.3	64.92	59.22	54.09	37.97	16.43	4.17	2.12		
140	2.1	1.47	1.3x10-3	0.17	0.46	0.62	100	99.45	97.57	93.01	87.79	79.86	47.84	14.09	2.48	1.21		
160	2.67	1.54	3.9x10-3	0.16	0.71	1.2	100	98.42	86.58	79.35	70.8	62.28	36.56	14.75	3.84	2.21		
180	3.27	1.67	5.4x10-4	0.14	1.9	3.3	100	87.69	74.74	60.69	50.22	42.55	30.17	17.86	7.66	5.61		

Table C.9. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
200			4.0x10 ⁻³	0.1	0.24	0.29	100	95.83	95.29	94.86	93.9	92.61	79.81	44.88	11.25	4.12	
205	3.09	1.51	2.5x10 ⁻³	0.12	0.36	0.49	100	98.07	92.16	88.66	83.55	78.65	56.78	30	8.66	4.11	
210	3.19	1.6	2.1x10 ⁻³	0.13	0.55	1.1	100	92.02	77.41	72.17	66.2	62.07	45.89	24.4	7.31	3.7	
215	3.64	1.69	3.2x10 ⁻⁴	0.11	1.5	3.4	95.67	83.6	65.74	59.8	52.9	48.18	37.08	23.29	9.81	5.46	
220																	
240	1.57	1.62	2.1x10 ⁻²	0.16	0.42	0.6	100	96.58	92.17	89.12	84.6	79.95	50.16	17.16	2.97	1.17	
260	4.11	1.53	1.3x10 ⁻³	0.071	0.29	0.43	91.13	86.16	82.11	79.44	75.71	72.2	60.27	42.07	19.31	11.2	
280	4.11	1.54	2.5x10 ⁻³														
300	3.84	1.53	7.7x10 ⁻³	0.16	0.64	0.95	100	97.37	88.13	79.74	72.71	64.91	40.06	16.68	4.03	2.2	
305	4.12	1.51	1.7x10 ⁻³	0.12	0.38	0.59	100	96.17	90.07	84.29	78.95	72.91	54.13	28.28	8.87	5.44	
310	3.59	1.59	4.5x10 ⁻³	0.16	0.93	3.2	72.14	68.64	63.95	60.25	57.16	53.4	37.69	15.97	4.15	2.43	
315	3.77	1.62	7.3x10 ⁻⁴	0.12	0.45	0.8	92.91	88.93	80.14	76.75	71.8	66.55	48.83	24.86	7.82	3.89	
320	3.86	1.53	1.1x10 ⁻³	0.11	0.36	0.5	100	98.63	91.3	88.37	82.35	77.28	56.87	30.62	10.26	6.3	
340	2.07	1.46	1.3x10 ⁻²	0.15	0.69	1.1	100	98.11	88.81	78.42	69.95	61.77	38.91	16.97	4.55	2.65	
360	3.48	1.58	1.4x10 ⁻³	0.14	0.45	0.79	90.8	86.61	82.28	77.32	72.78	67.68	48.96	21.81	6.01	3.01	
380																	

Table C.9. (Continued).

Distance (ft)	w (%)	ρ_b (g/cm ³)	K_s (cm/s)	d_{10}	d_{50}	d_{60}	% passing indicated seive size										ρ_s (g/cm ³)
							3/4	3/8	4	6	10	16	40	70	140	200	
400																	
405																	
410																	
415																	
420																	
440																	
460	3.64	1.53	1.6x10-3	0.13	0.36	0.48	100	98.52	94.23	91.82	87.16	81.7	57.83	56.01	7.14	3.95	
480																	
500																	
505																	
510																	
515																	
520																	
540																	
560																	
580																	
600																	

APPENDIX D

Table D.1. Water characteristic curve data for vertical cores from the fine layer of Trench 8.

<u>Distance = 0 ft</u>		<u>Distance = 110 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.345	0	0.355
9	0.331	16	0.344
29	0.315	34	0.336
75	0.205	98	0.213
510	0.138	510	0.139
3160	0.115	3020	0.112
23600	0.065	18000	0.062
<u>Distance = 10 ft</u>		<u>Distance = 120 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.364	0	0.360
11	0.356	12	0.347
29	0.334	32	0.337
76	0.222	96	0.212
510	0.136	520	0.136
3160	0.112	3020	0.114
18200	0.066	18000	0.064
<u>Distance = 20 ft</u>		<u>Distance = 160 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.344	0	0.328
12	0.336	14	0.317
32	0.324	31	0.313
97	0.199	97	0.206
520	0.131	510	0.139
3020	0.108	3020	0.113
25900	0.061	17700	0.071
<u>Distance = 60 ft</u>		<u>Distance = 200 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.349	0	0.323
12	0.317	11	0.319
29	0.305	31	0.305
88	0.199	96	0.231
520	0.132	520	0.148
3200	0.105	3200	0.118
16900	0.059	16900	0.071
<u>Distance = 100 ft</u>		<u>Distance = 210 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.342	0	0.310
13	0.338	13	0.306
29	0.334	29	0.299
96	0.220	95	0.241
510	0.153	520	0.151
3020	0.125	3200	0.120
17000	0.067	24300	0.070

Table D.1. (Continued).

Distance = 220 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.321
15	0.313
33	0.303
97	0.217
520	0.138
3020	0.111
25000	0.062

Distance = 260 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.333
21	0.328
36	0.321
104	0.229
520	0.143
3020	0.114
19200	0.067

Distance = 300 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.336
14	0.330
32	0.323
98	0.230
520	0.137
3020	0.111
20200	0.064

Distance = 310 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.350
13	0.341
31	0.335
98	0.248
510	0.143
3020	0.114
21500	0.066

Distance = 320 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.347
6	0.342
30	0.336
99	0.258
510	0.147
3020	0.120
15700	0.082

Distance = 360 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.342
12	0.333
31	0.326
97	0.212
520	0.129
3020	0.105
17000	0.063

Distance = 400 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.332
14	0.324
33	0.318
98	0.231
520	0.142
3020	0.115
2841900	0.065

Distance = 410 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.348
18	0.341
32	0.335
101	0.237
520	0.139
3020	0.114
25000	0.065

Distance = 420 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.343
11	0.337
30	0.330
83	0.215
510	0.140
3160	0.115
19200	0.067

Distance = 460 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.347
11	0.340
30	0.327
83	0.246
510	0.137
3160	0.113
19200	0.107

Table D.1. (Continued).

Distance = 500 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.335
12	0.325
30	0.314
100	0.224
520	0.143
3020	0.115
22100	0.065

Distance = 510 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.366
11	0.355
30	0.342
82	0.251
510	0.149
3160	0.121
19200	0.074

Distance = 520 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.350
11	0.301
30	0.324
83	0.247
510	0.146
3160	0.122
19500	0.071

Distance = 560 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.355
11	0.343
29	0.320
73	0.205
510	0.133
3160	0.109
27800	0.002

Distance = 600 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.361
12	0.354
30	0.334
75	0.219
510	0.136
3160	0.112
27700	0.004

Table D.2. Water characteristic curve data for horizontal cores from the fine layer of Trench 8.

<u>Distance = 0 ft</u>		<u>Distance = 80 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.342	0	0.315
11	0.339	11	0.304
30	0.312	28	0.290
74	0.185	72	0.192
510	0.122	510	0.118
3040	0.098	3019	0.097
18100	0.059	16800	0.059
<u>Distance = 10 ft</u>		<u>Distance = 100 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.348	0	0.333
12	0.356	12	0.322
28	0.330	33	0.311
83	0.222	89	0.233
510	0.137	510	0.137
3040	0.101	3019	0.112
15700	0.062	27310	0.063
<u>Distance = 20 ft</u>		<u>Distance = 110 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.348	0	0.354
13	0.336	12	0.348
28	0.325	28	0.335
80	0.217	77	0.213
510	0.129	510	0.124
3019	0.104	3040	0.098
22600	0.058	18200	0.060
<u>Distance = 40 ft</u>		<u>Distance = 120 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.331	0	0.326
11	0.325	10	0.319
31	0.308	28	0.305
78	0.197	79	0.184
510	0.128	510	0.128
3040	0.101	3040	0.101
18800	0.061	16900	0.064
<u>Distance = 60 ft</u>		<u>Distance = 160 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.350	0	0.328
13	0.341	12	0.322
29	0.325	31	0.305
77	0.225	82	0.192
510	0.139	510	0.124
3160	0.117	3019	0.100
22000	0.071	15200	0.060

Table D.2. (Continued).

Distance = 200 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.334
11	0.325
29	0.314
82	0.203
510	0.127
3019	0.104
20500	0.058

Distance = 210 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.335
10	0.326
27	0.302
77	0.181
510	0.122
3040	0.097
19000	0.057

Distance = 220 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.312
10	0.300
30	0.289
91	0.217
510	0.139
3019	0.112
16600	0.073

Distance = 260 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.333
12	0.322
33	0.311
89	0.233
510	0.137
3019	0.112
27300	0.063

Distance = 300 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.340
12	0.328
29	0.317
82	0.234
510	0.139
3019	0.115
30600	0.063

Distance = 310 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.315
11	0.310
35	0.297
90	0.217
520	0.133
3200	0.113
16200	0.071

Distance = 320 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.319
13	0.309
30	0.303
100	0.224
510	0.140
3020	0.112
17000	0.072

Distance = 360 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.315
12	0.314
35	0.303
87	0.221
520	0.131
3200	0.108
23500	0.062

Distance = 400 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.314
13	0.312
31	0.305
87	0.220
520	0.137
3200	0.113
21700	0.065

Distance = 420 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.307
12	0.303
34	0.292
88	0.220
520	0.145
3200	0.119
21300	0.072

Table D.2. (Continued).

Distance = 500 ft

h (cm)	θ (cm ³ /cm ³)
0	0.303
11	0.299
30	0.278
90	0.215
520	0.137
3200	0.111
15000	0.066

Distance = 505 ft

h (cm)	θ (cm ³ /cm ³)
0	0.316
12	0.314
32	0.306
83	0.213
520	0.134
3200	0.113
21300	0.057

Distance = 510 ft

h (cm)	θ (cm ³ /cm ³)
0	0.299
13	0.293
36	0.285
102	0.218
510	0.156
3020	0.124
23800	0.073

Distance = 520 ft

h (cm)	θ (cm ³ /cm ³)
0	0.327
11	0.324
32	0.311
87	0.243
520	0.157
3200	0.124
21500	0.071

Distance = 560 ft

h (cm)	θ (cm ³ /cm ³)
0	0.327
13	0.311
26	0.298
96	0.160
510	0.116
3020	0.095
23800	0.057

Distance = 600 ft

h (cm)	θ (cm ³ /cm ³)
0	0.323
11	0.342
31	0.334
98	0.197
510	0.135
3020	0.112
19200	0.071

Table D.3. Water characteristic curve data for vertical cores from the lower coarse layer of Trench 8.

Distance = 40 ft

h (cm)	θ (cm ³ /cm ³)
0	0.343
11	0.339
23	0.296
95	0.141
520	0.115
3060	0.099
15000	0.057

Distance = 60 ft

h (cm)	θ (cm ³ /cm ³)
0	0.352
11	0.342
20	0.290
96	0.103
520	0.092
3060	0.083
25200	0.043

Distance = 80 ft

h (cm)	θ (cm ³ /cm ³)
0	0.314
9	0.306
19	0.237
95	0.096
520	0.088
2233	0.084
16500	0.039

Distance = 100 ft

h (cm)	θ (cm ³ /cm ³)
0	0.333
11	0.327
33	0.310
94	0.170
520	0.117
2233	0.113
20000	0.054

Distance = 120 ft

h (cm)	θ (cm ³ /cm ³)
0	0.329
12	0.325
22	0.280
88	0.098
520	0.088
3060	0.080
17300	0.043

Distance = 140 ft

h (cm)	θ (cm ³ /cm ³)
0	0.310
12	0.285
25	0.229
103	0.159
570	0.140
3050	0.116
16700	0.083

Distance = 160 ft

h (cm)	θ (cm ³ /cm ³)
0	0.351
13	0.335
24	0.250
103	0.122
570	0.101
3050	0.083
18000	0.051

Distance = 180 ft

h (cm)	θ (cm ³ /cm ³)
0	0.363
14	0.356
22	0.272
99	0.100
571	0.087
3050	0.079
17500	0.054

Distance = 200 ft

h (cm)	θ (cm ³ /cm ³)
0	0.350
10	0.344
29	0.305
102	0.132
520	0.104
2233	0.100
27000	0.049

Distance = 220 ft

h (cm)	θ (cm ³ /cm ³)
0	0.394
11	0.368
20	0.320
88	0.212
570	0.192
3050	0.179
16000	0.150

Table D.3. (Continued).

Distance = 240 ft

h (cm)	θ (cm ³ /cm ³)
0	0.297
11	0.290
24	0.254
93	0.123
520	0.106
3060	0.094
18400	0.053

Distance = 360 ft

h (cm)	θ (cm ³ /cm ³)
0	0.324
11	0.322
30	0.307
91	0.166
520	0.109
3060	0.092
24000	0.048

Distance = 380 ft

h (cm)	θ (cm ³ /cm ³)
0	0.326
13	0.317
26	0.252
100	0.145
571	0.123
3050	0.101
17100	0.063

Distance = 405 ft

h (cm)	θ (cm ³ /cm ³)
0	0.307
20	0.301
31	0.291
97	0.166
570	0.123
3050	0.094
18600	0.055

Distance = 480 ft

h (cm)	θ (cm ³ /cm ³)
0	0.341
14	0.328
26	0.234
102	0.108
571	0.093
3050	0.079
14800	0.054

Distance = 540 ft

h (cm)	θ (cm ³ /cm ³)
0	0.362
19	0.356
32	0.343
95	0.165
570	0.120
3050	0.097
17200	0.063

Distance = 560 ft

h (cm)	θ (cm ³ /cm ³)
0	0.329
9	0.309
25	0.263
104	0.166
520	0.138
3060	0.110
16900	0.070

Table D.4. Water characteristic curve data for horizontal cores from the coarse layer of Trench 8.

<u>Distance = 40 ft</u>		<u>Distance = 140 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.374	0	0.326
10	0.364	9	0.299
17	0.295	20	0.234
103	0.166	98	0.125
520	0.156	520	0.115
3060	0.141	3060	0.111
19000	0.075	20300	0.058
<u>Distance = 60 ft</u>		<u>Distance = 160 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.297	0	0.333
7	0.277	9	0.317
16	0.209	21	0.268
92	0.079	87	0.135
520	0.070	520	0.118
3060	0.068	3059	0.113
31800	0.035	28982	0.061
<u>Distance = 80 ft</u>		<u>Distance = 180 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.353	0	0.374
10	0.344	16	0.369
24	0.309	25	0.224
97	0.148	100	0.139
520	0.120	570	0.115
3060	0.103	3050	0.097
14300	0.064	19800	0.058
<u>Distance = 100 ft</u>		<u>Distance = 200 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.351	0	0.327
12	0.348	17	0.321
25	0.317	32	0.301
93	0.162	101	0.171
520	0.119	570	0.120
3060	0.098	3050	0.095
15500	0.061	23300	0.054
<u>Distance = 120 ft</u>		<u>Distance = 240 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.341	0	0.328
10	0.328	12	0.324
20	0.277	22	0.260
93	0.147	100	0.103
520	0.136	520	0.094
3060	0.131	2233	0.091
27200	0.073	31600	0.048

Table D.4. (Continued).

Distance = 360 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.341
10	0.338
29	0.298
99	0.144
520	0.116
2233	0.112
18400	0.055

Distance = 405 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.311
11	0.299
24	0.233
104	0.109
520	0.093
2233	0.090
18800	0.047

Distance = 480 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.361
11	0.358
20	0.297
99	0.117
520	0.108
3060	0.097
22000	0.054

Table D.5. Water characteristic curve data for vertical cores from the fine layer of Pit 3.

<u>Distance = 0 ft</u>		<u>Distance = 200 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.375	0	0.353
15	0.368	14	0.350
32	0.347	27	0.312
85	0.222	102	0.178
510	0.133	510	0.146
2733	0.103	2580	0.107
17092	0.064	6521	0.077
<u>Distance = 40 ft</u>		<u>Distance = 240 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.341	0	0.337
17	0.338	15	0.333
33	0.329	35	0.322
97	0.206	90	0.202
510	0.134	510	0.130
3284	0.096	3661	0.088
18081	0.067	13869	0.068
<u>Distance = 80 ft</u>		<u>Distance = 280 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.361	0	0.327
15	0.354	13	0.317
36	0.344	33	0.306
97	0.240	96	0.208
510	0.146	510	0.153
4365	0.102	3100	0.102
25118	0.067	14318	0.075
<u>Distance = 120 ft</u>		<u>Distance = 320 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.332	0	0.343
12	0.332	17	0.343
34	0.326	35	0.331
96	0.221	98	0.200
510	0.142	510	0.133
2702	0.106	2692	0.095
15440	0.074	18917	0.062
<u>Distance = 160 ft</u>		<u>Distance = 360 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.353	0	0.332
16	0.346	16	0.326
38	0.338	34	0.319
91	0.230	98	0.179
510	0.145	510	0.120
4528	0.103	3641	0.085
17428	0.074	14655	0.068

Table D.5. (Continued).

<u>Distance = 400 ft</u>			<u>Distance = 600 ft</u>		
h	θ		h	θ	
(cm)	(cm ³ /cm ³)		(cm)	(cm ³ /cm ³)	
0	0.339		0	0.313	
15	0.332		11	0.300	
35	0.318		30	0.275	
98	0.189		100	0.199	
510	0.126		510	0.137	
3376	0.091		3692	0.095	
14481	0.063		22609	0.064	
<u>Distance = 440 ft</u>					
h	θ				
(cm)	(cm ³ /cm ³)				
0	0.296				
13	0.295				
34	0.278				
102	0.208				
510	0.136				
3529	0.096				
15980	0.070				
<u>Distance = 480 ft</u>					
h	θ				
(cm)	(cm ³ /cm ³)				
0	0.305				
16	0.302				
36	0.285				
98	0.192				
510	0.130				
2499	0.091				
20100	0.060				
<u>Distance = 520 ft</u>					
h	θ				
(cm)	(cm ³ /cm ³)				
0	0.351				
13	0.351				
36	0.342				
99	0.228				
510	0.141				
2825	0.107				
18917	0.076				
<u>Distance = 560 ft</u>					
h	θ				
(cm)	(cm ³ /cm ³)				
0	0.330				
18	0.327				
32	0.304				
98	0.195				
510	0.129				
3855	0.098				
24506	0.056				

Table D.6. Water characteristic curve data for horizontal cores from the fine layer of Pit 3.

<u>Distance = 0 ft</u>		<u>Distance = 200 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.346	0	0.335
14	0.342	13	0.324
30	0.335	26	0.300
99	0.241	110	0.136
530	0.150	530	0.114
2244	0.102	2753	0.087
15593	0.067	17173	0.057
<u>Distance = 40 ft</u>		<u>Distance = 240 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.359	0	0.346
13	0.356	13	0.333
30	0.347	28	0.318
102	0.199	107	0.158
530	0.137	530	0.123
4375	0.093	2539	0.098
15970	0.064	16674	0.064
<u>Distance = 80 ft</u>		<u>Distance = 280 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.360	0	0.336
14	0.358	18	0.334
31	0.352	31	0.324
102	0.189	107	0.174
530	0.134	530	0.129
3202	0.094	3090	0.095
18917	0.062	14889	0.064
<u>Distance = 120 ft</u>		<u>Distance = 320 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.354	0	0.342
17	0.354	16	0.343
29	0.343	31	0.332
103	0.208	107	0.193
530	0.146	510	0.142
3834	0.101	2957	0.105
14094	0.071	17439	0.067
<u>Distance = 160 ft</u>		<u>Distance = 360 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.347	0	0.363
14	0.344	12	0.360
32	0.334	30	0.352
104	0.204	106	0.191
530	0.142	530	0.135
2794	0.101	2815	0.100
16205	0.070	20702	0.061

Table D.6. (Continued).

Distance = 400 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.348
16	0.342
30	0.327
105	0.166
530	0.126
3263	0.090
17704	0.060

Distance = 440 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.350
16	0.349
31	0.337
107	0.195
530	0.141
2376	0.109
16980	0.071

Distance = 480 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.326
14	0.321
30	0.310
106	0.188
530	0.141
2702	0.101
15593	0.070

Distance = 540 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.305
15	0.303
31	0.295
112	0.206
530	0.139
2774	0.100
15634	0.069

Table D.7. Water characteristic curve data for vertical cores from the coarse layer of Pit 3.

<u>Distance = 0 ft</u>		<u>Distance = 200 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.375	0	0.385
12	0.368	11	0.373
26	0.344	22	0.335
70	0.134	75	0.162
510	0.091	510	0.132
4120	0.066	2295	0.104
22884	0.042	28004	0.061
<u>Distance = 40 ft</u>		<u>Distance = 240 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.314	0	0.328
15	0.295	12	0.321
29	0.273	28	0.306
112	0.144	77	0.198
510	0.123	510	0.134
4395	0.087	3641	0.091
25393	0.055	22130	0.059
<u>Distance = 80 ft</u>		<u>Distance = 280 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.374	0	0.378
11	0.364	10	0.366
32	0.352	25	0.339
112	0.153	78	0.168
510	0.119	510	0.129
5109	0.080	4049	0.095
18693	0.056	21049	0.058
<u>Distance = 120 ft</u>		<u>Distance = 320 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.374	0	0.315
13	0.368	11	0.314
30	0.356	30	0.305
112	0.153	83	0.211
510	0.120	510	0.141
3488	0.084	2947	0.105
19264	0.055	18724	0.069
<u>Distance = 160 ft</u>		<u>Distance = 360 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.327	0	0.337
11	0.319	14	0.330
27	0.296	33	0.321
77	0.182	112	0.195
510	0.119	510	0.139
3641	0.081	3763	0.092
16256	0.054	13645	0.070

Table D.7. (Continued).

Distance = 400 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.324
10	0.316
21	0.273
83	0.099
510	0.085
3294	0.066
13533	0.048

Distance = 560 ft

h	θ
(cm)	(cm ³ /cm ³)
0	0.340
11	0.328
31	0.317
97	0.200
510	0.143
2529	0.107
24587	0.062

Table D.8. Water characteristic curve data for horizontal cores from the coarse layer of Pit 3.

<u>Distance = 0 ft</u>		<u>Distance = 200 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.365	0	0.417
11	0.346	10	0.410
23	0.314	30	0.402
70	0.126	78	0.171
510	0.085	510	0.100
2386	0.063	4497	0.073
17673	0.038	14838	0.055
<u>Distance = 40 ft</u>		<u>Distance = 240 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.367	0	0.377
14	0.363	13	0.348
28	0.335	23	0.299
112	0.151	112	0.096
510	0.128	510	0.078
2906	0.103	4385	0.055
15674	0.063	22242	0.036
<u>Distance = 80 ft</u>		<u>Distance = 280 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.338	0	0.358
19	0.320	15	0.351
28	0.295	32	0.336
112	0.118	70	0.190
510	0.099	510	0.115
4569	0.070	4518	0.084
14502	0.053	14685	0.066
<u>Distance = 120 ft</u>		<u>Distance = 320 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.332	0	0.361
15	0.316	15	0.351
29	0.300	31	0.342
112	0.147	78	0.226
510	0.130	510	0.135
2723	0.091	3294	0.095
27841	0.057	16980	0.059
<u>Distance = 160 ft</u>		<u>Distance = 360 ft</u>	
h	θ	h	θ
(cm)	(cm ³ /cm ³)	(cm)	(cm ³ /cm ³)
0	0.349	0	0.337
13	0.304	14	0.327
26	0.273	31	0.313
112	0.202	112	0.149
510	0.181	510	0.123
3987	0.091	2702	0.094
14287	0.067	14022	0.064

Table D.8. (Continued).

Distance = 460 ft

h (cm)	θ (cm ³ /cm ³)
0	0.367
9	0.364
27	0.347
68	0.215
510	0.186
2784	0.095
23476	0.057

APPENDIX E

Table E.1. Hydrometer data for vertical cores from the fine layer of Trench 8.

<u>Distance = 10 ft</u>		<u>Distance = 100 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.08496	10.18	0.08794	11.28
0.06158	9.31	0.06362	10.18
0.04542	7.71	0.04662	8.37
0.03316	6.40	0.03387	6.91
0.02170	5.44	0.02183	5.82
0.01556	4.80	0.01563	5.09
0.01116	4.71	0.01112	4.73
0.00653	3.63	0.00658	4.00
0.00468	3.05	0.00470	3.27
0.00335	2.85	0.00335	2.91
0.00249	2.62	0.00239	2.55
0.00138	1.89	0.00142	2.18
<u>Distance = 20 ft</u>		<u>Distance = 110 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.08622	14.68	0.08726	13.70
0.06338	12.49	0.06432	11.35
0.04726	9.20	0.04726	8.99
0.03474	6.57	0.03420	7.49
0.02238	5.26	0.02190	6.64
0.01620	4.38	0.01591	5.57
0.01159	3.51	0.01132	5.14
0.00673	3.07	0.00658	4.71
0.00479	2.63	0.00469	4.07
0.00340	2.19	0.00335	3.43
0.00350	1.75	0.00244	3.21
0.00145	1.75	0.00143	2.57
<u>Distance = 60 ft</u>		<u>Distance = 160 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.08726	9.23	0.08517	11.52
0.06338	8.25	0.06219	10.20
0.04630	6.99	0.04581	8.39
0.03353	6.01	0.03353	6.74
0.02156	5.04	0.02163	5.76
0.01544	4.48	0.01544	5.27
0.01009	4.20	0.01102	4.77
0.00650	3.50	0.00654	3.95
0.00462	3.21	0.00465	3.62
0.00330	2.80	0.00331	3.19
0.00239	2.34	0.00239	2.80
0.00142	1.68	0.00142	2.14

Table E.1. (Continued).

Distance = 200 ft

Particle diameter (mm)	Percent finer (%)
0.08726	11.45
0.06362	10.06
0.04630	8.68
0.03364	7.29
0.02163	6.07
0.01544	5.55
0.01108	4.86
0.00648	4.16
0.00464	3.47
0.00331	3.47
0.00233	3.12
0.00140	2.43

Distance = 260 ft

Particle diameter (mm)	Percent finer (%)
0.08692	13.41
0.06267	12.38
0.04630	9.91
0.03375	8.05
0.02170	7.02
0.01554	6.19
0.01105	5.78
0.00654	4.93
0.00468	4.12
0.00334	3.51
0.00237	2.89
0.00141	2.68

Distance = 210 ft

Particle diameter (mm)	Percent finer (%)
0.08760	13.78
0.06362	12.30
0.04694	9.75
0.03409	8.06
0.02183	6.78
0.01563	5.94
0.01125	4.88
0.00654	4.45
0.00468	3.60
0.00335	3.39
0.00236	2.97
0.00141	2.54

Distance = 300 ft

Particle diameter (mm)	Percent finer (%)
0.08760	13.38
0.06385	11.68
0.04726	8.92
0.03431	7.22
0.02204	6.16
0.01573	5.23
0.01119	5.10
0.00659	4.46
0.00470	3.83
0.00335	3.40
0.00243	3.19
0.00142	2.55

Distance = 220 ft

Particle diameter (mm)	Percent finer (%)
0.09260	15.71
0.06661	14.14
0.04805	12.25
0.03506	9.11
0.02258	6.60
0.01615	5.34
0.01145	5.03
0.00673	3.46
0.00478	2.83
0.00340	2.83
0.00237	2.51
0.00142	2.20

Distance = 310 ft

Particle diameter (mm)	Percent finer (%)
0.08726	49.43
0.06338	44.02
0.04662	35.53
0.03452	24.72
0.02231	19.31
0.01582	18.54
0.01129	16.22
0.00659	13.13
0.00477	10.04
0.00338	9.27
0.00239	8.50
0.00143	6.18

Table E.1. (Continued).

Distance = 360 ft

Particle diameter (mm)	Percent finer (%)
0.08657	12.86
0.06385	10.73
0.04704	8.49
0.03437	6.56
0.02230	5.41
0.01601	4.44
0.01139	4.05
0.00661	3.67
0.00470	3.28
0.00335	2.90
0.00235	2.51
0.00140	1.93

Distance = 400 ft

Particle diameter (mm)	Percent finer (%)
0.08056	12.63
0.05931	11.24
0.04457	8.93
0.03293	7.09
0.02175	6.22
0.01560	5.55
0.01114	5.08
0.00648	4.31
0.00462	3.85
0.00333	3.33
0.00254	3.08
0.00138	2.31

Distance = 410 ft

Particle diameter (mm)	Percent finer (%)
0.08131	15.94
0.06058	13.55
0.04542	10.56
0.03339	8.37
0.02152	7.26
0.01556	6.97
0.01114	6.58
0.00650	5.38
0.00465	4.58
0.00332	4.50
0.00254	4.38
0.00138	3.19

Distance = 420 ft

Particle diameter (mm)	Percent finer (%)
0.08794	13.06
0.06314	12.24
0.04646	10.00
0.03409	7.75
0.02211	6.12
0.01582	4.90
0.01129	4.28
0.00665	3.06
0.00474	2.45
0.00337	2.65
0.00234	2.24
0.00141	1.84

Distance = 460 ft

Particle diameter (mm)	Percent finer (%)
0.05828	12.67
0.04389	10.20
0.03024	11.26
0.02137	6.91
0.01548	5.99
0.01103	5.93
0.00665	3.95
0.00463	3.95
0.00332	3.62
0.00249	3.29
0.00138	2.30

Distance = 500 ft

Particle diameter (mm)	Percent finer (%)
0.07933	16.26
0.06023	13.26
0.04525	10.33
0.03319	8.37
0.02160	7.14
0.01550	6.27
0.01108	5.63
0.00650	4.69
0.00460	4.32
0.00331	3.57
0.00235	2.82
0.00139	2.07

Table E.1. (Continued).

Distance = 510 ft

Particle diameter (mm)	Percent finer (%)
0.08425	16.17
0.06182	14.15
0.04625	10.78
0.03334	9.52
0.02153	8.13
0.01553	7.41
0.01106	7.05
0.00655	6.07
0.00465	5.17
0.00334	4.63
0.00246	4.27
0.00137	3.37

Distance = 600 ft

Particle diameter (mm)	Percent finer (%)
0.08532	9.98
0.06255	8.68
0.04608	7.09
0.03357	5.84
0.02204	5.27
0.01583	4.54
0.01132	4.05
0.00661	3.04
0.00469	2.89
0.00337	2.55
0.00256	2.31
0.00139	1.74

Distance = 520 ft

Particle diameter (mm)	Percent finer (%)
0.09050	13.62
0.06494	12.61
0.04754	10.09
0.03473	7.56
0.02277	5.55
0.01620	5.04
0.01156	4.29
0.00677	3.28
0.00481	2.77
0.00343	2.67
0.00254	2.52
0.00140	2.02

Distance = 560 ft

Particle diameter (mm)	Percent finer (%)
0.08638	9.23
0.06328	7.97
0.04641	6.57
0.03373	5.45
0.02180	4.53
0.01578	4.53
0.01127	4.11
0.00653	3.50
0.00469	2.80
0.00337	2.46
0.00252	2.52
0.00139	1.68

Table E.2. Hydrometer data for horizontal cores from the fine layer of Trench 8.

<u>Distance = 10 ft</u>		<u>Distance = 160 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.09292	10.21	0.08794	12.06
0.06661	9.32	0.06455	10.14
0.04867	7.10	0.04726	8.23
0.03549	4.88	0.03420	6.89
0.02278	4.22	0.02197	5.93
0.01624	3.55	0.01573	4.79
0.01165	2.88	0.01116	4.59
0.00677	2.44	0.00650	4.02
0.00481	2.00	0.00465	3.25
0.00341	1.78	0.00335	3.06
0.00242	1.55	0.00237	2.68
0.00141	1.33	0.00136	2.11

<u>Distance = 100 ft</u>		<u>Distance = 200 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.08760	9.20	0.08862	9.06
0.06314	8.45	0.06385	8.33
0.04710	6.23	0.04710	6.57
0.03452	4.60	0.03420	5.41
0.02231	3.86	0.02197	4.38
0.01592	3.41	0.01573	3.80
0.01142	2.97	0.01119	3.51
0.00665	2.52	0.00659	2.92
0.00473	2.22	0.00469	2.63
0.00336	1.93	0.00334	2.34
0.00239	1.63	0.00237	1.90
0.00140	1.33	0.00142	1.46

<u>Distance = 110 ft</u>		<u>Distance = 260 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.09162	16.36	0.08587	9.99
0.06661	13.74	0.06219	9.13
0.04913	9.49	0.04597	7.42
0.03580	6.22	0.03387	5.71
0.02297	5.23	0.02197	4.28
0.01648	4.25	0.01573	3.71
0.01172	3.60	0.01119	3.42
0.00678	3.27	0.00661	2.71
0.00482	2.62	0.00472	2.28
0.00342	2.29	0.00336	1.86
0.00242	1.96	0.00238	1.57
0.00141	1.96	0.00142	1.28

Table E.2. (Continued).

Distance = 300 ft

Particle diameter (mm)	Percent finer (%)
0.09129	8.90
0.06571	8.08
0.04820	6.26
0.03528	4.45
0.02271	3.13
0.01639	2.47
0.01169	1.98
0.00680	1.48
0.00483	1.32
0.00342	1.15
0.00249	0.82
0.00145	0.99

Distance = 360 ft

Particle diameter (mm)	Percent finer (%)
0.08267	10.94
0.06047	9.83
0.04532	7.76
0.03308	6.51
0.02142	5.26
0.01534	4.71
0.01112	4.02
0.00652	3.32
0.00464	3.05
0.00330	2.77
0.00240	2.35
0.00141	1.94

Distance = 310 ft

Particle diameter (mm)	Percent finer (%)
0.08517	9.66
0.06121	9.13
0.04548	7.38
0.03342	5.91
0.02156	4.83
0.01544	4.30
0.01105	3.76
0.00652	3.22
0.00466	2.68
0.00332	2.42
0.00238	2.15
0.00142	1.48

Distance = 420 ft

Particle diameter (mm)	Percent finer (%)
0.08829	9.73
0.06409	8.65
0.04710	6.95
0.03409	5.87
0.02197	4.63
0.01577	4.02
0.01125	3.55
0.00654	3.24
0.00468	2.63
0.00335	2.47
0.00237	2.32
0.00141	1.85

Distance = 320 ft

Particle diameter (mm)	Percent finer (%)
0.08657	10.90
0.06291	9.74
0.04662	7.59
0.03375	6.44
0.02183	5.28
0.01577	4.62
0.01122	4.29
0.00658	3.63
0.00470	2.97
0.00335	2.64
0.00239	2.48
0.00142	1.98

Distance = 500 ft

Particle diameter (mm)	Percent finer (%)
0.08726	12.52
0.06385	10.81
0.04646	9.29
0.03387	7.59
0.02183	6.07
0.01554	5.69
0.01112	4.93
0.00650	4.36
0.00468	3.22
0.00334	3.22
0.00231	2.66
0.00140	1.90

Table E.2. (Continued).

Distance = 505 ft

Particle diameter (mm)	Percent finer (%)
0.08375	13.00
0.06097	11.81
0.04465	10.27
0.03251	8.56
0.02099	7.53
0.01510	6.68
0.01078	6.16
0.00368	5.31
0.00455	4.79
0.00326	4.11
0.00233	3.77
0.00140	2.74

Distance = 600 ft

Particle diameter (mm)	Percent finer (%)
0.08862	10.14
0.06385	9.29
0.04694	7.44
0.03398	6.25
0.02170	5.75
0.01554	5.07
0.01105	4.73
0.00656	3.89
0.00468	3.38
0.00333	3.04
0.00241	2.70
0.00141	2.37

Distance = 510 ft

Particle diameter (mm)	Percent finer (%)
0.09324	9.32
0.06661	8.74
0.04851	6.99
0.03528	5.24
0.02291	3.69
0.01639	2.92
0.01169	2.33
0.00679	1.94
0.00481	1.75
0.00341	1.55
0.00250	1.16
0.00145	0.97

Distance = 520 ft

Particle diameter (mm)	Percent finer (%)
0.08657	11.82
0.06314	10.43
0.04614	8.86
0.03353	7.47
0.02149	6.43
0.01539	5.73
0.01099	5.21
0.00646	4.34
0.00462	3.65
0.00331	3.48
0.00231	3.30
0.00139	2.43

Table E.3. Hydrometer data for vertical cores from the lower coarse layer of Trench 8.

<u>Distance = 40 ft</u>		<u>Distance = 100 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10276	9.17	0.09889	11.89
0.07351	7.24	0.07158	8.23
0.05227	6.28	0.05114	6.59
0.03707	5.79	0.03630	5.95
0.02140	5.79	0.02306	4.76
0.01653	6.28	0.01628	5.03
0.01141	6.28	0.01148	5.03
0.00681	5.79	0.00673	3.66
0.00480	5.31	0.00476	3.66
0.00340	4.83	0.00326	3.66
0.00245	4.83	0.00243	3.20
0.00142	4.34	0.00141	2.74
<u>Distance = 60 ft</u>		<u>Distance = 105 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10513	5.73	0.10361	2.66
0.07495	4.17	0.07408	1.84
0.05315	3.65	0.05252	1.63
0.03768	3.13	0.03724	1.43
0.02383	3.65	0.02355	1.43
0.01602	3.65	0.01665	1.43
0.01157	4.17	0.01149	1.43
0.00688	4.17	0.00681	1.31
0.00484	4.17	0.00482	1.23
0.00344	3.13	0.00342	1.02
0.00247	3.13	0.00238	0.82
0.00143	2.61	0.00142	0.61
<u>Distance = 80 ft</u>		<u>Distance = 120 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10352	3.41	0.10425	6.35
0.07392	2.19	0.07495	3.63
0.05241	1.85	0.05343	2.27
0.03710	1.71	0.03788	1.82
0.02353	1.37	0.02396	1.82
0.01660	1.37	0.01694	1.82
0.01173	1.50	0.01205	1.82
0.00681	1.50	0.00696	1.82
0.00480	1.16	0.00490	1.36
0.00340	1.37	0.00344	1.82
0.00252	1.37	0.00256	1.36
0.00143	1.37	0.00145	1.36

Table E.3. (Continued).

Distance = 140 ft

Particle diameter (mm)	Percent finer (%)
0.10300	1.49
0.07384	1.03
0.05250	0.84
0.03722	0.75
0.02396	0.56
0.01694	0.56
0.01198	0.56
0.00692	0.47
0.00489	0.47
0.00348	0.28
0.00256	0.37
0.00141	0.37

Distance = 160 ft

Particle diameter (mm)	Percent finer (%)
0.10329	5.92
0.07364	4.74
0.05221	4.34
0.03702	3.95
0.02377	3.55
0.01685	3.16
0.01163	3.16
0.00686	3.16
0.00486	2.37
0.00345	1.97
0.00252	2.37
0.00140	1.97

Distance = 180 ft

Particle diameter (mm)	Percent finer (%)
0.10584	2.10
0.07484	2.10
0.05306	1.75
0.03762	1.40
0.02422	0.70
0.01708	1.05
0.01204	1.05
0.00695	1.05
0.00492	1.05
0.00348	1.05
0.00261	1.05
0.00142	1.05

Distance = 200 ft

Particle diameter (mm)	Percent finer (%)
0.10065	9.03
0.07280	5.42
0.05176	4.51
0.03660	4.51
0.02315	4.51
0.01647	3.16
0.01164	3.16
0.00676	3.16
0.00479	2.26
0.00339	2.44
0.00251	2.89
0.00143	2.71

Distance = 205 ft

Particle diameter (mm)	Percent finer (%)
0.09887	13.55
0.07119	10.64
0.05093	8.71
0.03622	7.74
0.02297	7.26
0.01629	6.77
0.01155	6.29
0.00669	5.81
0.00476	4.84
0.00337	4.35
0.00248	4.35
0.00143	4.35

Distance = 210 ft

Particle diameter (mm)	Percent finer (%)
0.10305	6.82
0.07390	4.93
0.05240	4.55
0.03716	4.17
0.02356	3.79
0.01666	3.79
0.01150	3.79
0.00671	3.03
0.00476	3.03
0.00338	3.03
0.00238	2.65
0.00141	2.65

Table E.3. (Continued).

<u>Distance = 220 ft</u>		<u>Distance = 380 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10414	5.74	0.10329	3.12
0.07424	4.31	0.07364	2.50
0.05264	3.83	0.05236	2.08
0.03732	3.35	0.03712	1.87
0.02402	2.39	0.02390	1.46
0.01694	2.87	0.01685	1.66
0.01169	2.87	0.01163	1.66
0.00692	2.39	0.00688	1.46
0.00487	2.39	0.00488	1.25
0.00346	2.39	0.00346	1.04
0.00254	2.39	0.00257	1.04
0.00140	2.39	0.00141	0.83
<u>Distance = 240 ft</u>		<u>Distance = 405 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10484	3.33	0.10096	7.53
0.07495	2.22	0.07263	5.57
0.05315	1.94	0.05193	4.26
0.03768	1.67	0.03682	3.93
0.02383	1.94	0.02377	2.95
0.01685	1.94	0.01681	2.95
0.01160	1.94	0.01163	2.62
0.00690	1.94	0.00688	2.29
0.00486	1.67	0.00489	1.64
0.00345	1.39	0.00345	1.97
0.00246	1.11	0.00258	1.97
0.00143	1.11	0.00141	1.64
<u>Distance = 360 ft</u>			
Particle diameter (mm)	Percent finer (%)		
0.10126	11.85		
0.07330	7.90		
0.05242	5.92		
0.03717	5.43		
0.02377	3.46		
0.01681	3.95		
0.01157	4.44		
0.00684	3.95		
0.00487	3.95		
0.00343	3.46		
0.00242	2.47		
0.00142	2.47		

Table E.3. (Continued).

Distance = 410 ft

Particle diameter (mm)	Percent finer (%)
0.10419	2.93
0.07388	2.63
0.05267	1.76
0.03734	1.46
0.02355	1.76
0.01661	2.05
0.01143	2.34
0.00680	1.76
0.00481	1.76
0.00342	1.17
0.00247	1.76
0.00143	1.76

Distance = 415 ft

Particle diameter (mm)	Percent finer (%)
0.10246	6.50
0.07328	5.06
0.05211	4.33
0.03705	3.61
0.02344	3.61
0.01647	3.61
0.01140	3.25
0.00674	3.25
0.00478	2.89
0.00339	2.53
0.00243	2.89
0.00142	2.89

Distance = 480 ft

Particle diameter (mm)	Percent finer (%)
0.10300	4.52
0.07384	3.10
0.05236	2.82
0.03722	2.26
0.02382	1.69
0.01684	1.69
0.01166	1.98
0.00675	1.69
0.00489	1.41
0.00346	1.41
0.00249	1.41
0.00140	1.13

Distance = 540 ft

Particle diameter (mm)	Percent finer (%)
0.10184	8.06
0.07283	6.45
0.05207	4.84
0.03692	4.43
0.02377	3.63
0.01681	3.63
0.01188	3.22
0.00686	3.22
0.00486	2.82
0.00345	2.42
0.00261	2.42
0.00141	2.02

Table E.4. Hydrometer data for horizontal cores from the lower coarse layer of Trench 8.

<u>Distance = 40 ft</u>		<u>Distance = 100 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10425	3.28	0.10126	10.82
0.07454	2.34	0.07371	6.31
0.05286	2.11	0.05242	5.41
0.03748	1.87	0.03717	4.96
0.02296	1.87	0.02357	4.96
0.01676	1.87	0.01667	4.96
0.01192	1.87	0.01150	4.96
0.00690	1.64	0.00680	4.51
0.00485	1.64	0.00481	4.51
0.00344	1.41	0.00341	4.06
0.00252	1.17	0.00242	3.15
0.00144	0.94	0.00142	2.70
<u>Distance = 60 ft</u>		<u>Distance = 110 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10390	4.25	0.09168	2.06
0.07428	2.83	0.07528	0.88
0.05281	2.12	0.05323	0.88
0.03734	2.12	0.03764	0.88
0.02369	2.12	0.02368	1.47
0.01685	1.77	0.01674	1.47
0.01188	2.12	0.01155	1.47
0.00688	1.77	0.00684	1.47
0.00485	2.12	0.00484	1.30
0.00345	2.12	0.00343	1.18
0.00241	1.77	0.00237	1.18
0.00140	1.42	0.00142	0.88
<u>Distance = 80 ft</u>		<u>Distance = 115 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.10246	7.54	0.10187	6.49
0.07392	4.90	0.07370	3.89
0.05271	3.77	0.05255	2.92
0.03727	3.77	0.03726	2.59
0.02357	4.14	0.02350	2.92
0.01667	4.14	0.01666	2.59
0.01179	3.77	0.01140	2.92
0.00684	3.77	0.00678	2.27
0.00483	3.39	0.00481	1.95
0.00342	3.01	0.00340	1.95
0.00244	3.01	0.00243	2.27
0.00142	2.26	0.00142	2.27

Table E.4. (Continued).

Distance = 120 ft

Particle diameter (mm)	Percent finer (%)
0.10274	3.38
0.07448	1.48
0.05281	1.27
0.03734	1.27
0.02369	1.27
0.01674	1.27
0.01163	1.06
0.00688	1.06
0.00485	1.27
0.00345	1.27
0.00240	1.06
0.00140	0.85

Distance = 180 ft

Particle diameter (mm)	Percent finer (%)
0.10329	5.12
0.07364	4.10
0.05221	3.76
0.03702	3.41
0.02369	2.73
0.01671	3.07
0.01163	2.73
0.00692	2.05
0.00486	2.39
0.00346	1.71
0.00249	2.09
0.00140	1.37

Distance = 140 ft

Particle diameter (mm)	Percent finer (%)
0.10448	1.70
0.07468	1.02
0.05295	0.85
0.03754	0.68
0.02396	0.51
0.01690	0.68
0.01195	0.68
0.00690	0.68
0.00485	1.02
0.00344	0.85
0.00244	0.68
0.00142	0.51

Distance = 200 ft

Particle diameter (mm)	Percent finer (%)
0.09889	11.10
0.07160	8.14
0.05135	6.29
0.03662	5.18
0.02356	3.70
0.01676	3.70
0.01157	3.70
0.00684	3.33
0.00486	2.59
0.00344	2.59
0.00250	2.59
0.00140	2.22

Distance = 160 ft

Particle diameter (mm)	Percent finer (%)
0.10303	2.71
0.07408	1.63
0.05267	1.27
0.03734	1.08
0.02362	1.08
0.01685	0.90
0.01192	0.90
0.00690	0.72
0.00485	1.08
0.00345	1.08
0.00242	0.90
0.00141	0.72

Distance = 205 ft

Particle diameter (mm)	Percent finer (%)
0.10361	3.28
0.07367	2.77
0.05238	2.27
0.03710	2.12
0.02346	2.12
0.01659	2.12
0.01146	2.02
0.00678	2.02
0.00481	1.77
0.00340	1.77
0.00239	1.51
0.00142	1.26

Table E.4. (Continued).

Distance = 210 ft

Particle diameter (mm)	Percent finer (%)
0.10480	3.74
0.07472	2.81
0.05298	2.49
0.03756	2.18
0.02369	2.49
0.01675	2.49
0.01156	1.87
0.00682	1.56
0.00483	1.25
0.00342	1.25
0.00241	1.56
0.00142	1.56

Distance = 215 ft

Particle diameter (mm)	Percent finer (%)
0.10476	2.99
0.07448	2.24
0.05281	1.87
0.03724	2.24
0.02355	2.24
0.01655	2.24
0.01181	1.87
0.00680	2.24
0.00481	2.24
0.00340	2.24
0.00250	2.62
0.00145	1.87

Distance = 220 ft

Particle diameter (mm)	Percent finer (%)
0.10357	3.06
0.07384	2.40
0.05264	1.75
0.03722	1.75
0.02354	1.75
0.01690	1.96
0.01198	1.75
0.00694	1.53
0.00483	1.31
0.00337	1.31
0.00259	1.31
0.00139	1.31

Distance = 240 ft

Particle diameter (mm)	Percent finer (%)
0.10409	2.10
0.07420	1.31
0.05269	0.89
0.03726	0.89
0.02356	0.89
0.01659	0.79
0.01149	0.79
0.00684	0.52
0.00484	0.37
0.00342	0.89
0.00246	0.79
0.00142	0.79

Distance = 360 ft

Particle diameter (mm)	Percent finer (%)
0.10094	6.36
0.07240	4.68
0.05148	4.01
0.03650	3.68
0.02315	3.01
0.01637	3.01
0.01154	3.01
0.00674	2.48
0.00477	2.34
0.00338	2.81
0.00241	2.68
0.00141	2.01

Distance = 410 ft

Particle diameter (mm)	Percent finer (%)
0.08866	3.23
0.07244	5.58
0.05166	4.59
0.03663	2.65
0.02330	3.61
0.01647	3.61
0.01137	3.61
0.00673	3.61
0.00478	2.95
0.00339	2.63
0.00241	2.43
0.00141	2.10

Table E.4. (Continued).

Distance = 415 ft

Particle diameter (mm)	Percent finer (%)
0.10422	2.48
0.07411	2.13
0.05269	1.77
0.03736	1.60
0.02363	1.60
0.01675	1.06
0.01156	1.06
0.00680	1.06
0.00482	0.89
0.00342	0.71
0.00242	0.89
0.00142	1.06

Distance = 480 ft

Particle diameter (mm)	Percent finer (%)
0.08910	4.00
0.07516	2.80
0.05315	2.80
0.03768	2.40
0.02377	2.80
0.01602	2.80
0.01157	3.20
0.00688	3.20
0.00485	2.80
0.00344	2.40
0.00250	2.40
0.00144	2.00

Table E.5. Hydrometer data for vertical cores from the fine layer of Pit 3.

<u>Distance = 80 ft</u>		<u>Distance = 520 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.08810	9.35	0.09075	8.53
0.06417	8.16	0.06577	7.45
0.04776	5.93	0.04899	4.97
0.03496	4.30	0.03590	3.10
0.02238	3.71	0.02316	2.02
0.01587	3.12	0.01645	1.77
0.01132	2.67	0.01161	1.40
0.00667	2.08	0.00680	1.02
0.00473	1.93	0.00483	0.76
0.00272	1.69	0.00276	0.62
0.00139	1.04	0.00140	0.53
<u>Distance = 440 ft</u>		<u>Distance = 540 ft</u>	
Particle diameter (mm)	Percent finer (%)	Particle diameter (mm)	Percent finer (%)
0.08944	9.26	0.08923	10.68
0.06509	8.00	0.06605	8.41
0.04823	5.81	0.04885	5.96
0.03538	3.92	0.03579	3.85
0.02264	2.83	0.02293	3.05
0.01619	2.20	0.01637	2.45
0.01158	2.04	0.01170	1.75
0.00676	1.41	0.00679	1.40
0.00480	1.16	0.00483	1.05
0.00277	0.94	0.00339	1.02
0.00140	0.69	0.00244	0.74
		0.00138	0.74
<u>Distance = 515 ft</u>			
Particle diameter (mm)	Percent finer (%)		
0.09063	9.68		
0.06639	8.12		
0.04928	5.77		
0.03601	4.06		
0.02289	2.81		
0.01635	2.25		
0.01170	1.56		
0.00683	0.94		
0.00485	0.66		
0.00341	0.59		
0.00244	0.37		
0.00138	0.53		

Table E.6. Hydrometer data for horizontal cores from the fine layer of Pit 3.

Distance = 415 ft

Particle diameter (mm)	Percent finer (%)
0.08446	12.76
0.06121	11.81
0.04614	9.09
0.03387	7.34
0.02231	5.27
0.01611	4.15
0.01111	3.51
0.00672	1.91
0.00480	1.31
0.00337	1.21
0.00240	0.67
0.00138	0.64

Distance = 460 ft

Particle diameter (mm)	Percent finer (%)
0.08862	10.16
0.06399	9.32
0.03956	6.33
0.03485	5.53
0.02264	4.18
0.01599	3.35
0.01145	2.69
0.00674	1.64
0.00480	1.25
0.00337	1.14
0.00242	0.66
0.00138	0.63

Table E.7. Hydrometer data for horizontal cores from the coarse layer of Pit 3.

Distance = 105 ft

Particle diameter (mm)	Percent finer (%)
0.08862	9.18
0.06399	8.32
0.04662	7.04
0.03420	5.35
0.02228	3.89
0.01601	3.06
0.01118	2.45
0.00672	1.59
0.00476	1.53
0.00334	1.22
0.00230	0.98
0.00141	0.92

Distance = 260 ft

Particle diameter (mm)	Percent finer (%)
0.08726	9.59
0.06409	8.09
0.04845	5.16
0.03591	2.85
0.02330	1.50
0.01655	1.26
0.01145	1.11
0.00680	0.90
0.00482	0.81
0.00338	0.60
0.00230	0.75
0.00142	0.66

END

DATE

FILMED

4/7/94