State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
P.O. Box 27687 · Raleigh, North Carolina 27611-7687

James G. Martin, Governor
William W. Cobey, Jr., Secretary

William L. Meyer
Director

May 30, 1991

Carmen Johnson
Fac/Perm/Co ID # ~~42-03~~ 42-04 cp
Date 3/21/12
Doc ID#
DIN

MEMORANDUM

TO: Jim Coffey

FROM: Bobby Lutfy

RE: Hydrogeological Review of the Halifax Ash Monofill Site Plan Application

Upon completion of a review of the above referenced site plan application, it appears that the site is suited for development of an ash disposal landfill facility. Some additional water table information will be necessary in order to properly design the landfill and design an effective ground water monitoring system.

The site has relatively good hydrogeological characteristics for development of an ash monofill. There appears to be an adequate depth to ground water and/or rock to enable the required excavation for the facility. On site soils also appear suitable for use as liner and final cover material.

Some additional information on ground water tables should be included in the Construction Plan Application. Specifically, the depth to ground water and the direction of ground water flow needs to be better defined for the northeast corner of the site, where the ridge is located. There also needs to be some evaluation and comments on the projected long-term seasonal high water table.

On page 6-8 of the Site Suitability Study, reference is made to the possibility on "heavy ripping" and "light blasting". Blasting is not permitted at Solid Waste Management facilities. Ripping should be avoided if at all possible. If ripping is found to be necessary, then the amount of ripping should be kept to a minimum and limited to small areas necessary to the construction of the liner system.

Details of the proposed monitoring plan may be included in the Construction Plan Application. Apparently a phased construction of the ash monofill is planned, with several small cells to be constructed for an estimated life of approximately five years each. Therefore, the monitoring system must be designed to adequately monitor each phase of development, as well as the effect of the proposed facility as a whole.

In addition to some changes that may be necessary in the proposed monitoring well locations, a couple of changes should be made in the proposed well design. The "Typical Well Schematic", (figure 13), does not show an inner cap or concrete collar for the proposed wells. A vented inner cap should be provided for each well. Each well should also have a concrete collar to anchor the outer casing and shed surface water from the immediate area of the well. (Refer to "Typical Monitoring Well Schematic" used by the Solid Waste Section.)

There is a discrepancy in the proposed screen lengths in the Site Suitability Study. Table 9 indicates the use of 10 foot screens, while Figure 13 shows 5 foot screens. It is generally best to use 15 foot screens for monitoring wells screened at the water table. This allows for seasonal fluctuations in the water table and ensures that the water table will always fall within the screened interval. Deeper wells, that may be required as part of well nests, should be constructed using 10 foot screens.

Overall, the Site Suitability Study is an excellent report and indicates that this is a good site for the Halifax Ash Monofill. The requested additional water table information and changes in the proposed monitoring plan should be reflected in the Construction Plan Application. Also, proposed surface water monitoring points need to be included as part of the monitoring plan.

cc: Sherri Hoyt

G · N · Richardson & Associates
CONSULTING ENGINEERING

May 2, 1991

North Carolina Department of Environment,
Health, and Natural Resources
Post Office Box 27687
Raleigh, North Carolina 27611-7687

Atention: Mr. Bobby Lufty
Hydrogeologist
Solid Waste Section

Reference: Halifax County Ash Monofill
Site Suitability Application Corrections
GNRA Project Number 90-001

Dear Bobby;

① Table 5
② Table of G.W. Level Data

①MW-8 ②MW-9

I am enclosing copies of corrections to two Tables and two Well Construction Records from the Site Suitability Application for the Halifax County Ash Monofill that we submitted to your office on March 22, 1991. The Tables that were corrected are "Table 5 - Summary of Groundwater Level Data" located in the Table section of the Appendix, and an unnumbered table entitled "Summary of Groundwater Level Data" located in "Appendix A - Field Investigation". The two Well Construction Records are for Piezometers MW-8 and MW-9 and are located in Appendix A. Since four copies of the report were forwarded to your office, I have enclosed four full sets of the corrections. Please direct these corrections to those individuals holding copies of the report so that they can be inserted into the appropriate sections.

Additionally, I have enclosed a copy of the report from Law Engineering from July 1981, detailing the construction of the monitoring wells from the current sanitary landfill. The numbering system of the wells that Law used in their report was different than that used in the permit. A copy of the sketch used in the permit is enclosed to show you the locations and numbers of the wells as presented in the permit. Additionally, we have made a table to correlate the well number from the permit (shown on the sketch) to the well number shown in the Law report.

12600 SHOOTING CLUB ROAD • RALEIGH, NORTH CAROLINA 27613 • TEL. 919-848-2371 • FAX 919-676-1425

Halifax County Ash Monofill
Site Application Corrections
May 2, 1991

The following table equates the well numbers used in the permit to those used in the Law report:

Permit Well Number	Law Well Number
MW-1	MW-1
MW-2	MW-4
MW-3	MW-5
MW-4	MW-6
MW-5	MW-2
MW-6	MW-3

If you have any questions please contact at us.

Very Truely Yours,
G.N. Richardson and Associates

John C. Robins, PE
Associate

Enclosures
CC: 1- File GNRA 91-001
2- Sherri Hoyt, Engineer
Solid Waste Section

July 17, 1981

McDavid Associates, Inc.
Post Office Drawer 49
Farmville, North Carolina 27828

Attention: Mr. Mike Barnette, Jr.

Subject: Installation of Groundwater Monitoring Wells
Halifax County Landfill
Halifax County, North Carolina
LETCO JOB No. RA-1673A

Gentlemen:

Law Engineering has completed the installation of six groundwater monitoring wells at the subject site. This work was accomplished in accordance with our proposal PRS-1-071 dated June 17, 1981.

Six groundwater monitoring wells were installed generally according to the requirements of the North Carolina Department of Human Resources, Division of Health Services. Locations of the wells were staked by McDavid Associates, Inc. The actual placement of the wells was as close as practical to the stakes and within the tolerances allowed to us.

Details of the monitoring wells, including depths of the particular well components and water levels recorded are shown on Drawing No. 1. After completing the well installations, each well was developed by bailing and a lock placed on each standpipe. The keys have been sent to Mr. John Kelly at the landfill.

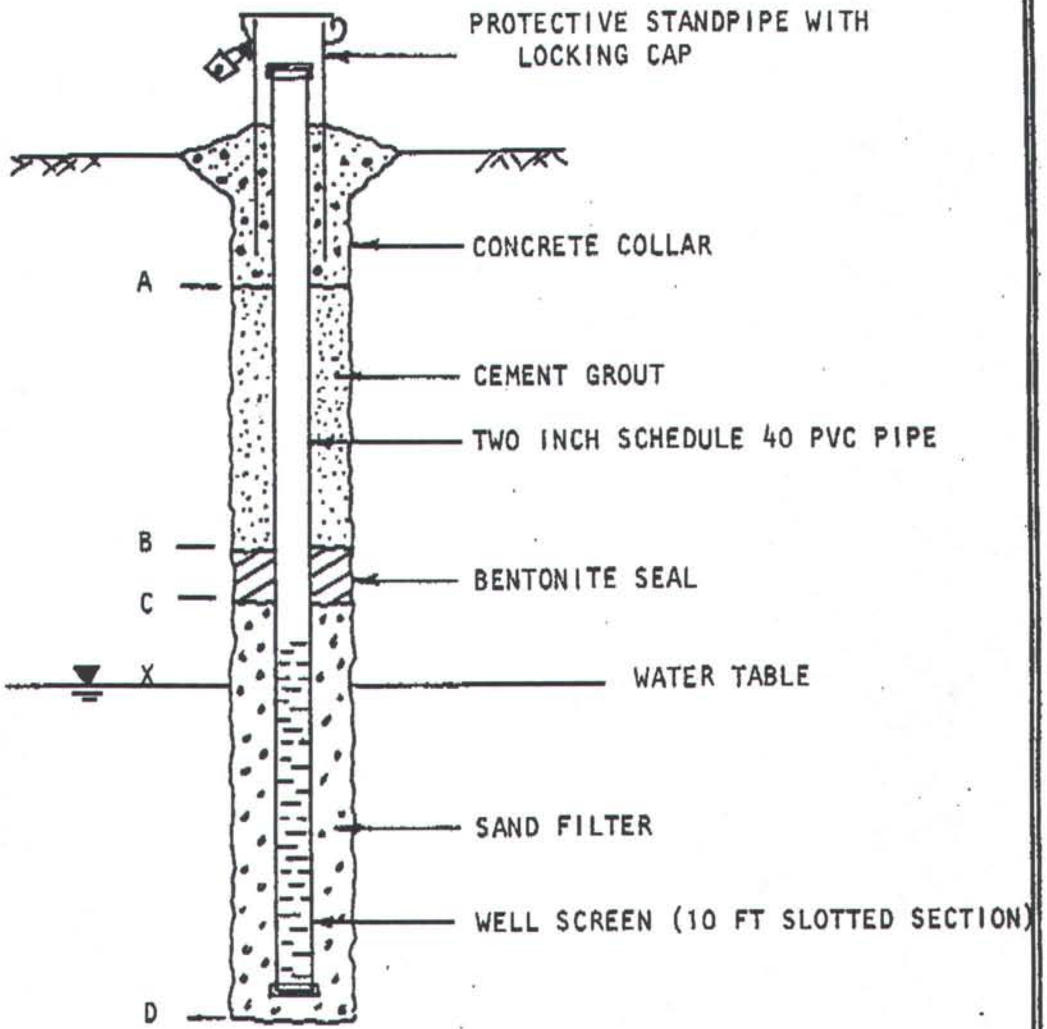
We appreciate the opportunity to be of continued service on the project. If you have any questions, don't hesitate to call on our office.

Very truly yours,

LAW ENGINEERING TESTING COMPANY

J. Richard Rhudy, P.E.
Staff Geotechnical Engineer

Peter Fleming, P.E.
Senior Engineer
Geotechnical Department Manager



DEPTHS BELOW GROUND SURFACE, FEET

WELL NO	A	B	C	D	X	(DATE)
W-1	3.0	25	27	40	34	7/7/81
W-2	2.0	2.0	3.0	15	3.3	7/7/81
W-3	2.0	2.3	3.7	16	3.0	7/7/81
W-4	2.0	2.0	3.0	15	3.5	7/1/81
W-5	2.5	3.0	4.0	15	12	7/1/81
W-6	3.0	4.0	5.0	20	15	7/7/81

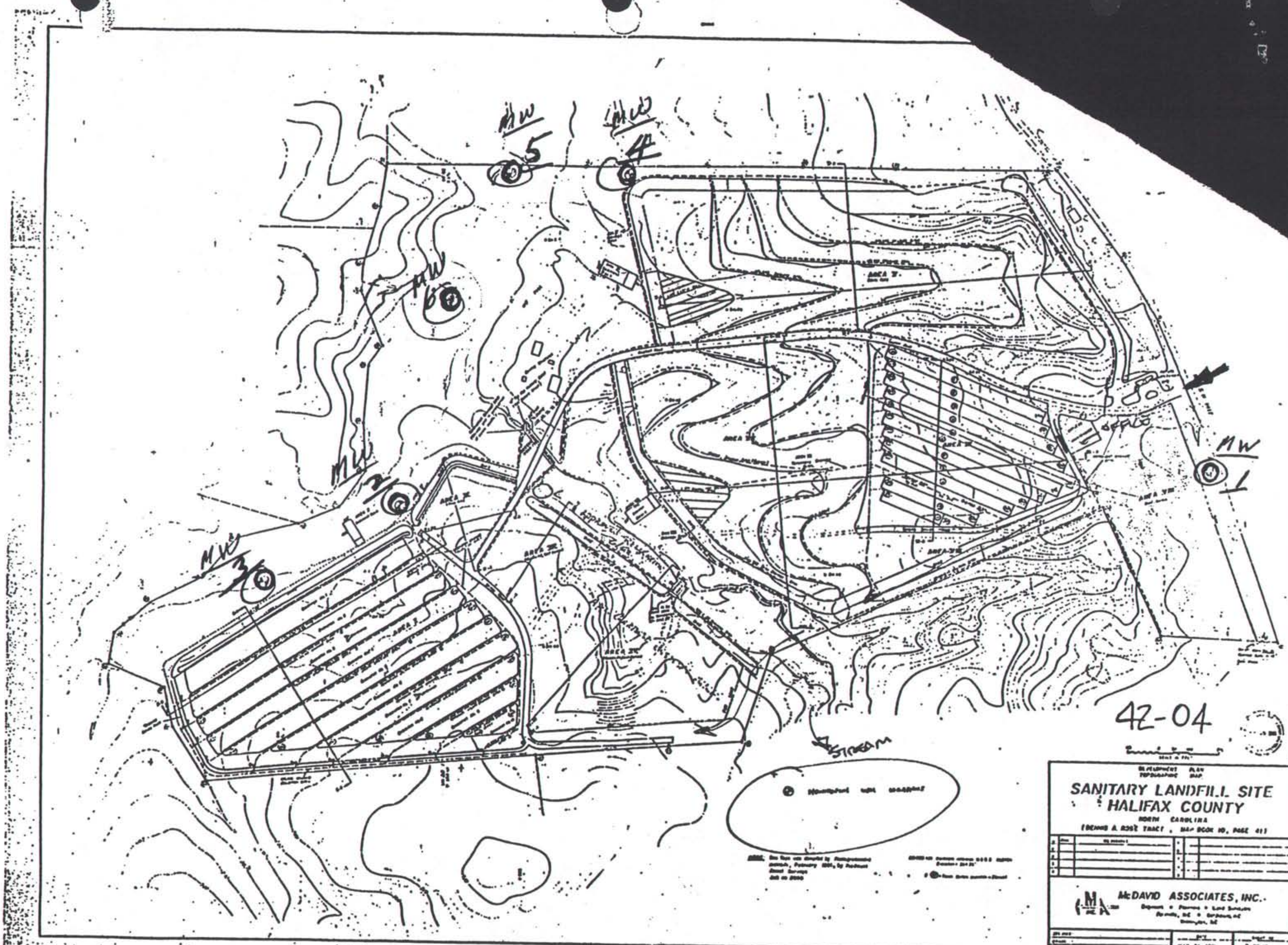
GROUNDWATER MONITORING WELLS

HALIFAX COUNTY LANDFILL

HALIFAX COUNTY, NORTH CAROLINA

LAW ENGINEERING TESTING CO.
RALEIGH, NORTH CAROLINA

SCALE	Drawn: JRR	Job No. RA-1673A
N.T.S.	Checked: PF	Dwg. No. 1
	Date: 7/16/81	


MW 1
MW 2
MW 3
MW 4
MW 5
MW 6
OFFICE
STREAM
42-04
SANITARY LANDFILL SITE
HALIFAX COUNTY
NORTH CAROLINA
McDAVID ASSOCIATES, INC.

May 1991

Halifax County
Ash Monofill

Site Plan Review (Hydrogeological)

1-1 15 yr. capacity
4-7 depth to rock ? >50'
6-4 " , except B-8 27', 4-8 Central Ridge
6-8 ~~blasting~~, ~~heavy ripping~~ X
6-8 ✓ 5 ft. separation bottom of waste
HDPE liner

9-1 240 acres fill
9-2 5 acre cells (4-5 yrs)

Addition Water Table Data G.W. Flow

Table 9 / Figure 12 — Proposed Mon. Wells ?
Well nests (?)
seasonal high G.W. level
long-term "

8-1 ash material impervious (1x10^{-8})
cap design ?
8-3 buffers - 50'
9-1 " - 100'
9-3 no daily cover
9-4 final cap design ?
figure 12 Well Locations
figure 13 Well Design

Typical Well Schematic
No rock characterization
gen. >50' deep

figure 10 Potentiometric Map
* more data needed for NE corner
- long term seasonal high water table

Well Records

H2O ? Levels

MW-1 (B-1)	38.5-48.5	7.8 / 4.1	Fine to Coarse Sand	1.0 x 10^{-4}
MW-3 (B-3)	39 - 49	29.2 / 14.8	Fine Sandy Silt	8.72 x 10^{-6}
MW-5 (B-5)	40 - 50	23.0 / 21.4	Sltly. Silty F to C Sand	4.81 x 10^{-5}
MW-7 (B-7)	39 - 49	5.4 / 2.8	(Silt), PWR - Silty F to C Sand	2.85 x 10^{-5}
MW-8 (B-8)	17 - 27	14 / ~~31.7~~ 15.9	Silt, PWR-Sand, PWR-Silt	1.89 x 10^{-5}
MW-9 (B-9)	38.5 - 48.5	35.2 / ~~31.7~~ 30.3	F to C Sdy. Cly. Silt	1.0 x 10^{-5}

H2O Levels Boring Logs
B-1 ?
B-7 —

- Blasting X, Ripping ?
  additional data needed
- Water Table + GW flow dir, for NE corner (Central ridge)
- long term seasonal high W.T. projections
- Proposed Mon. Wells
  locations
  screen intervals
  design
  } modify in constr. Plans
- Cap design ?

BL-60

(ii) Potential or existing sources of ground-water and surface water pollution;
(iii) Water intakes;
(iv) Airport and runways; and
(v) Subdivisions.

(c) A geological and hydrological study of the site which provides:

(i) Soil borings for which the numbers and depths have been confirmed by the Division and lab testing of selected soil samples that provide:

(A) standard penetration - resistance;
(B) particle size analysis;
(C) soil classification - USCS;
(D) geologic considerations (slopes, solution features, etc.);
(E) undisturbed representative geologic samples of the unconfined or confined or semiconfined hydrological units within a depth of 50 feet that provide the following information for each major lithologic units:

(I) saturated hydraulic conductivity (or by in-situ);
(II) volume percent water; and
(III) porosity;

(F) remolded sample of cover soils that provide:

(I) saturated hydraulic conductivity,
(II) total porosity,
(III) atterberg limits;

(G) stratagraphic cross-sections identifying hydrogeological units including lithology;
(H) tabulation of water table elevations at time of boring, 24 hours, and seven days (The number of cased borings to provide this information shall be confirmed by the Division.); and
(I) boring logs;

(ii) A boundary plat locating soil borings with accurate horizontal and vertical control which are tied to a permanent onsite bench mark;
(iii) A potentiometric map of the surfical aquifer based on stabilized water table elevations; and
(iv) A report summarizing the geological and hydrological evaluation.

(d) A conceptual design plan presenting special engineering features or considerations which must be included or maintained in site construction, operation, maintenance and closure.

(e) Local government approvals:

(i) If the site is located within an incorporated city or town, or within the extra-territorial jurisdiction of an incorporated city or town, the approval of the governing board of the city or town shall be required. Otherwise, the approval of the Board of Commissioners of the county in which the site is located shall be required. Approval may be in the form of either a resolution or a vote on a motion. A copy of the resolution, or the minutes of the meeting where the vote was taken, shall be forwarded to the Division.
(ii) A letter from the unit of government having zoning jurisdiction over the site which states that the proposal meets all of the requirements of the local zoning ordinance, or that the site is not zoned.

(f) A discussion of compliance with siting standards in Rule .0503(1) of this Subchapter.

(g) A report indicating the following:

(i) population and area to be served;
(ii) type, quantity and source of waste;
(iii) the equipment that will be used for operating the site;
(iv) a proposed groundwater monitoring plan including well location and schematics showing proposed screened interval, depth and construction; and
(v) a more detailed geologic report may be required depending on specifics of the site. This report may be based on physical evidence, initially, or due to information obtained from the site plan application.

(h) Any other information pertinent to the suitability of the proposed site.

(2) The following information shall be is required for reviewing a construction plan application for a proposed sanitary landfill:

(a) A map showing existing features to include:

(i) existing topography of the site on a scale of at least 1 inch equals 200 feet with five foot contours;
(ii) bench marks;

.0504 APPLICATION REQUIREMENTS FOR SANITARY LANDFILLS

	LOCATION IN REPORT
This Rule contains the information required for a permit application for each sanitary landfill. It is recommended that the site application be submitted and acted upon prior to submitting the application for the construction plan. A minimum of four sets of plans will be required in each application. Note that a permit for a sanitary landfill is based upon a particular stream of identified waste, as set forth in .0504 (g)(i) and (ii) of this Rule. Any substantial change in the population or area to be served, or in the type, quantity or source of waste will require a new permit and operation plan, including waste determination procedures where appropriate. (1) The following information is required for reviewing a site plan application for a proposed sanitary landfill:	
(a) An aerial photograph (scale 1 ' 400 ft. or larger) and a blueprint of the photograph accurately showing the area within one-fourth mile of the proposed site's boundaries with the following specifically identified: (i) Entire property owned or leased by the person proposing the disposal site; (ii) Land use and zoning; (iii) Location of all homes, industrial buildings, public or private utilities, and roads; (iv) Location of wells, watercourses, dry runs, and other applicable details regarding the general topography; and (v) Flood plains.	FIGURE 2 & ROLLED PHOTO
(b) A map (scale 1 ' 1000 ft. or larger) showing the area within two miles of the proposed site's boundaries with the following specifically identified: (i) Significant ground-water users; (ii) Potential or existing sources of ground-water and surface water pollution; (iii) Water intakes; (iv) Airport and runways; and (v) Subdivisions.	FIGURE 1
(c) A geological and hydrological study of the site which provides: (i) Soil borings whose numbers and depths have been confirmed by the division and lab testing of selected soil samples that provide: (A) standard penetration - resistance; (B) particle size analysis; (C) soil classification - USCS; (D) geologic considerations (slopes, solution features, etc.);	SECTIONS 3,4,5,&6
(E) undisturbed representative geologic sample(s) of the unconfined and/or confined or semi-confined hydrological unit(s) within a depth of 50′ that provide the following information for each major lithologic unit(s): (I) saturated hydraulic conductivity (or by in-situ); (II) volume percent water; and (III) porosity;	ATTACHMENT B
(F) remolded sample of cover soils that provide: (I) saturated hydraulic conductivity, (II) total porosity, (III) atterberg limits;	ATTACHMENT C
(G) stratagraphic cross-sections identifying hydrogeological units including lithology;	FIGURES 7,8,&9
(H) tabulation of water table elevations at time of boring, 24-hours, and seven days (The number of cased borings to provide this information shall be confirmed by the division.); and	TABLE 5
(I) boring logs;	ATTACHMENT A
(ii) A boundary plat locating soil borings with accurate horizontal and vertical control which are tied to a permanent onsite bench mark;	FIGURE 14
(iii) A potentiometric map of the surfical aquifer based on stabilized water table elevations; and	FIGURE 10

APPLICATION REQUIREMENTS (Continued)	LOCATION IN REPORT
(iv) A report summarizing the geological and hydrological evaluation.	SECTIONS 3,4,5,&6
(d) A conceptual design plan presenting special engineering features or considerations which must be included or maintained in site construction, operation, maintenance and closure.	SECTIONS 8 & 9 FIGURES 11,12,&13
(e) Local government approvals: (i) If the site is located within an incorporated city or town, or within the extra-territorial jurisdiction of an incorporated city or town, the approval of the governing board of the city or town shall be required. Otherwise, the approval of the Board of Commissioners of the county in which the site is located shall be required. Approval may be in the form of either a resolution or a vote on a motion. A copy of the resolution, or the minutes of the meeting where the vote was taken, shall be forwarded to the Division of Health Services. (ii) A letter from the unit of government having zoning jurisdiction over the site which states that the proposal meets all of the requirements of the local zoning ordinance.	ATTACHMENT E
(f) A discussion of compliance with siting standards in Rule .0503(1) of this Subchapter.	SECTION 8
(g) A report indicating the following: (i) population and area to be served; (ii) type, quantity and source of waste; (iii) the equipment that will be used for operating the site; (iv) a proposed groundwater monitoring plan including well location and schematics showing proposed screened interval, depth and construction; and	SECTION 9 SECTION 1
(v) a more detailed geologic report may be required depending on specifics of the site. This report may be based on physical evidence, initially, or due to information obtained from the site plan application. (h) Any other information pertinent to the suitability of the proposed site.	N/A

HALIFAX COUNTY ASH MONOFILL

AURELIAN SPRINGS, NORTH CAROLINA

SITE SUITABILITY STUDY

MARCH 1991

ENSCI
ENVIRONMENTAL DESIGN GROUP
HIGH POINT, NORTH CAROLINA

Halifax County

Richardson & Assoc.
(Formerly ENSCI Corp.)

John Robins

phone 848-2371

fax 676-1725

County of Halifax

ENSCI CORPORATION

March 22, 1991

SOLID WASTE SECTION
MAR 26 1991

North Carolina Department of Environment,
Health, and Natural Resources
Solid Waste Management Division
Solid Waste Section
401 Oberland Road
Raleigh, NC

ATTN: Jim Coffee, P.E.

RE: Site Suitability Permit Application
Halifax County Ash-Monofill
Halifax County, NC
ENSCI-EDG Job No. 90-001

Gentleman:

The attached site suitability permit application was prepared to meet the requirements of 10NCAC 10G Section.0500 - Disposal Sites. Note, however, that the proposed facility will exceed the State requirements and offers a significant improvement over ash monofills currently permitted. Using waste disposal cells that are compositely lined and provide full liquids collection systems, the proposed ash monofills will provide greater environmental protection than all but a few of your currently permitted MSW facilities.

The ash monofills are part of a cooperative program between Halifax County and Westmoreland-Hadson Partners (WHP). This program will enable Halifax to economically transition to a lined MSW facility and provides WHP with a reliable disposal facility for ash that it generates.

Detailed design of the ash monofill cells will progress as the site suitability application is under review. Please let us know if specific questions arise as to design or operational considerations for the ash monofills.

1108 Old Thomasville Rd. • High Point, NC 27260 • 919-883-7505 • Fax 919-882-7958

Thank you for a speedy review.

Cordially,

ENSCI Environmental Design Group

Gregory N. Richardson Ph.D., P.E
N.C. Registration No. 8895

G. David Garrett, P.G.
N.C. Registration No. 983

John Barnard, E.I.T.

TABLE OF CONTENTS

ATTACHMENTS

D. **Environmental and Archaeological Studies**
- *Letter from U.S. Fish and Wildlife (3-6-91) regarding endangered species in the area
- *Letter from N.C. Natural Heritage Program (12-11-90) regarding endangered species and State Park/Recreation areas
- *Letter to U.S. Corps of Engineers (3-22-91) regarding Wetlands
- *Letter from N.C. Division of Archives and History (1-31-91) regarding archaeological sites in the area
- *Phase I Cultural Resource Study of the site by Archaeological Associates, LTD

E. **Local Government Correspondence**
- *Letter from Halifax County Manager regarding County commitment to project

SECTION 1.0 - INTRODUCTION

Halifax County and Westmoreland-Hadson Partners (WHP) are cooperating on the development of a Coal Ash-Monofill. The Ash-Monofill will service a coal fired electrical generation facility Westmoreland-Hadson is planning to construct in Weldon, North Carolina. It is anticipated that 120,000 tons of bottom and fly ash will be produced in this facility annually. A disposal facility for this ash must be constructed as part of the generation facility start-up. It is planned that this ash will be disposed of in a Ash-Monofill located on an 88 acre tract of land directly east and adjoining the existing Halifax County Landfill. This site is located approximately 14 miles southwest of Roanoke Rapids on S.R. 1417. The Ash-Monofill will be owned by the County and operated in conjunction with the existing County Municipal Sanitary Landfill. No municipal solid waste will be placed on the site defined by this permit application.

ENSCI Corporation was retained by the county to evaluate this new site for its suitability as an Ash-Monofill and to prepare this site suitability application. A conceptual design of this facility focused on providing WHP a fifteen (15) year capacity for ash.

Detailed cell concepts developed during this study show that this capacity can be achieved without deep excavation for the containment cells. Thus the cell bottom elevations are established based on depths to obtain sufficient soil inventory to complete the embankments and final cover requirements.

The site evaluation consists of geotechnical and hydrogeological studies of the site along with evaluations of the surrounding vicinity. The main objectives of these studies are provided for in this site suitability application and included the following:

- Evaluation of the geotechnical properties of the site soils. Properties evaluated include:
  - Grain size distributions
  - Standard Penetration Test Resistances
  - Atterberg limits
  - In-place hydraulic conductivity
  - Remolded hydraulic conductivity
  - Standard Compaction properties

- Evaluation of the Geologic and Hydrogeologic properties of the site including an evaluation of the major lithologic units on site, the potentiometric surface, groundwater flow gradients, and in-place hydraulic conductivity.

- Evaluation of the environmental aspects of the site including:
  - Wetlands
  - Endangered Species, and
  - Archaeology

- Evaluation of the Physiographic aspects of the site and surrounding area.

- A conceptual design of the proposed Ash-Monofill

The results of these tests, investigations and inspections are included in the body and appendices of this site suitability application.

SECTION 2.0 - GEOGRAPHIC & PHYSIOGRAPHIC SETTING

Halifax County is located in Northeastern North Carolina, 95 miles west of the Atlantic Ocean and 75 miles northeast of Raleigh. The county has a total area of 462,080 acres and is home to some 55,000 people. Roanoke Rapids, Enfield, Scotland Neck and Weldon are the main population centers; Roanoke Rapids being the largest with approximately 16,000 people.

Commerce in the county ranges from agriculture to manufacturing. Agriculture employs approximately 1,200 people and utilizes some 150,000 acres of land. Some of the main crops include peanuts, tobacco, cotton, corn and soybeans. There are also a number of swine, poultry and cattle farms throughout the county. Commercial foresting is also a large business, with 257,000 acres of commercial timberlands. Manufacturing is the largest employer in the county. Approximately 7,000 people work in manufacturing jobs which include paper products, textiles, exotic metals and a range of other items.

The county contains portions of both the piedmont and coastal plain physiographic provinces. Western Halifax County is mainly piedmont topography with some scattered coastal plain deposits. This section of the county is typified by a gently rolling topography with broad ridge tops and relatively complex drainage features. The eastern half of the county is coastal plain. This is typified by relatively flat topography and sandier soils. Elevations within the county range from 10 to 390 feet above sea level.

The project site is an 88 acre tract located in Northwest Halifax County. The site is approximately 1.5 miles Northwest of the intersection of N.C. 48 and State Route (S.R.) 1001 on S.R. 1417. The property is currently unused. Approximately 25% has been farmed in the past and is still cleared. The remaining 75% is relatively young forest with both hard and softwoods present.

This section of Halifax County is primarily agricultural land mixed with timberlands. There are both cattle and poultry farms within a mile of this site. The property is bordered to the west by the current Halifax County MSW landfill, to the North by timberlands, to the east by timberlands and fields and to the south by timberlands and plowed fields.

The site is marked by relatively flat fields in the northern section. The topography slopes gently downward from north to south. A stream crosses the property from east to west in the southern section of the site. Elevations within the site range from approximately 250 to 330 feet above sea level. The creek is a small spring fed woodlands stream which starts a few hundred feet to the east of the site.

This site, as well as the current MSW landfill and the majority of the county, is zoned R/A (Residential/Agricultural). Halifax County has jurisdiction over this area.

The county does not supply water or sewer service in this area. All water supplies are obtained from relatively shallow wells. All sewage facilities consist of septic systems. *

There is one airport in the county. It is located in Roanoke Rapids approximately 14 miles north from the project site. The next closest airport is in Rocky Mount, approximately 26 miles south of the site.

3.0 REGIONAL GEOLOGIC SETTING

REGIONAL BEDROCK AND STRUCTURAL GEOLOGY

The vicinity of the Halifax landfill consists of an eroded peneplain and exhibits numerous broad, flat-topped ridges dissected by a well defined dendritic drainage pattern, which produces the gently rolling topography that is characteristic of the Piedmont province. The proposed ash-monofill site is situated on the crest and southeast flank of a broad northeast trending ridge, with ground surface elevations in the immediate vicinity of the site varying from approximately elevation 250 to elevation 330. Maximum topographic relief in the area is approximately 80 feet or less, with values typically on the order of 30 to 40 feet. Maximum slopes on the order of 10 to 15 percent, based on inspection of the USGS "Thelma" and "Aurelian Springs" 7.5 minute topographic quadrangle maps, which are shown as Figure 1. Photographs 1-4 exhibit the relatively flat to gently rolling topography which exists within the uplands of the site.

The proposed landfill site and vicinity is located along the eastern edge of the so-called Eastern Piedmont geologic province. The area of western Halifax County is underlain by an assemblage of felsic to intermediate crystalline igneous and metamorphic rocks of early to late Paleozoic age. The rocks exhibit a regional northeast strike and a gentle eastward dip resulting from a late Paleozoic thermotectonic event which metamorphosed and folded the rocks of the province into a broad plunging anticline, axially centered just east of Raleigh. During this event the area was simultaneously intruded by a number of felsic plutons, which were subjected to local cracking and regional jointing due to residual mechanical stresses which occurred during and after the thermal event.

One such unnamed pluton of granitic composition underlies the subject site and vicinity. The rock exhibits a coarse grained porphyritic texture based on observation of local outcrops, consisting of relatively large (1 to 2 inches across) potassic feldspar crystals embedded in a finer matrix of chiefly feldspar, quartz, abundant mica and minor accessory minerals. Local outcrops exhibit a least two widely spaced steeply dipping joint sets and surficial exfoliation cracking.

A few miles east of the site the crystalline rocks of the Piedmont plunge beneath non-indurated fluvial and deep-marine sedimentary formations of the Coastal Plain. During late Tertiary times, portions of the eastern Piedmont were overwashed by deltaic streams and shallow seas, which resulted in the deposition of a thin veneer of clayey sands and rounded quartz gravel, which is still visible along the uplands above approximately Elevation 270. Relatively rapid erosion along fractures and other planes of weakness has occurred, leaving large rounded boulders and outcrops of the granite exposed along the creek bottoms in the area. Figure 3 presents an excerpt from the 1985 North Carolina Geologic map (1), depicting the complex geological relationships present in the area.

REGIONAL SOIL CONDITIONS

Subsurface conditions within the higher elevations of the area generally consist of residual soils which are the in-situ weathering products of the underlying granitic formation. The soils are generally clayey due to the decomposition of feldspars, and depths to hard rock or partially weathered rock is generally in excess of 30 to 40 feet based on a survey of water well records in the area. The predominantly fine grained soils typically exhibit Unified Soil Classification System (USCS) classifications of ML, CL, SM, SC and occasionally MH or CH. Within lower lying areas, transported soils (alluvium and colluvium) have accumulated, which are generally sandier.

The predominant soil mapped at the proposed landfill site in the SCS literature is Wedowee on a B slope (2% - 5%) and C slope (10% - 15%). Wedowee soils generally comprise gentle to moderately steep slopes in the upper coastal plains with moderate permeability. This soil is typically a yellow clay, however, a silty sand and clayey sand are also present at this site. Other soil complexes are mapped in the area but have not been clearly delineated on the preliminary soil map by the Soil Conservation Service (2). These complexes include Pacolet on a B (2% - 6%) slope, Cecil on a B (2% - 6%) slope, and Abell sandy loam. The areas mapped as Abell have not been clearly defined and do not meet all criteria for this soil group. Abell, which has been mapped along drainage ways as an upland soil, will possibly be reclassified by SCS as Helena, which characterizes the soil similarly to Abell soil and continues to be listed as moderately drained soil.

Pacolet sandy loam with a gravely, sandy texture occurs on the western side of the proposed site. Pacolet, also an upland soil, is well drained and occurs on side slopes adjacent to major drainageways. Cecil sandy loam, present at the northeast corner of the site, is a mixture of the remaining original surface layer and material from the subsoil. Normally occurring in the eroded stage, surface layers tend to exhibit colors ranging from a yellowish-brown to a reddish-brown and textures of a sandy loam to a clay loam in more eroded spots.

4.0 REGIONAL HYDROGEOLOGIC CONDITIONS

CLIMATIC CONDITIONS

The climate of Halifax County is relatively warm and humid. Table 1 presents historical and recent climatic data for the Halifax County area. Based on data for earlier this century reported by Mundorff (3), the average mean rainfall for the area is 45.45 inches, with the period of June, July and August being the wettest months. Average annual rainfall recorded in this publication varies from 32.6 to 61.2 inches. The average annual snowfall is reported as approximately 8 inches. More recent information (1970) from SCS is consistent with the earlier rainfall data. Data from the NCSU Agricultural Extension (4) indicate an average annual rainfall of 47.2 inches for the period covering 1981 through 1990 with a yearly high of 63.9 inches (1989) and a low of 35.9 inches (1981). Mean monthly temperatures in the area vary from 26.4°F in January to 91.7°F in July, with an average annual mean of 59.7°F, based on recently compiled information. The twenty-five (25) year, twenty-four (24) hour percipitation for this site is 6.5 inches based on the Department of Agriculture Soil Conservation Service records.

REGIONAL HYDROGEOLOGY

Groundwater recharge occurs due to infiltration from precipitation, primarily within areas of gentle to moderate slope which are underlain by rather permeable deeply weathered soils, such as the broad ridge crests which occur in the proposed landfill vicinity. Infiltrated water tends to migrate downward due to gravity through the permeable surficial soils to the deeper, less weathered clayey saprolite and typically fractured partially weathered rock which overlies relatively unweathered competent rock, where the water collects in fractures and forms a phreatic or saturated zone. The groundwater generally migrates slowly downgradient along the upper boundary of the less permeable competent rock toward swales and valleys, where the groundwater "daylights" as springs and streams. The phreatic surface or water table fluctuates with seasonal and climatic changes and is usually highest between mid December to early May, when evapotranspiration rates are lowest and infiltration rates tend to be highest.

Rock

When deep open fractures along joints, bedding or foliation extend into the competent unweathered rock, groundwater will migrate into these fractures and can be present to depths of several hundred feet. However, based on a study of the hydraulic properties of the granites in the area by Mundorff, it appears that the tightness of the granite and relatively wide-spacing of joints observed in area quarries significantly lessen the probability for groundwater to exist deep into the granite. Ground water can exist at depth where highly fractured zones occur which intersect the ground surface or the permeable near surface soils within the recharge area. Such zones are difficult to predict without extensive site specific field data. However, observation of local granite outcrops on the site supports the published premise that the unweathered granitic rock in this area is generally massive with only occasional widely spaced fractures, which are not usually capable of transmitting and storing significant amounts of groundwater.

NEIGHBORHOOD WATER WELL SURVEY

An inspection of water well records on file with the North Carolina Department of Environment, Health and Natural Resources, Groundwater Section (5), revealed only a handful of wells having been recorded within a several mile area of the sites since 1966. A summary of the nearby wells on record and an index map are included with this report as Table 2 and Figure 4, respectively. A majority of the wells on record were drilled between 1970 and 1985. Based on available records at DEM, it appears that a majority of the wells in the area are underlain by the granite and are relatively shallow, typically ranging from 30 to 50 feet deep, with only a couple of exceptions where depths of 150 and 405 feet were recorded. Based on the various water well drillers' descriptions of the strata encountered, it appears that most of the shallow wells terminated in partially weathered rock or upon encountering "refusal" on rock, whereas the deeper wells penetrated into granite. Recorded yields within the shallow wells varied from 2 to 8 gallons per minute (GPM), with values typically on the order of 2 to 3 gpm, and static water levels were typically recorded at 15 to 20 feet (below the ground surface). The 405 foot well (No. 1880) by comparison yielded only 5 gpm (the water level was not indicated). Only one high yield well found in the DEM records was located at Northwest High School, approximately 2 miles north of the site, which yielded 60 gpm with a total depth of 150 feet. This well does not appear to be downgradient of the landfill site.

A field survey of 13 recently installed domestic water wells within an approximately 2,500 foot radius of the perimeter of the site was conducted to gain information not recorded or difficult to correlate to DEM records. Several homeowners were interviewed and limited visual inspection of well heads was performed. Most, if not all, of the surveyed wells are on the fringe of the 2,000 foot radius. A summary of the neighborhood water well survey and an index map are presented on Table 3 and Figure 5, respectively. Each of the inspected wells, with one exception, consisted of 24 inch diameter bores, most equipped with surface mounted jet pumps which are typically used for relatively shallow depths. Static water levels were estimated (by counting visible casing or pipe joints) to be on the order of 10 to 15 feet, and most of the wells were reported or assumed to be relatively shallow (30 feet or so), except site #7 on the neighborhood survey which had a total depth of 97 feet inscribed on the well head tag. Only one 6 inch diameter drilled well was observed (site #11), which may correlate to No. 1880 in the DEM records (precise well locations were sometimes difficult to establish in the records). None of the surveyed wells are downgradient of the proposed landfill site.

One other source of water well information is given by Mundorff (3). Two drilled wells located at Aurelian Springs School were advanced to 87 and 185 feet into granite. Each yielded approximately 10 gpm, and observed static water levels were on the order of 30 feet. Mundorff's text suggests that the water producing zones in the granite typically exist within the partially weathered rock, between the overburden soil and deeper competent rock, and that deeper wells typically produce yields similar to those of shallow wells in this area because the fractures are relatively tight and widely spaced within the competent rock. This information appears to be confirmed by the results of the neighborhood water well survey.

FLOW PATTERNS

Groundwater in the vicinity of the landfill appears to exist within a relatively restricted zone of saturation contained within the fractured partially weathered rock and permeable overburden soils. The groundwater tends to migrate within this zone from the hilltop recharge zones toward the stream valleys where phreatic discharge occurs. The migration pattern appears to roughly conform to the topography of the land, as does the upper rock surface.

The rock in the area consists of a granite which typically exhibits relatively tight, widely spaced fractures and joints. Available water well data suggests that the zone of partially weathered rock between the overburden soil and the underlying competent rock is the chief aquifer in the area. This zone appears to exist at depths typically on the order of 30 to 50 feet beneath the ground surface at the surveyed well locations, and the deeper drilled wells which penetrate into the granite typically do not produce significantly higher yields then the wells which penetrate the partially weathered rock zone. Thus the deeper competent granite in the area does not appear to be a significant source of water except in isolated cases.

Based on the USGS topographic map, the area is well dissected by numerous streams, valleys and swales which provide outlets for phreatic discharge. Based on the geology of the area, it appears that groundwater flows will approximately conform to the topography of the area; that is, groundwater flow is expected to occur from the crest of the dividing ridges down-slope toward the nearest stream valley. The central ridge on the proposed landfill site divides surface drainage and presumably the groundwater toward the northwest and southeast directions. The maximum distance of horizontal groundwater travel appears to be approximately 1,000 feet based on the topographic map. Each of the surveyed well locations is either upgradient or across a stream from the perimeter of the site, separated by a distance of at least 2,000 feet.

WATER BUDGET

A water budget can be used to evaluate the potential infiltration at the proposed landfill site by making use of available climatic data and site specific parameters such as slope, area and vegetation. The infiltration is the difference between precipitation and losses due to runoff, storage, evaporation and transpiration. These parameters will vary from existing conditions and design parameters should be established during advanced phases of the design. Historically, Mundorff (3) reports that out of the 45.5 inches of annual precipitation in the area, approximately one-third is lost to runoff and another one-third is lost to evapotranspiration. Thus, the balance of approximately 15 inches of precipitation becomes available to recharge the groundwater annually. Given the relatively restricted occurrence of groundwater due to topographic and geologic conditions in the area, it appears likely that groundwater discharges to springs and streams should roughly equal the annual recharge.

5.0 GEOLOGIC AND HYDROGEOLOGIC INVESTIGATIONS

EXPLORATION TECHNIQUES

Subsurface conditions at the site were investigated with a total of 10 soil test borings located as shown on Figure 6. The borings were advanced to depths on the order of 50 feet below existing ground surfaces. Borings were performed with a CME 45 drill rig mounted on an all-terrain vehicle, utilizing 6 inch hollow stem augers to advance the borings, and standard penetration test techniques (ASTM D-1586) to sample and evaluate the density of the subsurface materials. Samples obtained from penetration testing were examined and classified under the direction of a registered geologist according to the Unified Soil Classification System guidelines. All phases of the field work, including soil test boring, monitoring well installation and field permeability testing, were performed under the field supervision of a qualified geotechnical engineer and the direction of a registered geologist. A summary of the test boring data is presented in Table 4.

GROUNDWATER MONITORING

Groundwater levels at the test borings were recorded at the time of boring completion and following a period of at least 24 hours after completion of the borings. Permanent monitoring wells were installed at six boring locations (B-1, B-3, B-5, B-7, B-8 and B-9) for long-term groundwater level observation and sampling. The monitoring wells were constructed and remaining boreholes were sealed and abandoned in accordance with North Carolina DEM guidelines. Groundwater levels at the monitoring well locations were recorded after a period of seven days following completion of the borings. A summary of the recorded groundwater elevation data is presented on Table 5. Based on this data, it appears that groundwater levels experienced a rise between time of boring (T.O.B.) readings and the 24 hour readings, then remained fairly stable within the following seven days.

IN-SITU PERMEABILITY TEST RESULTS

In-situ hydraulic conductivity (permeability) evaluations were performed at the six monitoring well locations using the Bouwer and Rice (6) procedures for analysis of rising head slug tests. The result of this analysis yields an approximate value of the bulk hydraulic conductivity coefficient, k. For selected cases the calculated values were compared to values of k calculated by both NAVFAC and Hvorslev's equations referenced in Cedergren (7). A summary of the calculated results using both methods is presented in Table 6. Based on this data, it appears that the permeability characteristics of the saturated zone can be represented by a k value on the order of 10^{-5} cm/sec. Supporting calculations are also presented in the Appendix to this report.

LAB TESTING

Laboratory grain size, natural moisture and Atterberg limits testing has been performed on selected samples recovered from standard penetration testing to verify visual soil classifications. All test were performed in accordance to applicable ASTM (American Society of Standards and Materials) standard procedures. In addition, laboratory standard Proctor tests (ASTM D-698) and flexible wall remolded permeability tests were performed on represented bulk samples of the on-site soils to evaluate the compaction and permeability characteristics of these soils for use as liner material. The results of laboratory testing are presented in Table 7 and accompanying compaction and grain size curves.

On-site soils generally consist of moderately plastic silty clays and sandy or clayey silts (CL and ML, respectively), plastic clays and silts (CH and MH) and occasional silty sands (SM). The laboratory noted a significant, though variable, amount of mica in the samples. Remolded permeability k values varied from 10^{-5} to 10^{-8} cm/sec for the clayey upper soils on the site.

6.0 GEOLOGIC AND HYDROGEOLOGIC SITE CHARACTERISTICS

SITE GEOLOGY

Generalized subsurface profiles prepared from the test boring data are presented on Figures 7, 8 and 9 to graphically illustrate geologic conditions at the site. More detailed descriptions of the conditions at the individual test boring locations are presented on the test boring records.

The typical subsurface soil profile within the higher elevations of the central and northern portions of the site consists of a relatively thin veneer of gravelly, clayey cultivated topsoil underlain by a friable clayey subsoil horizon. Within wooded portions of the property, the soils are root penetrated an average depth of 6 to 8 inches. The subsoil consists of a generally moist, firm to stiff, tan and orange-brown, moderately plastic fine sandy silty clay (CL and CL-ML) exhibiting standard penetration test (SPT) values generally on the order of 8 to 15 blows per foot (bpf). These soils extend to depths of 5 to 7 feet beneath existing ground surfaces and are underlain by firm to stiff reddish orange, tan and red-brown silty clays and clayey silts (CL and ML), which vary in moisture content and appear to be generally less plastic than the upper soils. These soils often exhibit a distinct mottling of iron pigments, which is indicative of the percolation of water, likely due to seasonal groundwater fluctuation in the past.

The soils in this horizon generally appear to be highly weathered in-situ from the granitic rock formation, as evidenced by a rather non-distinct rock-like texture and healed joints observed in some of the samples recovered at B-2 through B-6 and, B-9 and B-10. However, some of these soils are probably derived from the Tertiary sediments, particularly near the ground surface. Standard penetration resistance values vary from 4 to 12 within the deeply weathered soils and tend to increase with depth. The percentage of clay in the samples also increases with depth. Penetration test values exceed 30 bpf below depths from 35 to 40 feet at B-5, B-6 and B-10. No rock or partially weathered rock (PWR) was encountered within these borings, except at a depth of approximately 40 feet at B-10. The PWR at B-10 extended to a depth of approximately 50 feet. Groundwater levels within the higher portions of the site are generally on the order of 20 to 30 feet beneath existing ground surfaces, except at B-3 where groundwater was observed at a depth of approximately 14 feet. Boring B-4 located at the crest of the central ridge was dry, but the boring had caved at a depth of approximately 14 feet after a period of 24 hours.

Subsurface conditions within the lower elevations of the site along the southern and western fringes somewhat contrast those encountered within the higher elevations. Overall, soils within these areas, characterized by B-1, B-7 and B-8, consist of very moist to saturated tan clayey micaceous silts and silty sands which closely resemble the texture of the granite rock formation observed at the nearby outcrops. These soils are generally denser and grade to partially weathered rock (100+ bpf material) in B-7 and B-8 at depths of approximately 36 and 16 feet respectively. Hard rock (rotary tricone refusal) was encountered at B-8 at a depth of approximately 27 feet. Boring B-8 was located in close proximity to the outcrops shown in Photographs 5 and 6 in the Appendices. Groundwater levels within the lower portions of the site appear to be on the order of 3 to 4 feet, except at B-8, where groundwater was recorded at approximately 15 feet.

SITE HYDROGEOLOGY

A generalized groundwater potentiometric surface map (10 foot contour intervals) has been prepared from the groundwater level measurements made during the investigation and is presented on Figure 10. The groundwater contours shown on Figure 10 and the subsurface profiles Figures 7, 8 and 9 illustrate that groundwater levels are relatively deep within the presumed recharge area in the higher elevations of the site. The groundwater appears to migrate downslope within the deeper, generally denser and more clayey soils and discharges along the stream bed along the southern boundary of the site. Borings did not penetrate deep enough to determine the lower limit of the saturated zone, but based on published regional hydrogeologic studies, the more competent granite appears to serve as a partial confining layer toward downward migration into the formation. Thus, it appears unlikely that groundwater of the proposed landfill site migrates beyond the stream. No groundwater was encountered within 50 feet beneath the ground surface at the crest of the ridge, which appears to divide groundwater flow between the northern and southern portions of the site.

5-23-91

$K = 1 \times 10^{-5}$ cm/sec

$= 1 \times 10^{-5}$ cm/sec $\times 3.28 \times 10^{-2}$ ft/cm

$= 3.28 \times 10^{-7}$ ft/sec $\times$ 60 sec/min

$= 1.97 \times 10^{-5}$ ft/min $\times$ 60 min/hr

$= 1.18 \times 10^{-3}$ ft/hr $\times$ 24 hr/day

$= 2.83 \times 10^{-2}$ ft/day

$K = 1 \times 10^{-5}$ cm/sec

$= 1 \times 10^{-5} \times 2.83 \times 10^{3}$

$= 2.83 \times 10^{-2}$ ft/day

$V = Ki/n$

$$V = \frac{2.83 \times 10^{-2} \text{ ft/day} \times 0.015 \text{ ft/ft}}{.30}$$

$V = 4.25 \times 10^{-4} / 0.30$

$V = 1.42 \times 10^{-3}$ ft/day $= .5$ ft/yr

Reference Table 6

Avg $K = 3.6 \times 10^{-5}$ cm/sec

$K \simeq 1.02 \times 10^{-1}$ ft/day

$V = 1.02 \times 10^{-1} \times 0.015$ ft/ft $\div 0.30$

$= 1.53 \times 10^{-3} / 0.30$

$= 5.1 \times 10^{-3}$ ft/day

$= 1.9$ ft/yr

if $V = 4 \times 10^{-3}$ ft/day

$V = 1.46$ ft/yr

6-8 Blasting / Ripping
— 5 ft. separation
8-1 Ass. material impervious
8-3 } Buffers (50')
9-1 }
9-2 Well Locations, No, depth
Well Design (fig 13)
Piezometer Depths
NNE Corner GW.
Rock - B-8
Monitoring Plan
- long term seasonal high Water Table
depth to rock

3×10^{-7} cm/sec

9-3 & 4 Final Cover?

$\times$ .0328 ft/cm

9×10^{-7} ft/sec

$\times$ 60 sec/min $\times$ 60 min/hr $\times$ 24 hrs/day

7.8×10^{-4}

6-5 ?

$\frac{10^{-5} \text{ cm/sec} (1.5 \times 10^{-2})}{.3}$

$\frac{(2.83 \times 10^{-2})(1.5 \times 10^{-2})}{.3}$

$2.83 \times 10^{-2} (5 \times 10^{-2})$

14.15×10^{-4}

1.415×10^{-3} ft/day

10^{-5} cm/sec

.5 ft/yr ?

10^{-5} /sec (0.0328 ft/cm)

$10^{-5} (3.28 \times 10^{-2})$ ft/sec

3.28×10^{-7} ft/sec $\times$ 60 sec/min $\times$ 60 min/hr $\times$ 24 hr/day

(3.28×10^{-7}) 86,400

$(3.28 \times 10^{-7}) (8.64 \times 10^{4})$

28.3×10^{-3}

2.83×10^{-2}

Based on the groundwater contour map (Figure 10), an average horizontal flow gradient of 0.015 feet/feet has been estimated perpendicular to the generalized flow direction. An approximate horizontal seepage velocity has been calculated, using a saturated k value of 10^{-5} cm/sec and an assumed effective porosity (n) of 30 percent, by the following equation referenced in Cedergren (7):

$$v = Ki/n,$$

where v is expressed in feet per day. The average calculated seepage velocity is 4×10^{-3} feet per day, or 1.4 feet per year. This information is representative of existing field conditions and is subject to modification due to variations in head and surface runoff due to the proposed landfill construction.

GEOTECHNICAL PROPERTIES

Based on visual observation of recovered soil samples and laboratory testing, the majority of the on-site soils likely to be involved with the proposed construction are generally clayey, somewhat micaceous silts, which appear to be slightly wet of optimum compaction moisture. Unified soil classifications of the soils are generally CL and ML, with some CH or MH classifications present in the more clayey or micaceous samples. The soils are highly variable in composition due to variable lithology in the parent rock from which the soils were derived and, thus, difficult to stratify precisely.

Based on standard proctor testing, optimum compaction moisture varies from 12.7 to 21.0 percent by weight, whereas, natural (in-situ) moisture levels tend to vary between 19 to 35 percent. As such, the soils will likely require drying prior to placement and compaction as fill, thus aeration and/or stockpiling may be required to condition the soils to prevent sticking to metal tools and to enhance compaction. However, a majority of the soils in the higher elevations exhibit rather high sand and silt contents (on the order of 25 to 50 percent), and these soils should respond favorably to common drying techniques (such as aeration), particularly during the warmer months of the year. The soils once properly dried should compact adequately with commonly available landfill compaction equipment.

The remolded permeability characteristics of the upper soil horizons has been discussed briefly in Section 5.0. Based on the permeability coefficients shown in Table 7 for the remolded soils, it appears that suitable on-site soils for liner construction (having k value of at least 10^{-6} cm/sec) are available within portions of the site. The tests were run at 98 percent standard Proctor maximum dry density with moisture 2 percent wet of optimum. The on-site soils should be capable of being compacted to these levels in the field, provided compaction moisture is adequately controlled. The actual quantity of available liner soils and their compaction criteria will be determined during the advanced design stage.

Based on the soil classifications and standard penetration resistance values, it appears that a majority of the on-site soils can be excavated using conventional excavation techniques such as scraper pans and loaders. However, residual soils elsewhere in similar geologic formations (granite) have been found to transition abruptly to partially weathered rock and/or hard rock within relatively small vertical or horizontal distances. In addition, isolated pockets of hard rock or nests of boulders may tend to occur, Blasting

Ripping

particularly within the lower elevations, which may require heavy ripping with a D-8 or equivalent dozer or light blasting to expedite the rate of excavation. One such "peak" of hard partially weathered rock and/or rock was encountered in the present landfill (see Photo 7), which was excavated around and left in place. This practice may not be desirable in the new landfill. As such, some difficult excavation may be required, particularly in the area of known outcrops near B-8. However, none of the borings within the higher elevations of the site encountered rock or partially weathered rock within the anticipated excavation depths, thus the likelihood of encountering rock above proposed bottom elevations is statistically insignificant within a majority of the site.

BOTTOM PROFILE AND SOIL BALANCE

During advanced design stages, landfill bottom profiles will be determined such as to maintain a minimum separation of 5 feet between the bottom of the waste and the seasonal high groundwater level and minimize the amount of rock excavation. Also, a balance of excavated soil and required cover soil will be maintained when performing advanced earthwork computations.

7.0 ENVIRONMENTAL INVESTIGATION

The proposed Ash-monofill is located in the northwest part of the Halifax County. Boundaries of the property are SR 1417 to the northwest and the Halifax County Municipal Solid Waste landfill to the west.

Working in accordance with North Carolina Solid Waste Management Rules Section .0503 of 10 North Carolina Administrative Code Subchapter 10G, the following siting and design requirements for the site were evaluated:

(a) the site location shall not restrict the flow of the 100 year flood, reduce the temporary water storage capacity of the floodplain, or restrict the flow of natural watercourses;

(b) the site location shall not threaten or contribute to the endangerment of any plant, fish, or wildlife species;

(c) archaeological or historical sites shall not be damaged or destroyed.

(d) the site location shall not adversely impact state parks, recreational or scenic areas, or lands included in the state nature or historic preserve; and

(e) surface waters shall not receive discharge from dredged or fill materials that are in violation of the requirements under Section 404 of the Clean Water Act, as amended.

FLOOD PLAIN RESTRICTIONS

According to currently published Flood Insurance Rate maps, areas of the 100 year flood, base flood elevations, and flood hazard factors have not been determined. The southernmost region of the property has an active spring-fed stream that also handles the run-off from the wooded areas. Generally, the floodplain occurs in this depression and flows away from all landfilling operations. The 100 year floodplain elevation will be determined such that all landfilling operations can be constructed and maintained above this elevation. The proposed landfill will not reduce storage capacity or restrict the watercourse flow.

ENDANGERED SPECIES

Federal and State agencies were contacted by ENSCI Corporation to review their records of threatened or endangered plant and wildlife in Halifax County. Several rare plant species, endangered species, and species under status review by the federal government, are known to exist in the upper coastal plains of Halifax County. The U. S. Department of Interior Fish and Wildlife service listed the red-cockaded woodpecker (Picoides borealis) as a federally-listed species which may occur in the area. Review of the proposed site by ENSCI did not reveal any nesting sites for this species. The NCNHP (North Carolina Natural Heritage Program) in their review of the proposed ash-monofill site, did not uncover any plant or wildlife that was threatened or endangered near Aurelian Springs. Correspondences are included in Appendix D.

WETLANDS

Areas currently classified as wetlands occur toward the southernmost portion of the proposed ash-monofill site along the spring-fed creek. Proposed waste disposal operations will not occur in this area of the site. As required, a 50 foot buffer zone will be established and maintained along the watercourse. Necessary sediment and erosion control measures will be established to ensure that no sediment loads are discharged to surface waters. Dredge and fill operations will not be performed in the region.

ENSCI Corporation contacted Eric Alsmeyer of the U. S. Army Corps of engineers for concurrence with the proposed landfilling operations. Wetland areas were determined and clearly identified. The wetland areas are protected by the required buffer zones for the proposed landfill and will not be impacted by the operation.

ARCHAEOLOGICAL

Archaeological and historical information of the area was provided to ENSCI Corporation by the North Carolina Department of Cultural Resources and by an archaeologic survey. A survey of the proposed landfill was conducted by Dave Van Horne of Archaeological Associates. Findings of this investigation revealed no archaeological or historical resources in the proposed area. Archaeological survey information is provided in Appendix D. The Department of Cultural Resources located two (2) sites with historical or architectural importance within the general area of the proposed landfill site. Both site locations are beyond the proposed landfill area. Landfill operations will not result in damage or destruction to these sites.

STATE PARKS, RECREATIONAL AREAS

Review of surrounding tracts of land revealed no recreational parks, scenic areas, or any lands included in the state nature or historic preserve within 5 miles of the project site. No adverse impact will occur to these areas.

SECTION 8.0 - CONCLUSIONS AND SITING REQUIREMENTS

The subject site is suitable for development of the proposed Ash-Monofill. The site is located east of the existing Halifax County landfill within a relatively isolated, sparsely populated portion of the county. The site is not visible from major highways, and both public and environmental impact is considered to be low. Existing residences and water supply wells are located generally in excess of 2,000 feet away from the disposal site boundaries, and there are no significant groundwater users within approximately 2 miles of the site. Due to topographic and geologic controls on groundwater occurrence and movement, it appears that groundwater flow activity is limited to relatively short distances contained entirely within the site and none of the known water supply wells exist down gradient of the site. Depths to groundwater are generally in excess of 20 feet on the areas of the site intended for development; as such, the planned excavations of 10 to 15 feet can be performed without penetrating the water table.

The proposed waste is an incinerated ash by-product of coal-fired energy production. The material is impervious ($k < 1x10^{-8}$ cm/sec) when compacted and does not decompose. As such, the proposed development does not pose a significant threat to groundwater supplies in the vicinity of the site. *

∴ Cap Design?

SITING REQUIREMENTS

The site of the proposed Halifax County Ash-Monofill has been studied and is considered to meet the following siting requirements of the North Carolina Solid Waste Management Rules, Section .0503 (1 and 2) of 10 NCAC 10G:

(1) The site is not located within a 100 year floodplain, nor will the flow of a 100 year flood be restricted (Section 7).

(2) Siting of the proposed Ash-Monofill does not threaten any known habitats of endangered species of plants, fish and/or wildlife (Section 7).

(3) The site does not contain any archaeological or historical sites, nor are any state parks, recreation or designated scenic areas located within the immediate vicinity of the site (Figure 1).

(4) The site is not located within 5,000 feet of an airport or within 10,000 feet of a turbo-jet runway (Figure 1).

(5) On-site soils are suitabile and are present in sufficient quantities to meet cover requirements (Section 9).

(6) It is not anticipated that explosive gases will be generated due to decomposition of the wastes stored at the site (Section 9).

(7) The site will have controlled access at the main gate on S.R. 1417 to limit unauthorized public access (Section 9).

(8) The site will be designed and operated in accordance with Sections 402 and 404 of the Clean Water Act, and the design and operation will not violate assigned stream standards due to non-point source pollutants (Section 9).

(9) The site will be designed in accordance with groundwater standards established under 15 NCAC 2L. A minimum vertical separation of 5 feet (ENSCI criteria) between the waste and the seasonal high water table will be maintained (Section 9).

(10) The operation at the site will not engage in open burning of wastes.

(11) Minimum buffers of 50 feet will be maintained between waste disposal areas and property boundaries and between waste

disposal areas and streams. No private wells and/or private dwellings are located within 500 of the site boundaries (Section 9).

(12) Sedimentation and erosion control features will be designed in accordance with 15 NCAC 4 (Section 9).

9.0 CONCEPTUAL DESIGN

The project site is adjacent to the existing Halifax County MSW Landfill. The County will operate a redesigned, lined MSW landfill on its existing permitted property and will develop a lined Ash-Monofill on the new tract of land. This new tract will not be permitted to accept MSW waste.

The new tract of land contains a total of 88 acres. Approximately 40 acres of this will be used for the Ash-Monofill. The remaining 40 to 50 acres will be absorbed by buffers, composting, or not used at all. Buffers for the ash will be set at 100 feet from property lines, 300 feet from the roadway, and 50 feet from creeks or streams. Preliminary designs for the Ash-monofill indicate that the available air-space within the new tract exceeds the storage requirements of the proposed power plant. For this reason, the larger roadway buffer is acceptable.

The cells will be excavated to accomplish three (3) tasks; first, a minimum groundwater separation of five (5) feet (ENSCI criteria) will be met or exceeded in all places; second, rock will be avoided as much as is practical; and third, the soils excavated will slightly exceed the amount required for construction and final cover. Excessive excavation will not be required to achieve required air-space. Proposed cell bottom elevations are shown on Figure 12.

Monitoring?

The Ash-monofill will be built in segments or cells. These cell are lined with a composite liner formed of a 60 mil HDPE synthetic liner overlying 18-inches of compacted low permeability soils. Each cell will be approximately 5 acres in plan area and provide for 4 to 5 years disposal capacity. These cells allow the facility to be constructed in easily managed segments as airspace is required. Each cell is further subdivided into smaller subcells. These smaller subcells allow stormwater/ash runoff separation within the cell. The stormwater is discharged to a sedimentation pond and then to the stream. The ash runoff is discharged to a separate ash sedimentation pond. The ash sediments removed from this pond are placed within the Ash-Monofill. A revised sedimentation and run-off control plan will be submitted to the State prior to construction of each cell.

Ash cells on the new tract will be filled from north to south. The basic concept is to begin ash placement at the high elevations, with subsequent cells added down gradient. The first 'flow' line of cells will be placed on the eastern portion of the new tract, with cell additions moving west. This strategy allows for the potential use of portions of the new tract for MSW disposal if the need for ash disposal decreases. However, the new site is not being permitted for this at present. The ash is placed within the cells such that a single common cover will be placed over the system of cells. Elevation contours of the proposed ash cover are shown on Figure 11. The top contours are set to obtain the minimum require ash disposal air-space.

Operations on the ash monofill will be similar to the MSW operations. Trucks will back onto the active face and dump. A dozer of loader will then spread each load onto the active area. Due to the nature of the ash, very little compaction will be required. Utilizing the dozer to "track in" each load of ash should be sufficient for compaction. Daily covers will not be used because the ash is very similar to fine silty soils. A water truck will be used to minimize dust during dry periods of the year. For this same reason, nuisance control will be simplified: no birds, vectors or odors will be associated with the monofill.

Upon completion of an ash cell, the cell will be covered with approximately 12 inches of intermediate cover consisting of stockpiled on site soils. Upon completion of sufficient cells to bring the ash to the final cover elevation, the final cover will be applied. This consists of a additional agricultural cover and seeding of the cover. The ash will produce no gases so the final cover system will not contain a gas collection/control system. Additionally, the exceptional low permeability of the ash will eliminate the need for a distinct moisture barrier within the final cap. ?

ash less permeable than soils

final cap design?

LIST OF REFERENCES

1. Geologic map of North Carolina, N. C. Geologic Survey, Raleigh, N. C., 1985.

2. Soils Map of Halifax County, U.S. Soil Conservation Service, unpublished.

3. Mundorff, M. J., Groundwater in the Halifax Area, North Carolina, N. C. Department of Conservation and Development, 1946, out-of-print.

4. Phillips, R. Douglas, Agent, N. C. State University Agricultural Extension Service, Rainfall and Temperature Records on File, 1981-1990, Halifax, N.C., personal communication.

5. N. C. Department of Environment, Health and Natural Resources, Division of Environmental Management, Groundwater Section, Raleigh, N.C., open file water well records.

6. Bouwer, H., The Bouwer and Rice Slug Test - An Update, Groundwater, May-June, 1989, pp 304-309.

7. Cedergren, H.R., Seepage, Drainage and Flow Nets, 2nd Ed, 1967, pp. 66-85.

Tables

TABLE 1

SUMMARY OF HISTORICAL CLIMATIC DATA
(AFTER MUNDORFF)

MEAN MONTHLY AND ANNUAL PRECIPITATION, IN INCHES, AT U. S. WEATHER BUREAU STATIONS WITHIN THE AREA, FOR THE PERIOD OF RECORD TO 1943

STATION	Elevation (feet above sea level)	Year station was established	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Nashville	190	1895	3.26	4.08	3.72	3.66	3.79	4.89	6.08	4.88	4.05	3.10	2.34	3.60	47.45
Rocky Mount 1	105	1905	3.40	4.00	3.40	3.40	3.90	4.41	5.40	5.00	3.60	3.20	2.20	3.60	45.50
Rocky Mount No. 2	105	1915	3.40	3.80	3.60	3.60	4.00	4.20	5.60	4.40	3.60	3.20	2.30	3.70	45.40
Scotland Neck	80	1905	3.20	3.80	3.60	3.40	3.60	4.60	5.50	4.40	3.40	2.80	2.20	3.60	44.10
Weldon	81	1872	3.10	3.39	3.85	3.26	3.72	4.60	5.43	4.75	3.37	2.74	2.28	3.50	43.99
Enfield	99	1910	3.20	3.60	3.80	3.60	3.60	4.60	5.20	4.80	3.80	2.70	2.10	3.70	44.70
Tarboro	50	1817	3.44	4.12	3.79	3.46	3.74	4.60	5.87	5.39	3.59	2.89	2.33	3.79	47.01
Average			3.29	3.83	3.68	3.48	3.76	4.56	5.58	4.80	3.63	2.95	2.25	3.64	45.45

MONTHLY RAINFALL
HALIFAX, NC

YEAR / MONTH	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
JAN	0.69	4.79	2.58	4.21	4.48	2.45	7.70	3.56	2.55	3.11
FEB	3.33	5.75	5.67	5.79	4.71	1.99	5.25	4.15	6.11	4.25
MAR	2.16	3.88	4.91	4.64	1.85	2.26	5.00	2.31	8.84	4.57
APR	1.69	2.44	4.97	5.88	0.52	1.67	7.72	4.60	6.51	3.62
MAY	4.75	5.26	3.60	7.72	4.39	1.87	2.16	4.68	3.71	6.57
JUN	3.58	3.68	2.75	2.25	3.07	2.48	3.48	7.33	9.72	0.85
JUL	2.21	4.76	0.99	7.50	6.71	5.97	3.63	3.40	2.77	1.96
AUG	7.24	3.05	0.80	3.71	4.84	12.43	4.25	2.83	6.89	7.10
SEP	1.46	3.57	3.23	3.41	5.07	0.65	6.67	2.17	3.52	0.20
OCT	3.38	3.44	3.22	0.58	3.85	3.50	1.48	4.21	4.46	3.83
NOV	0.67	2.50	3.66	1.83	11.09	2.01	3.17	4.13	4.65	2.12
DEC	4.72	4.36	7.13	2.34	0.57	3.50	3.56	0.78	4.18	2.81
TOTAL	35.88	47.48	43.51	49.86	51.15	40.78	54.07	44.15	63.91	40.99

LONGITUDE 77'36"
LATITUDE 36'20"
ELEVATION 133'

Data Compiled by NCSU Agricultural Extension Service, Halifax, N.C.

TABLE 1 (Continued)

AVERAGE HIGH TEMPERATURES
HALIFAX, NC

YEAR MONTH	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
JAN	46	41	45	43	44	48	47	43	55	60
FEB	58	53	49	60	52	51	51	52	52	62
MAR	62	62	62	61	68	64	61	63	60	67
APR	79	69	66	69	79	74	68	69	70	73
MAY	83	82	77	80	83	82	82	80	78	79
JUN	96	82	85	90	88	91	89	85	88	90
JUL	96	88	93	86	89	94	95	92	90	94
AUG	85	85	94	89	88	86	91	91	86	89
SEP	79	81	85	81	85	83	84	81	83	84
OCT	68	70	71	79	76	76	69	68	74	78
NOV	59	63	63	62	70	62	66	65	63	68
DEC	46	56	48	62	51	53	54	53	42	58
YR. AV	71	69	70	72	73	72	71	70	70	75

LONGITUDE 77'36"
LATITUDE 36'20"
ELEVATION 133'

AVERAGE LOW TEMPERATURES
HALIFAX, NC

YEAR MONTH	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
JAN	22	21	27	23	23	27	28	24	34	35
FEB	30	32	28	36	31	34	27	31	32	38
MAR	31	36	38	35	39	37	36	37	39	43
APR	48	41	41	46	49	46	45	45	46	47
MAY	52	55	51	56	58	57	58	54	54	57
JUN	68	62	60	66	65	66	67	61	68	64
JUL	69	70	66	69	70	71	71	69	71	70
AUG	64	64	66	68	67	67	70	71	69	68
SEP	54	56	58	58	60	62	64	61	64	59
OCT	42	45	49	58	55	53	40	42	50	50
NOV	35	39	36	35	50	45	41	39	41	37
DEC	27	35	27	40	28	32	34	29	24	36
YR. AV	45	46	46	49	50	50	48	47	49	50

LONGITUDE 77'36"
LATITUDE 36'20"
ELEVATION 133'

Data Compiled by NCSU Agricultural Extension Service, Halifax, N.C.

TABLE 2

SUMMARY OF DEM LOCAL WELL RECORDS

PERMIT NO.	DATE DRILLED	STATIC H_2O	YIELD GPM	WATER ZONES	TOTAL DEPTH
NA - (SEE NW-1)	1971	25′	60	110,115 130,140′	150′
1726	1981	16′	NA	NA	32′
1694	1980	12′	2	NA	34′
1675	1981	20′	NA	NA	58.5′
1611	1977	15	3	NA	50′
1501	1977	15	3	NA	34′
1462	1977	15	3	NA	39′
1880	1985	NA	5	NA	405′
1883	1985	NA	8	NA	41′

NA = NOT RECORDED ON WELL COMPLETION RECORD

TABLE 3

SUMMARY OF NEIGHBORHOOD WATER WELL SURVEY*

MARCH 11, 1991

STOP NO.	HOUSEHOLD NAME	EST'D AGE	CASING DIAMETER	TYPE PUMP	WATER DEPTH	TOTAL DEPTH	PERMIT NO.
1	ALSTON	>7 YRS	24"	SET	UNK	±125	UNK
2	JONES	±2 YRS	24"	SET	±15'	UNK	UNK
3	HAWKINS	UNK	24"	SET	UNK	UNK	UNK
4	UNK	UNK	24"	SET	±10'	UNK	UNK
5	UNK	UNK	24"	SET	±10'	UNK	UNK
6	DAVIS	<1 YR	24"	SET	±10'	UNK	UNK
7	BUTTS	1981	24"	SET	±10'	97'(TAG)	UNK
8	WARREN	>30 YRS	24"	SET	±12'	±30'	UNK
9	JOHNSTON	1985(?)	24"	SET	UNK	41'(?)	1883(?)
10	UNK	UNK	UNK	UNK	UNK	UNK	UNK
11	WARREN	1985(?)	6"	SUBM.	UNK	405(?)	1880(?)
12	UNK	<1 YR	24"	SET	UNK	UNK	UNK
13	HALIFAX LANDFILL	1981	18"	SUBM.	UNK	UNK	UNK
14	ABANDONED STRUCTURE						
15	ABANDONED FOUNDATION						

* BASED ON PERSONAL INTERVIEWS W/OCCUPANTS AND LIMITED VISUAL INSPECTION

TABLE 4

SUMMARY OF TEST BORING DATA

Boring	Ground Elev.	Boring Depth	Depth to 30+bpf[1]	Depth to PWR[2]	Depth to Rock[3]	Depth to G.W.[4]
B-1	291.73	50.0	24	NA	NA	4.1
B-2	326.23	50.0	NA	NA	NA	24.7 → CI 34'
B-3	318.20	50.0	NA	NA	NA	14.8
B-4	330.63	50.0	NA	NA	NA	Caved @ 13'
B-5	310.61	50.0	47	NA	NA	21.4
B-6	296.80	50.0	39	NA	NA	22.5
B-7	271.61	49.0	11.4	36.7	NA	2.8
B-8	273.94	27.1	2.8	16.7	27.1	15.9
B-9	314.59	50.0	NA	NA	NA	30.3
B-10	295.50	50.0	34.4	39.5	NA	Caved @ 16'

(1) 30+ bpf material, characterizes hard residual (saprolitic) soil.

(2) PWR, Partially Weathered Rock, defined as 100+ bpf material which can be penetrated by soil auger.

(3) Hard Rock, defined as material which cannot be penetrated by soil auger or rotary tricone.

(4) G. W., stabilized groundwater 24+ hours after completion.

Corrected Table (5-2-91)

TABLE 5

SUMMARY OF GROUNDWATER LEVEL DATA

BORING	GROUND ELEV.	T.O.B. DATE	G.W.@ T.O.B.	G.W.AFTER 24 HR	G.W. ON 3-14-91
B-1	291.73	2-21-91	273.4 18.3	287.6 * 4.1	287.3 4.4
B-2	326.23	2-15-91	295.8 30.4	Caved 292.2 34	NA
B-3	318.20	2-20-91	289.0 29.2	303.4 14.8	303.3 14.9
B-4	330.63	2-15-91	DRY	Caved 317.6 13.0	NA
B-5	310.61	2-25-91	287.6 23.0	289.2 21.4	288.7 21.9
B-6	296.80	2-18-91	272.5 24.3	Caved 274.3 22.5	NA
B-7	271.61	2-27-91	266.2 5.4	268.8 2.8	268.0 3.6
B-8	273.94	2-28-91	259.9 14.0	258.0 15.9	256.9 17.0
B-9	314.59	2-13-91	279.4 35.2	284.3 30.3	283.1 31.5
B-10	295.50	2-18-91	266.4 29.1	Caved 279.5 16.0	NA

* Ground water after a minimum 24 hour period was 287.6, and at a 12 hour reading it was 283.9

ALL ELEVATIONS ARE MEAN SEA LEVEL

original Submittal

TABLE 5

SUMMARY OF GROUNDWATER LEVEL DATA

BORING	GROUND ELEV.	T.O.B. DATE	G.W.@ T.O.B.	G.W. AFTER 24 HR	G.W. ON 3-14-91
B-1	291.73	2-21-91	273.4 18.3	287.6 4.1	287.3 4.4
B-2	326.23	2-15-91	295.8 30.4	301.5 24.7	NA
B-3	318.20	2-20-91	289.0 29.2	303.4 14.8	303.3 14.9
B-4	330.63	2-15-91	DRY	Caved 317.6 13.0	NA
B-5	310.61	2-25-91	287.6 23.0	289.2 21.4	288.7 21.9
B-6	296.80	2-18-91	272.5 24.3	Caved 274.3 22.5	NA
B-7	271.61	2-27-91	264.1 7.5	268.8 2.8	268.0 3.6
B-8	273.94	2-28-91	259.9 14.0	258.0 15.9	256.9 17.0
B-9	314.59	2-13-91	279.4 35.2	284.3 30.3	283.1 31.5
B-10	295.50	2-18-91	266.4 29.1	Caved 279.5 16.0	NA

ALL ELEVATIONS ARE MEAN SEA LEVEL

TABLE 6

SUMMARY OF FIELD PERMEABILITY TESTS (SLUG TESTS)

BORING	BOUWER-RICE (PARTIAL DEPTH)	BOUWER-RICE (FULL DEPTH)	NAVFAC	HVORSLEV TIME-LAG
B-1	1.0×10^{-4}	---	4.64×10^{-5}	3.64×10^{-5}
B-3	8.72×10^{-6}	---	---	---
B-5	4.81×10^{-5}	---	---	---
B-7	2.85×10^{-5}	---	---	---
B-8	1.89×10^{-5}	2.29×10^{-5}	4.64×10^{-5}	8.40×10^{-6}
B-9	1.00×10^{-5}	---	---	---
	3.6×10^{-5}			

ALL VALUES IN CM/SEC

<u>NOTE</u>: SEE LIST OF EQUATIONS AND FIGURES AND ACOMPANYING DATA AND CALUCULATIONS IN APPENDIX B.

screen intervals

soil types

TABLE 7

SUMMARY OF LABORATORY TESTS

BORING NUMBER	SAMPLE	DEPTH	NATURAL MOIST CONT		ATTERBURG LIMITS LL	PL	PI	AMOUNT OF SOIL (%) COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	USCS CLASS
B-1	BULK-A	0-3.5	19.1	A-4	37	29	8	0	6.9	46	15.1	32	SM-ML
B-1	BULK-B	0-3.5	24.3	A-5	50	47	3	---	---	---	---	---	ML-MH
B-1	S-2	3.5-5	32.8	A-7	50	27	23	0	7.7	17	35.4	39.9	CL-CH
B-1	S-5	18.5-20	28										
B-1	S-7	28.5-30	20.3										
B-1	S-9	38.5-40	9.5										
B-2	S-2	3.5-5	23	A-7	61	25	36	0	2.2	39.4	14.3	44.1	CH
B-2	S-5	18.5-20	26.6										
B-2	S-7	28.5-30	39.2										
B-2	S-9	38.5-40	34.1										
B-3	S-2	3.5-5	26.6	A-5	47	37	10	0	2.2	30	48.8	19	ML
B-3	S-5	18.5-20	44.3	A-5	54	45	9	0	7.1	29.3	50.6	13	MH
B-3	S-7	28.5-30	34.7										
B-3	S-9	38.5-40	38.9										
B-4	S-2	3.5-5	19										
B-4	S-5	18.5-20	25.6										
B-4	S-7	28.5-30	68.6	A-7	99	68	31	0	0	4.3	67.7	28	MH
B-4	S-8	33.5-35	35.9										
B-5	S-2	3.5-5	34.6	A-7	69	44	25	0	1.1	24.1	40.8	34	MH
B-5	S-5	18.5-20	34.2		NP	NP	NP	0	19.1	31.7	42.2	7	SM-ML
B-5	S-7	28.5-30	22										
B-5	S-9	38.5-40	36.6										
B-6	S-2	3.5-5	37.6										
B-6	S-4	13.5-15	31.9		NP	NP	NP	0	3.1	44.1	44.8	8	ML-SM
B-6	S-6	23.5-25	29										
B-6	S-9	38.5-40	35.6										
B-7	S-11	48.5-50	12										
B-7	S-2	3.5-5	23.7										
B-7	S-5	18.5-20	26.5										
B-7	S-9	38.5-40	15.5										

TABLE 7 (Continued)

SUMMARY OF LABORATORY TESTS

BORING NUMBER	SAMPLE	DEPTH	NATURAL MOIST CONT		ATTERBURG LIMITS LL	PL	PI	AMOUNT OF SOIL (%) COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	USCS CLASS
B-8	BULK-A	0-5	9.8		NP	NP	NP	20.4	23.3	21.8	22.3	*	SM
B-8	BULK-B	5-10.0	16.1	A-6	33	21	12	---	---	---	---	---	ML
B-8	S-2	3.5-5	26.1										
B-8	S-5	18.5-20	11.4										
B-8	S-6	23.5-25	43.8										
B-9	BULK	0-10	---	A-7	44	30	14	0.6	14.8	28.1	56.5	*	ML
B-9	BULK	10-20	20	A-7	44	28	16	2	14.4	30.1	22.5	31	ML
B-9	S-2	3.5-5	20.2										
B-9	S-5	18.5-20	23										
B-9	S-7	28.5-30	59.8	A-7	89	60	29	0	0.3	6.5	70.2	23	MH
B-9	S-9	38.5-40	24										
B-10	S-10	43.5-45	18.2										
B-10	S-2	3.5-5	15.7										
B-10	S-5	18.5-20	29.2										
B-10	S-8	33.5-35	21.6										

* Total percentage of soil passing the #200 sieve.

TABLE 8

SUMMARY OF PERMEABILITY TEST RESULTS

Remolded

	SAMPLE NO.	DEPTH (FEET)	SPECIFIC GRAVITY	ASTM D 698 PROCTOR DATA: MAX. DRY DENSITY (pcf)	ASTM D 698 PROCTOR DATA: OPT. MOISTURE CONTENT (%)	ACTUAL SPECIMEN COMPACTION DATA: DRY DENSITY (pcf)	ACTUAL SPECIMEN COMPACTION DATA: MOISTURE CONTENT (%)	PERCENT COMPACTION	PERCENT MOISTURE CONTENT ABOVE OPTIMUM	HYDRAULIC CONDUCTIVITY k (cm/sec)	USCS CLASSIFICATION
A-7	B-1	3.5 - 5.0	2.65	102.4	21.0	100.7	23.0	98	2	2×10^{-8}	CL-CH
A-4	B-1	0 - 3.5	2.69	107.4	18.2	102.7	18.6	96	0.1	3.1×10^{-6}	SM-ML
A-6	B-8	5 - 10	2.65	117.0	12.7	111.1	12.8	95	0.1	1.7×10^{-5}	SM
A-7	B-9	0 - 10	2.71	106.4	18.8	105.5	19.2	99	0.4	1.6×10^{-7}	ML

?

TABLE 9

Proposed Monitoring Well Elevations

		Monitoring Well No.	Gd. Elev.	Proposed Screen Elevation Top	H_2O Elev.	Bottom (10 ft. X)	
Silt	B-3	PMW - 1	318.20	305	303.4	295	Downgradient
Silt	B-2	PMW - 2	326.23	305	301.5	295	Upgradient
Clay X	B-1	PMW - 3	291.73	290	287.6	280	Downgradient
(PWR) Silt	B-8	PMW - 4	273.94	265	258.0	255	Downgradient
Silt / Sand	B-7	PMW - 5	271.61	275	268.8	265	Downgradient

B-7 PWR 39'
B-8 Rock 27'
B-10 PWR 39'

Proposed Mon. Wells
Screen intervals

TABLE 9

Proposed Monitoring Well Elevations

Monitoring Well No.	Proposed Screen Elevation (10 ft.) Top	Bottom	
PMW - 1	305	295	Downgradient
PMW - 2	305	295	Upgradient
PMW - 3	290	280	Downgradient
PMW - 4	265	255	Downgradient
PMW - 5	275	265	Downgradient

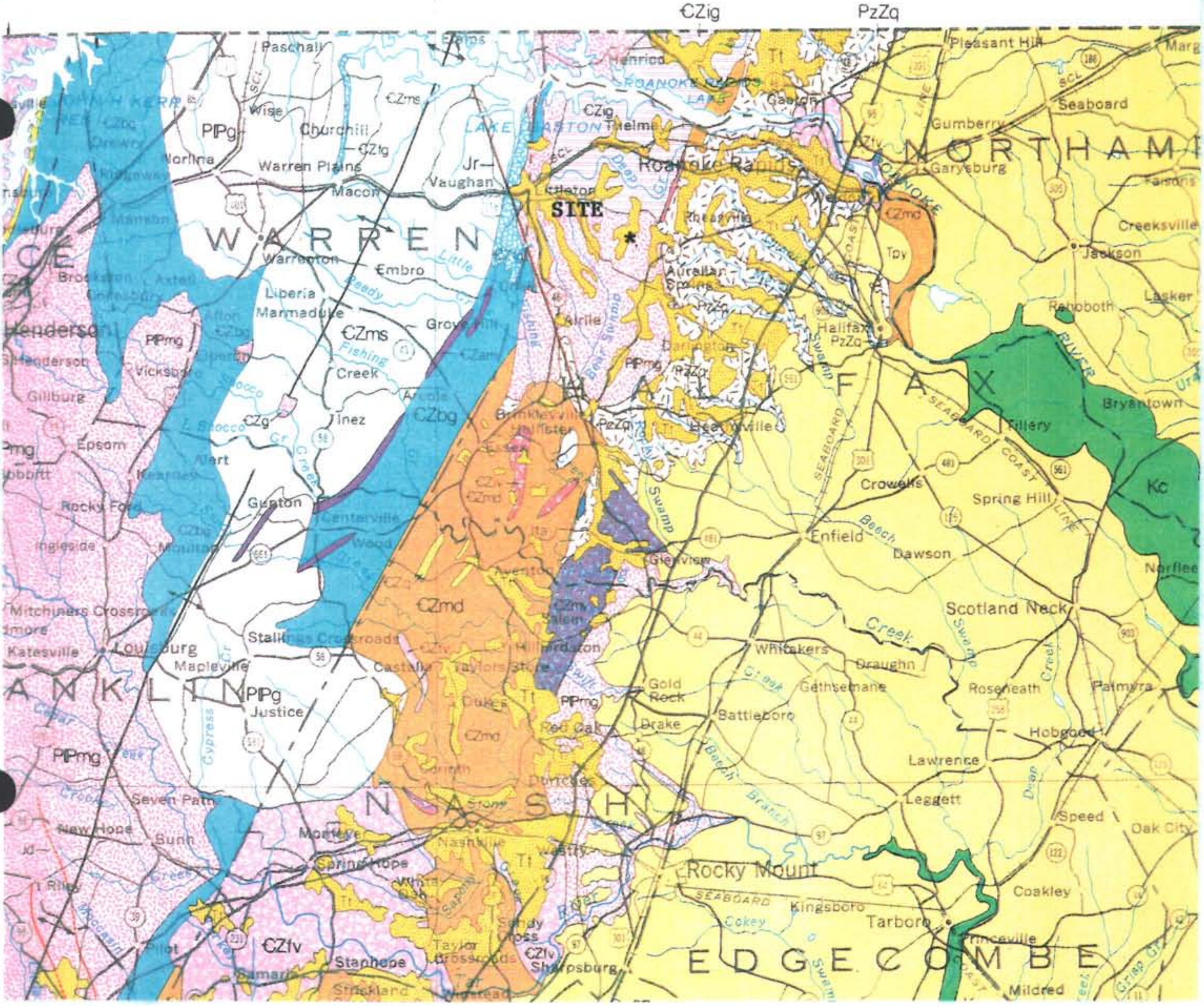
?

Figures

"Under Seperate Cover"

Figures 1, 2, 6, 10 and 11

"Under Seperate Cover"



Tt	TERRACE DEPOSITS AND UPLAND SEDIMENT — Gravel, clayey sand, and sand, minor iron-oxide cemented sandstone
PIPmg	FOLIATED TO MASSIVE GRANITIC ROCK (Pennsylvanian to Permian, 270-320 my, 8) — Megacrystic to equigranular Butterwood Creek intrusive and Rocky Mount intrusive suite
PzZq	METAMORPHOSED QUARTZ DIORITE — Foliated to massive

ENSCI
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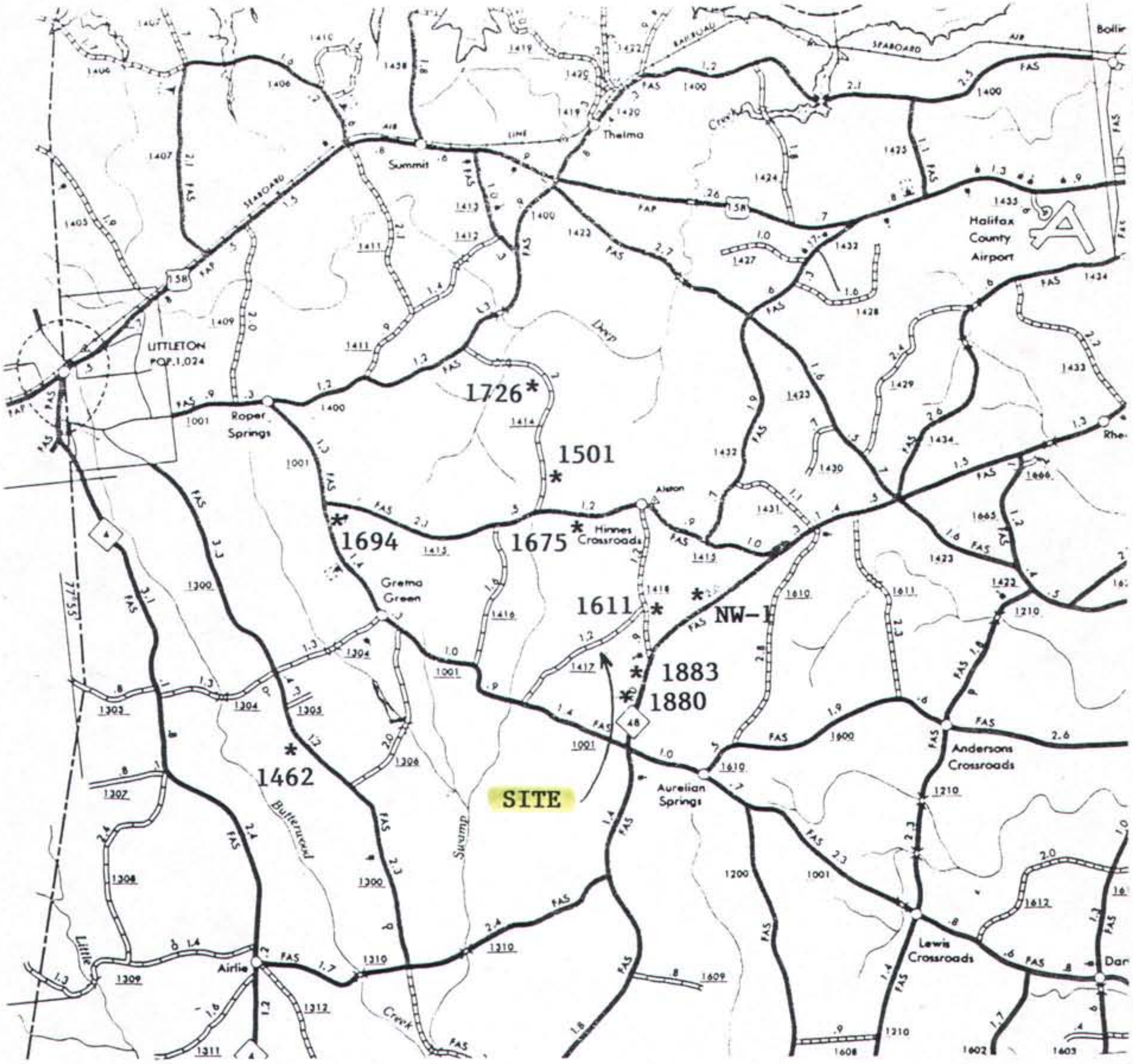
HALIFAX COUNTY ASH MONOFILL
N.C. GEOLOGICAL MAP EXCERPT
FIGURE 3

DRAWN BY: DJM	SCALE:	JOB NO.:
CHECKED BY: DG	DRWG NO.	REV.:



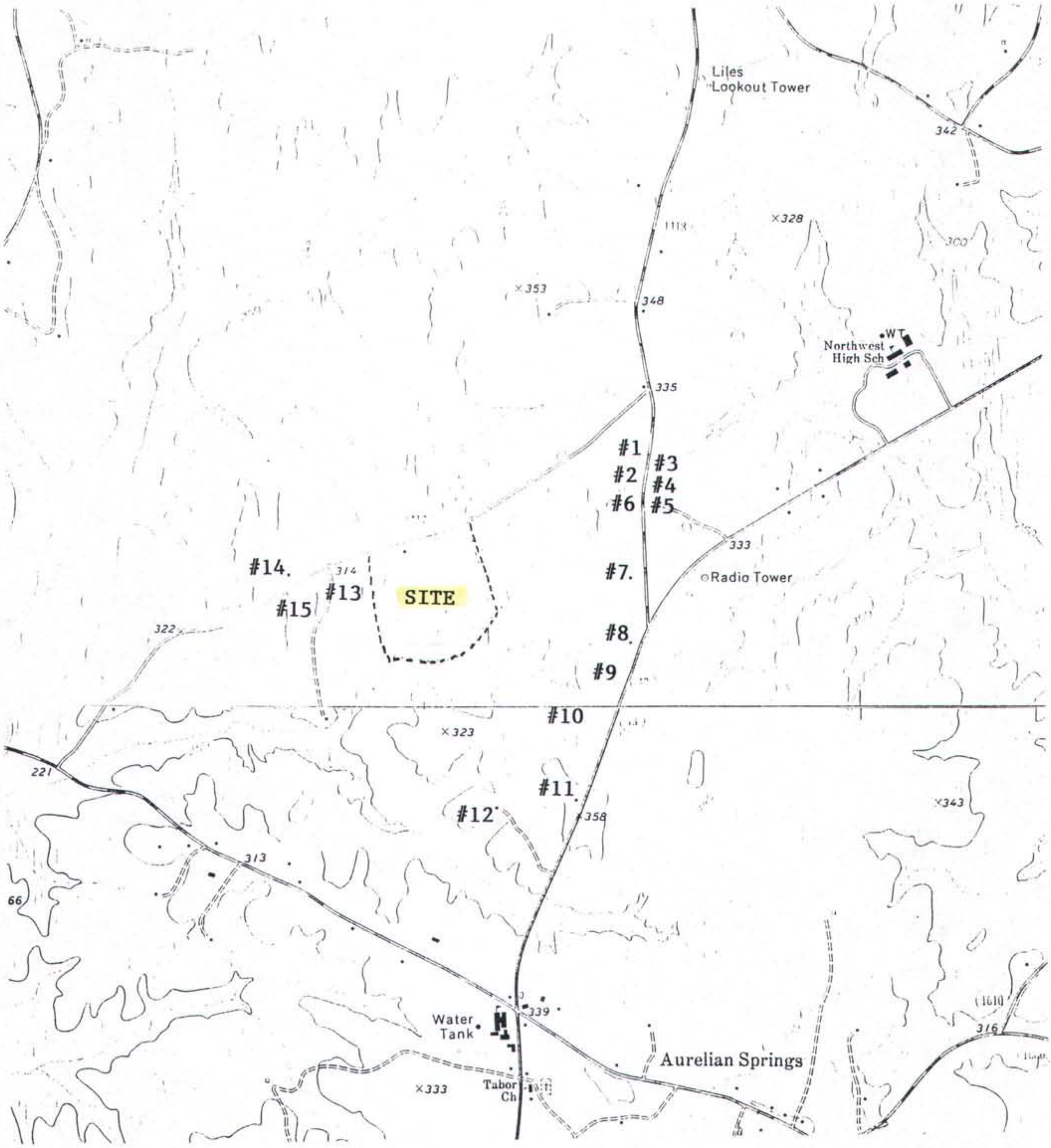
Bold Numerals Represent Selected NCDEM Well Permit Numbers on Record for Halifax County

Locations are Approximate

ENSCI
ENVIRONMENTAL DESIGN GROUP

HALIFAX COUNTY ASH MONOFILL
INDEX MAP TO DEM
RECORDED WATER WELL LOCATIONS
FIGURE 4

DRAWN BY: DJM	SCALE: NTS	JOB NO.:
CHECKED BY: DG	DRWG NO. 4	REV.:

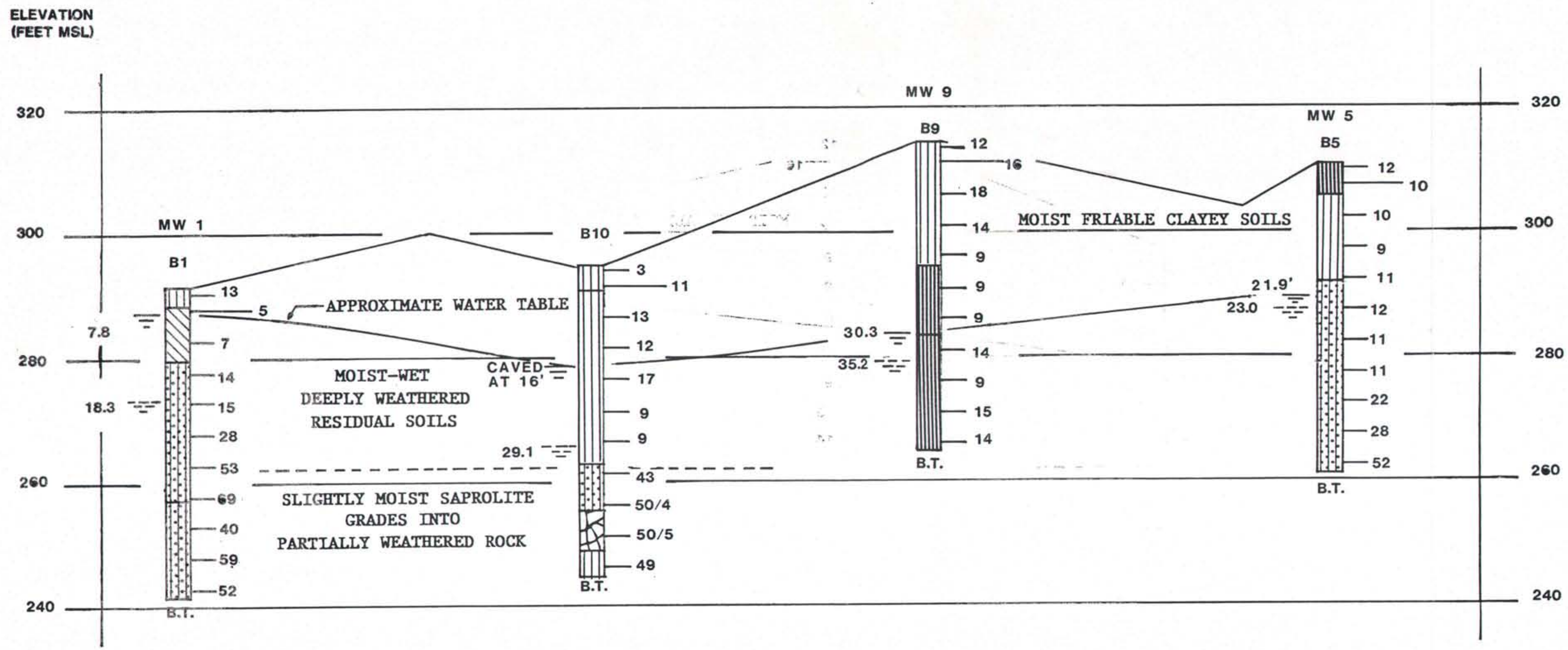


See Descriptions of Stops on Table

Scale: 1" = 2000'

ENSCI ENVIRONMENTAL DESIGN GROUP

HALIFAX COUNTY ASH MONOFILL INDEX MAP TO NEIBORHOOD WATER WELL LOCATIONS SURVEYED MARCH 11, 1991 FIGURE 5		
DRAWN BY: DJM	SCALE: NTS	JOB NO.:
CHECKED BY: DG	DRWG NO. 5	REV.:



LEGEND

ML: Low to Moderate Plasticity, Fine to Coarse Sandy Clayey Silts

MH: Moderate to High Plasticity, Fine to Coarse Sandy Clayey Silts

CL: Low to Moderate Plasticity, Fine to Coarse Sandy Silty Clays

CH: Moderate to High Plasticity, Fine to Coarse Sandy Silty Clays

SM: Silty Fine to Coarse Sands

SC: Clayey Fine to Coarse Sands

PWR: Partially Weathered Rock. Defined by Standard Penetration Resistances Greater Than 100 Blows Per Foot

32.5' Groundwater Level at Boring Termination

24.3' Stabilized Groundwater Level

B.T. Boring Terminated

T.C.R. Boring Terminated Due to Tri-Cone Refusal

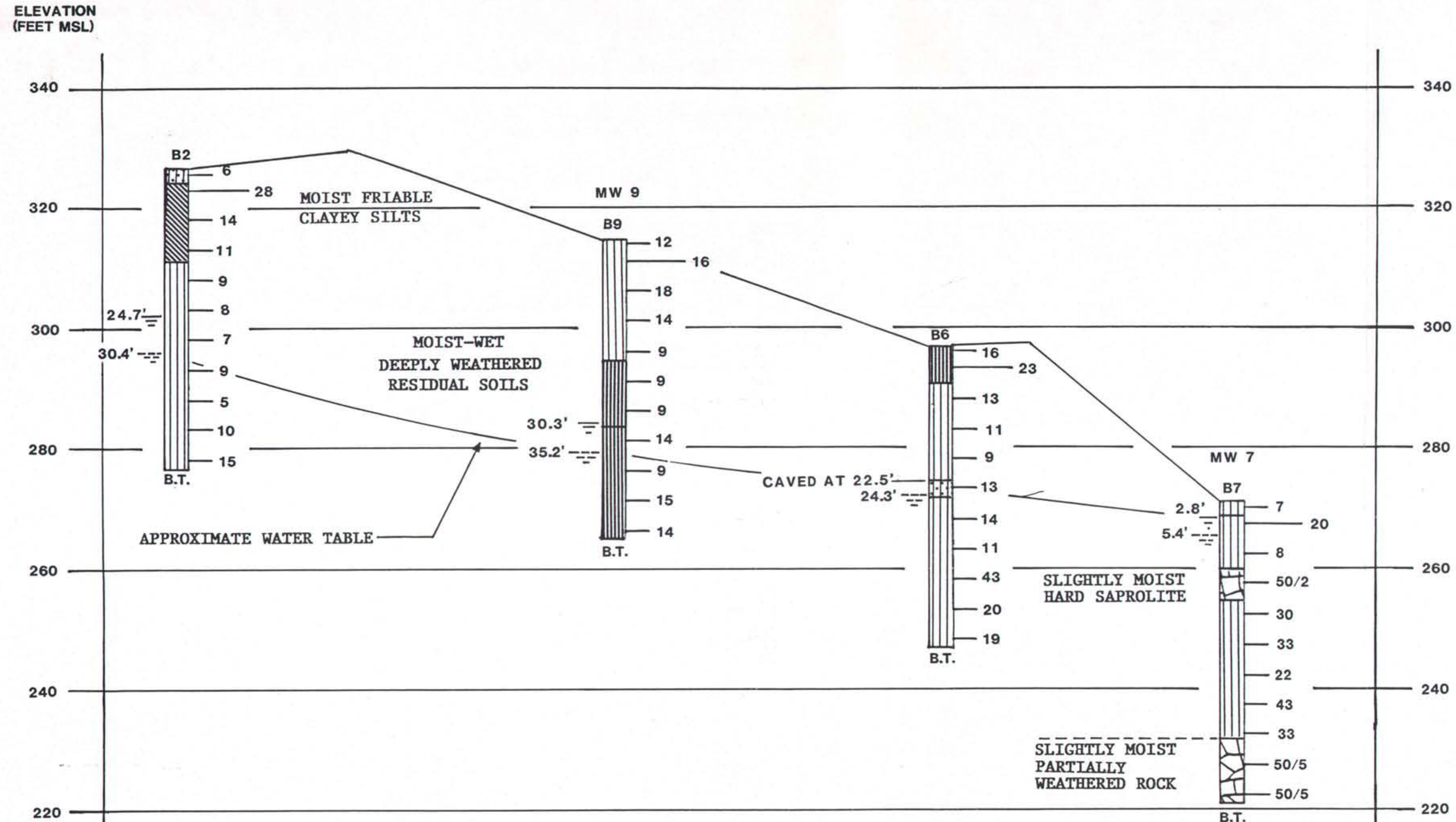
15 Standard Penetration Resistances: Blows Per Foot

ENSCI
ENVIRONMENTAL DESIGN GROUP
1108 OLD THOMASVILLE RD.
HIGH POINT, N.C. 27260

SUBSURFACE PROFILE – SECTION A
HALIFAX COUNTY ASH MONOFILL

FIGURE 7

SCALE: 1"=200 H 1" =20' V	DATE: 3/91 DWN BY: DJM	REV: CK BY: JB	JOB NO. ES90 – 001



LEGEND

ML: Low to Moderate Plasticity, Fine to Coarse Sandy Clayey Silts

MH: Moderate to High Plasticity, Fine to Coarse Sandy Clayey Silts

CL: Low to Moderate Plasticity, Fine to Coarse Sandy Silty Clays

CH: Moderate to High Plasticity, Fine to Coarse Sandy Silty Clays

SM: Silty Fine to Coarse Sands

SC: Clayey Fine to Coarse Sands

PWR: Partially Weathered Rock. Defined by Standard Penetration Resistances Greater Than 100 Blows Per Foot

32.5' Groundwater Level at Boring Termination

24.3' Stabilized Groundwater Level

B.T. Boring Terminated

T.C.R. Boring Terminated Due to Tri-Cone Refusal

—15 Standard Penetration Resistances: Blows Per Foot

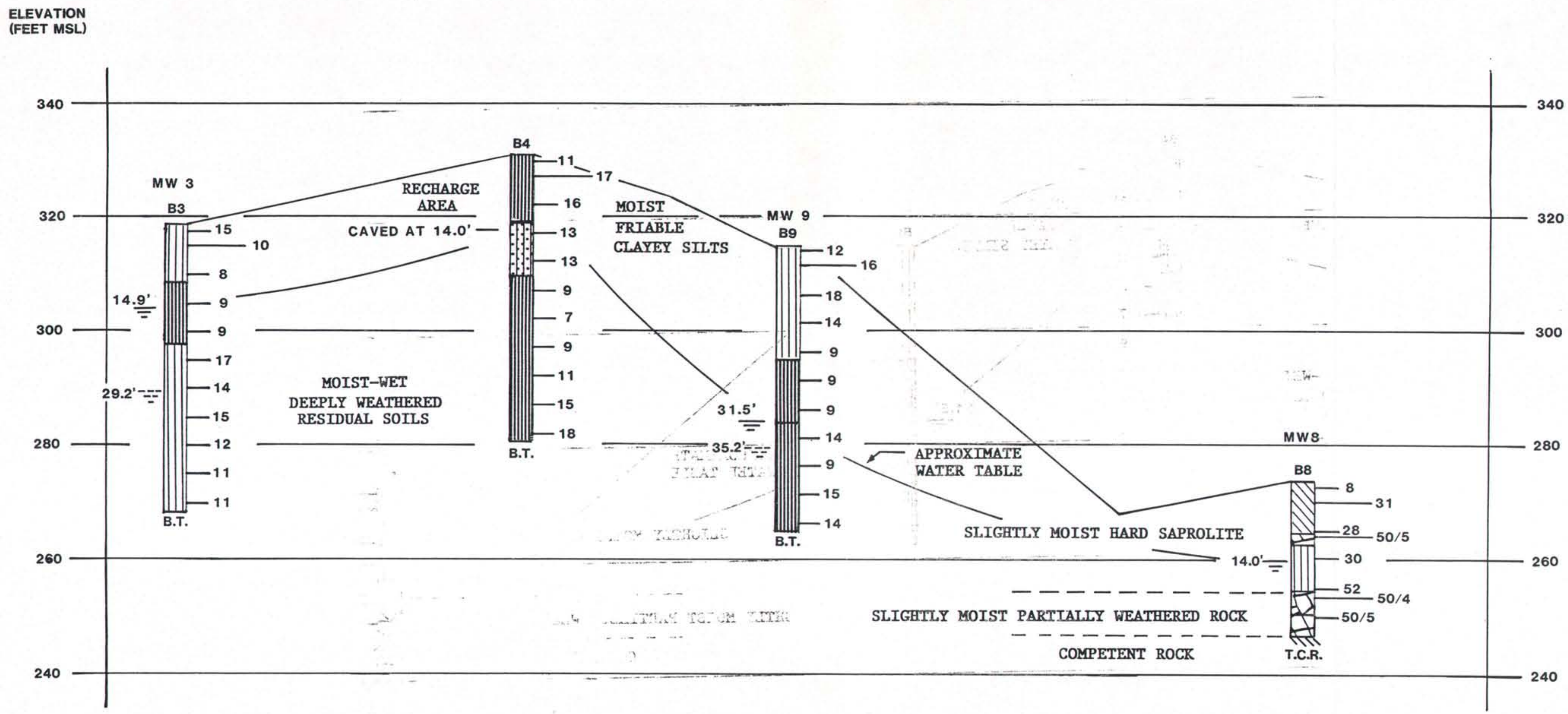
ENSCI
ENVIRONMENTAL DESIGN GROUP
1106 OLD THOMASVILLE RD.
HIGH POINT, N.C. 27260

SUBSURFACE PROFILE – SECTION B

HALIFAX COUNTY ASH MONOFILL

FIGURE 8

SCALE: 1" =200 H 1" =20' V	DATE: 3/91	REV:	JOB NO. ES90 – 001
	DWN BY: DJM	CK BY: JB	



LEGEND

ML: Low to Moderate Plasticity, Fine to Coarse Sandy Clayey Silts

MH: Moderate to High Plasticity, Fine to Coarse Sandy Clayey Silts

CL: Low to Moderate Plasticity, Fine to Coarse Sandy Silty Clays

CH: Moderate to High Plasticity, Fine to Coarse Sandy Silty Clays

SM: Silty Fine to Coarse Sands

SC: Clayey Fine to Coarse Sands

PWR: Partially Weathered Rock. Defined by Standard Penetration Resistances Greater Than 100 Blows Per Foot

32.5' — Groundwater Level at Boring Termination

24.3' — Stabilized Groundwater Level

B.T. — Boring Terminated

T.C.R. — Boring Terminated Due to Tri-Cone Refusal

—15 Standard Penetration Resistances: Blows Per Foot

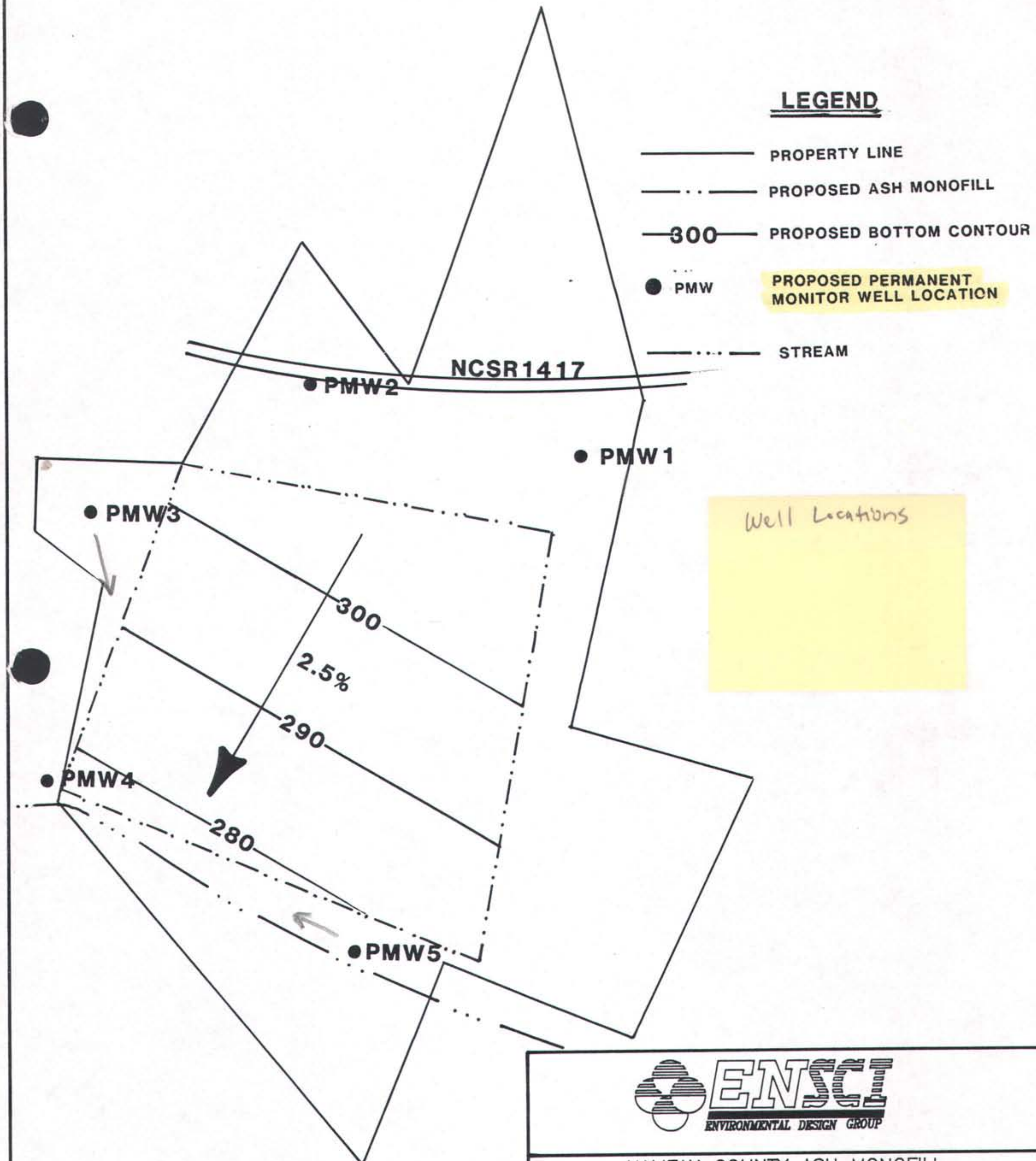
ENSCI
ENVIRONMENTAL DESIGN GROUP
1108 OLD THOMASVILLE RD.
HIGH POINT, N.C. 27260

SUBSURFACE PROFILE – SECTION C

HALIFAX COUNTY ASH MONOFILL

FIGURE 9

SCALE: 1"=200 H 1"=20' V	DATE: 3/91 DWN BY: DJM	REV: CK BY: JB	JOB NO. ES90 – 001



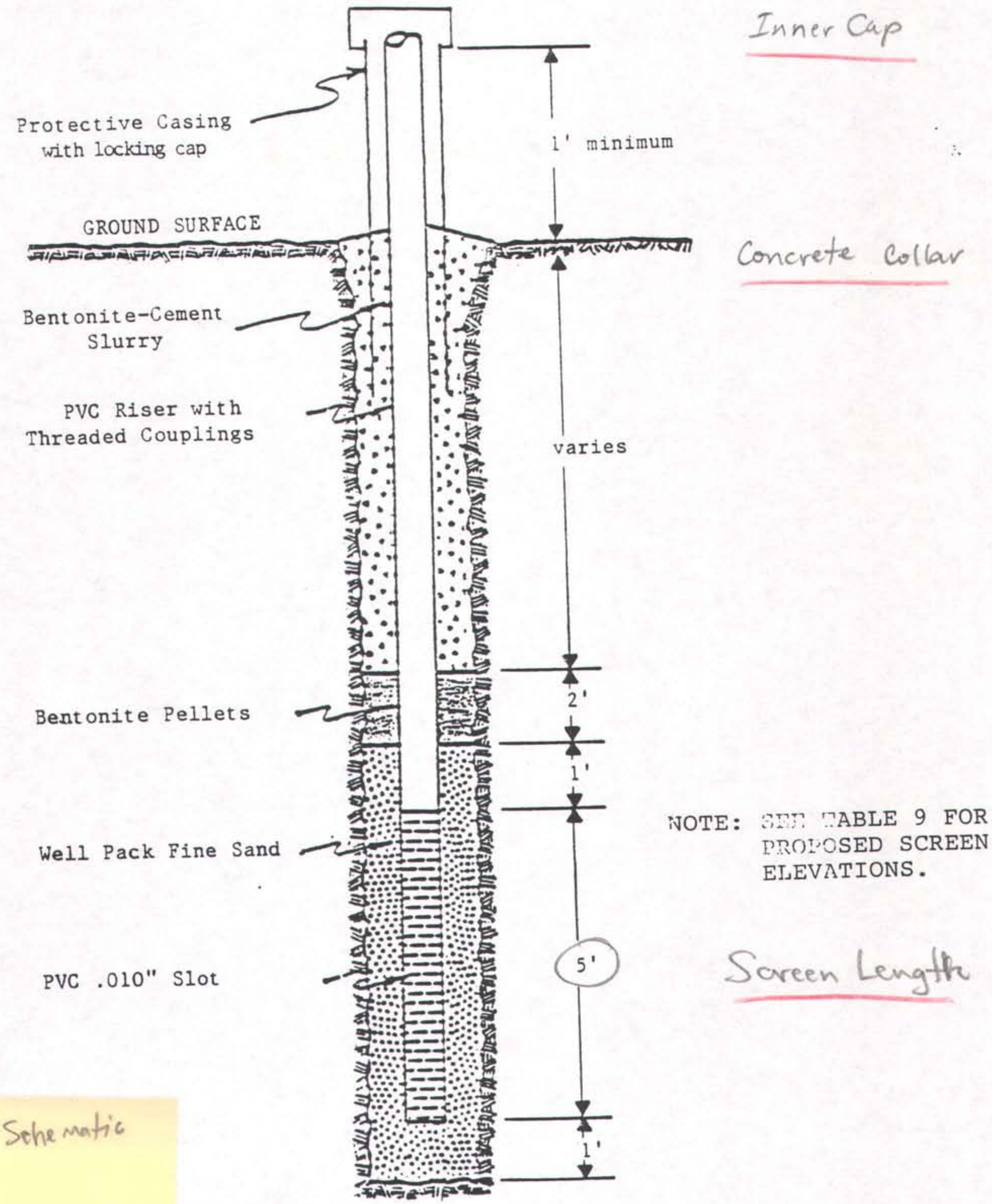
ENSCI ENVIRONMENTAL DESIGN GROUP

HALIFAX COUNTY ASH MONOFILL

PROPOSED BOTTOM CONTOURS

FIGURE 12

DRAWN BY: DJM	SCALE: 1":400'	JOB NO.:
CHECKED BY: DG	DRWG NO.	REV.:



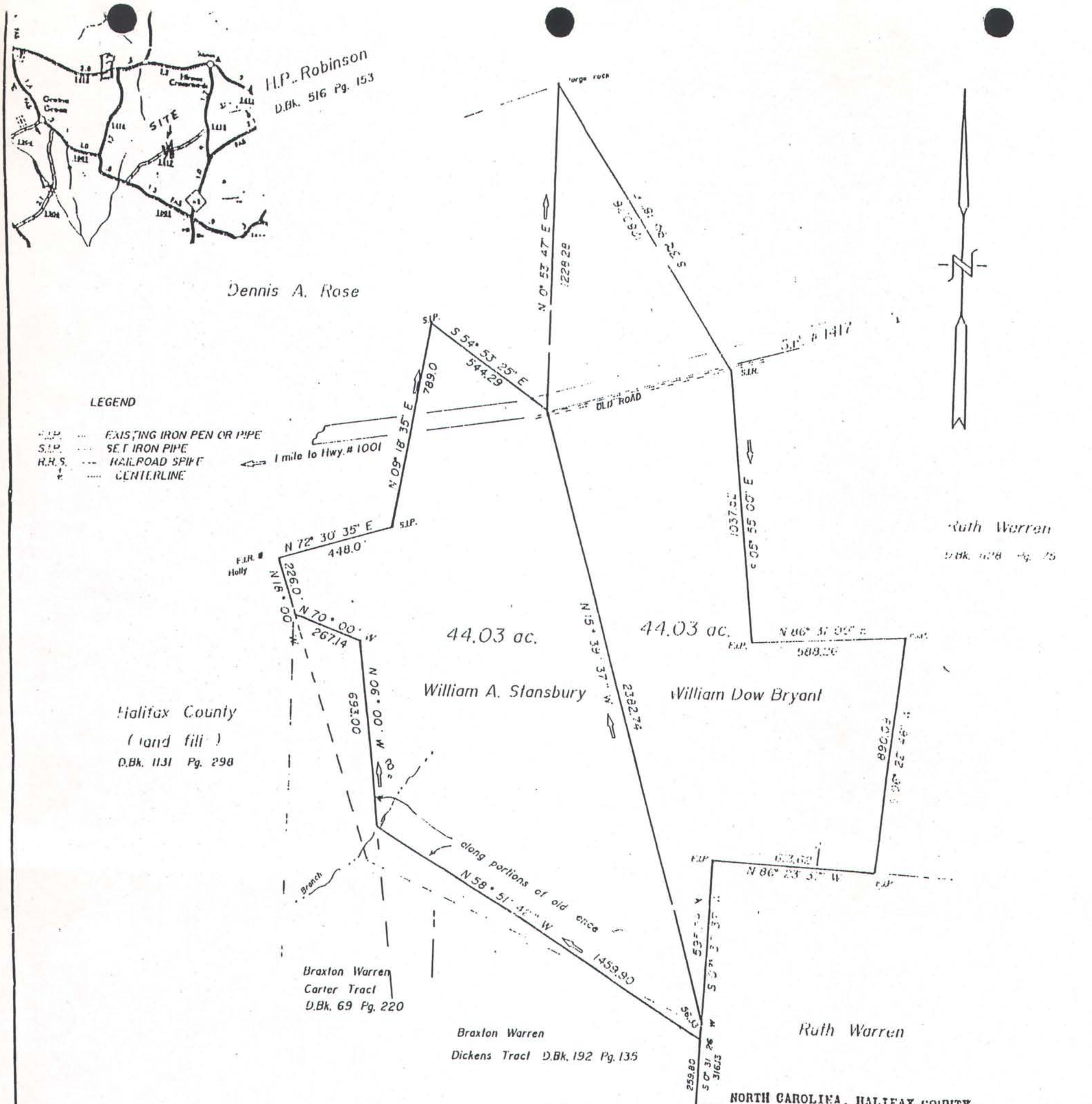
NOTE: SEE TABLE 9 FOR PROPOSED SCREEN ELEVATIONS.

Well Schematic

TYPICAL WELL SCHEMATIC

FIGURE 13

ENSCI CORPORATION



State of North Carolina, Halifax County

I, Hunter Traylor a R.L.S. certify that this map was drawn from actual survey made by me. Refer M.BK. Pg. , Deed BK. Pg. The ratio of precision as calculated by latitudes and departures is 1- 10,000. This map was prepared in accordance with G.S. 47-30 as amended.

Witness my hand and seal this 20 day of April 1990

Sign Hunter Traylor R.L.S. 3077

NORTH CAROLINA REGISTERED SEAL L-3077 LAND SURVEYOR W.M. HUNTER TRAYLOR

I, Notary Public of the county and state aforesaid, certify that Hunter Traylor, a registered land surveyor, personally appeared before me this day and acknowledged the execution of the foregoing instrument. Witness my hand and official seal this 20 day of April 1990

Sign Wanda H. Traylor

My commission expires. 2/07/94

WANDA H. TRAYLOR NOTARY PUBLIC HALIFAX COUNTY, NC

NORTH CAROLINA, HALIFAX COUNTY.
The foregoing certificate of [illegible] a Notary Public of [illegible] County is certified [illegible]
This 25 day of [illegible], 1990.
Recorded [illegible] M. in Plat Cab. [illegible], Slide [illegible]
[illegible]
Travis E. Uzzell, Register of Deeds, [illegible]

Map Showing Property of
WILLIAM DOW BRYANT
WILLIAM A. STANSBURY

Butterwood Twsp., Halifax Co., N.C.
scale 1" = 400' April 20, 1990

J.W. Traylor & Son
Reg. Land Surveyors
45 [illegible]
Littleton, N.C.

NOTE: ALL POINTS ARE S.I.P., UNLESS OTERWISE DENOTED.

Figure 14

0 400 800

NOTE: THIS PLAT IS SUBJECT TO ALL EASEMENTS, AGREEMENTS, AND RIGHTS-OF-WAY OF RECORD PRIOR TO THE DATE OF THIS PLAT.

Photographs

PHOTOGRAPH INDEX

Photos 1-4 taken near abandoned structure depicting highest elevations of site.

Photo 1 - directional view toward southeast.

Photo 2 - view toward northeast showing shallow drainage feature; B-3 located in clearing in trees.

Photo 3 - view toward south-southwest; existing landfill on next hill beyond farm machinery.

Photo 4 - view of gravelly surficial soil; S.R. 1417 on far left; B-3 in clearing in trees across field.

Photo 5 - view of granite outcrop below B-8 (located on hill, toward left); flat surface on right side of outcrop is a joint; rounded appearance characteristic of the formation.

Photo 6 - rounded outcrop adjacent to stream near B-8; spherical cracking (exfoliation) visible toward top produces flakes of rock and rounding of outcrop; note massive appearance due to relatively wide spacing of joints.

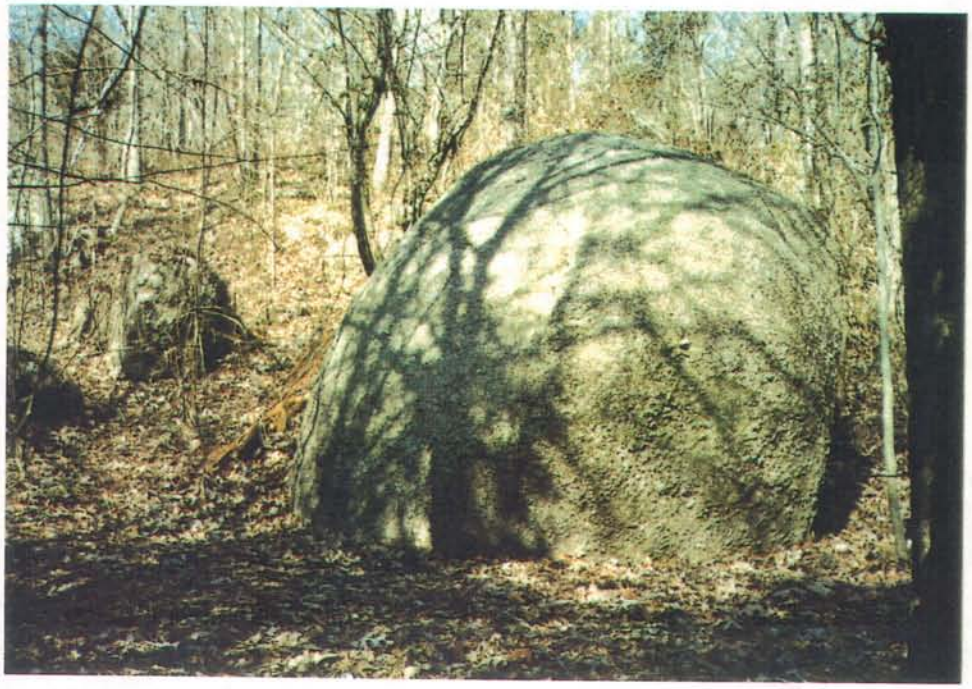
Photo 7 - Rounded knolls of rock or partially weathered rock which were excavated around in existing landfill; elevation similar to that of outcrops in previous photos.

Photograph 1

Photograph 2

Photograph 3

Photograph 4



Photograph 5

Photograph 6

Photograph 7

A-Field Investigation

FIELD TEST PROCEDURES

Soil Test Boring: Ten (10) soil test borings were drilled at the approximate locations shown on the attached Site Plan (Figure No. 6). Soil sampling and penetration testing were performed in accordance with ASTM D 1586.

The borings were advanced with hollow-stem augers and, at selected intervals, soil samples were obtained with a standard 1.4-inch I.D., 2-inch O.D., split-tube sampler. The sampler was first seated 6 inches to penetrate any loose cuttings, then driven an additional foot with blows of a 140-pound hammer falling 30 inches. The number of hammer blows required to drive the sampler the final foot was recorded and is designated the "Standard Penetration Resistance" (N-Value). The Standard Penetration Resistance, when properly evaluated, is an index to soil strength, density, and compressibility.

Representative portions of each sample were placed in glass jars and taken to our laboratory. The samples were examined by a qualified geotechnical engineer under the direction of a registered geologist. Test Boring Records are attached showing the soil description and Standard Penetration Resistances.

Monitoring Wells: Six (6) monitoring wells were installed at boring locations B-1, B-3, B-5, B-7, B-8, and B-9, as shown on the Site Plan (Figure No. 6). The monitoring wells were installed to depths ranging from 27.1 to 50.0 feet below existing grade. The wells were installed generally in accordance to North Carolina State guidelines. The wells are constructed of 2 inch diameter Schedule 40 Polyvinylchloride (PVC) pipe with threaded connections. A ten (10) foot section of PVC #20 slotted well screen was installed on each well and solid PVC pipe was attached and extended to the ground surface. Graded sand was installed around the screen to fill the annular space between the borehole wall and the pipe. A minimum two (2) foot bentonite seal was placed above this sand and a concrete slurry was placed above this seal. A protective locking cap was placed over the well pipe to protect the well and prevent tampering. Detailed well construction records are attached in this Appendix.

Bulk Samples: Large bulk samples were collected from selected locations on site in order to perform specific soil laboratory tests. These samples were taken from hand excavations and from cuttings from the augering operations. The samples were placed in sealed five (5) gallon containers and a sealed jar sample was placed in the container for natural moisture content testing.

SUMMARY OF TEST BORING DATA

Boring	Ground Elev.	Boring Depth	Depth to 30+bpf[1]	Depth to PWR[2]	Depth to Rock[3]	Depth to G.W.[4]	
B-1	291.73	50.0	24	NA	NA	4.1	287.6
B-2	326.23	50.0	NA	NA	NA	24.7 ?	301.5
B-3	318.20	50.0	NA	NA	NA	14.8	303.4
B-4	330.63	50.0	NA	NA	NA	Caved @ 13'	(317.6)
B-5	310.61	50.0	47	NA	NA	21.4	289.2
B-6	296.80	50.0	39	NA	NA	22.5	274.3
B-7	271.61	49.0	11.4	36.7	NA	2.8	268.8
B-8	273.94	27.1	2.8	16.7	27.1	15.9	258.0
B-9	314.59	50.0	NA	NA	NA	30.3	284.3
B-10	295.50	50.0	34.4	39.5	NA	Caved @ 16'	(279.5)

(1) 30+ bpf material, characterizes hard residual (saprolitic) soil.

(2) PWR, Partially Weathered Rock, defined as 100+ bpf material which can be penetrated by soil auger.

(3) Hard Rock, defined as material which cannot be penetrated by soil auger or rotary tricone.

(4) G. W., stabilized groundwater 24+ hours after completion.

Corrected Data 5-02-91

SUMMARY OF GROUNDWATER LEVEL DATA

BORING	GROUND ELEV.	T.O.B. DATE	G.W.@ T.O.B.	G.W.AFTER 24 HR	G.W. ON 3-14-91
B-1	291.73	2-21-91	273.4	287.6 *	287.3
B-2	326.23	2-15-91	295.8	Caved 292.2	NA
B-3	318.20	2-20-91	289.0	303.4	303.3
B-4	330.63	2-15-91	DRY	Caved 317.6	NA
B-5	310.61	2-25-91	287.6	289.2	288.7
B-6	296.80	2-18-91	272.5	Caved 274.3	NA
B-7	271.61	2-27-91	266.2	268.8	268.0
B-8	273.94	2-28-91	259.9	258.0	256.9
B-9	314.59	2-13-91	279.4	284.3	283.1
B-10	295.50	2-18-91	266.4	Caved 279.5	NA

* Ground water after a minimum 24 hour period was 287.6, and at a 12 hour reading it was 283.9

ALL ELEVATIONS ARE MEAN SEA LEVEL

Original Submittal

SUMMARY OF GROUNDWATER LEVEL DATA

BORING	GROUND ELEV.	T.O.B. DATE	G.W.@ T.O.B.	G.W. AFTER 24 HR	G.W. ON 3-14-91
B-1	291.73	2-21-91	273.4	287.6	287.3
B-2	326.23	2-15-91	295.8	301.5	NA
B-3	318.20	2-20-91	289.0	303.4	303.3
B-4	330.63	2-15-91	DRY	Caved 317.6	NA
B-5	310.61	2-25-91	287.6	289.2	288.7
B-6	296.80	2-18-91	272.5	Caved 274.3	NA
B-7	271.61	2-27-91	264.1	268.8	268.0
B-8	273.94	2-28-91	259.9	258.0	256.9
B-9	314.59	2-13-91	279.4	284.3	283.1
B-10	295.50	2-18-91	266.4	Caved 279.5	NA

ALL ELEVATIONS ARE MEAN SEA LEVEL

Corrected Table (5-2-91)

TABLE 5

SUMMARY OF GROUNDWATER LEVEL DATA

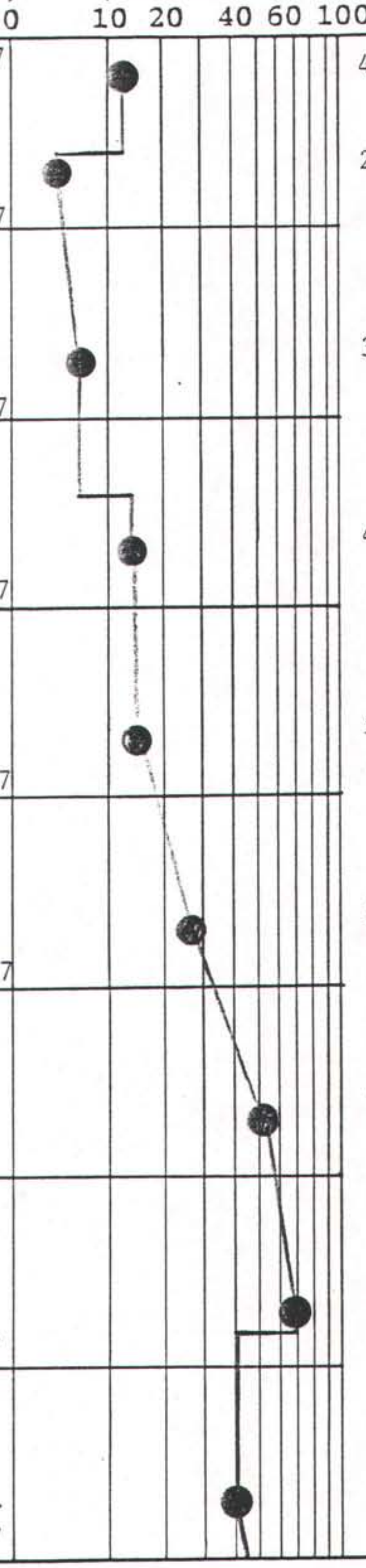
BORING	GROUND ELEV.	T.O.B. DATE	G.W.@ T.O.B.	G.W.AFTER 24 HR	G.W. ON 3-14-91
B-1	291.73	2-21-91	273.4 18.3	287.6 * 4.1	287.3 4.4
B-2	326.23	2-15-91	295.8 30.4	Caved 292.2 34?	NA
B-3	318.20	2-20-91	289.0 29.2	303.4 14.8	303.3 14.9
B-4	330.63	2-15-91	DRY	Caved 317.6 13.0	NA
B-5	310.61	2-25-91	287.6 23.0	289.2 21.4	288.7 21.9
B-6	296.80	2-18-91	272.5 24.3	Caved 274.3 22.5	NA
B-7	271.61	2-27-91	266.2 5.4	268.8 2.8	268.0 3.6
B-8	273.94	2-28-91	259.9 14.0	258.0 15.9	256.9 17.0
B-9	314.59	2-13-91	279.4 35.2	284.3 30.3	283.1 31.5
B-10	295.50	2-18-91	266.4 29.1	Caved 279.5 16.0	NA

* Ground water after a minimum 24 hour period was 287.6, and at a 12 hour reading it was 283.9

ALL ELEVATIONS ARE MEAN SEA LEVEL

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	BLOWS PER SIX IN.	
0.0	Stiff, Tannish Brown Fine Sandy SILT (Residuum)	ML	291.7	4-5-8	
3.0	Firm, Brown to Grey Fine Sandy CLAY (Residuum)	CL	286.7	2-2-3	
			281.7	3-3-4	? 7.8'
12.0	Firm to Very Dense Mottled Grey Brown Slightly Silty Clayey Fine to Coarse SAND (Residuum)	SM	276.7	4-6-8	
			271.7	5-7-8	18.3'
			266.7	13-13-15	
			261.7	7-17-36	
				28-33-36	
34.0	Dense to Very Dense Pink and Grey Fine to Coarse SAND (Residuum)	SM	256.7		
			251.7	14-17-23	



(Continued on next page)

JOB NUMBER ES90-001
BORING NUMBER B-1
DATE 2/21/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
	(Continued from Previous page)	251.7		
				23-28-31
		246.7		
				24-24-28
50.0		241.7		
	Boring Terminated at 50.0' Groundwater Encountered at 18.3' at Boring Termination 7.8' at 12 hours Piezometer set to a depth of 48.5' at Boring Termination			

JOB NUMBER ES90-001
BORING NUMBER B-1
DATE 2/21/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT_0)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	
	Loose Brown Silty Fine SAND (Possible Fill)	SM	326.2	6	3-3-3	
2.0	Stiff to Very Stiff Purplish Brown to Brown Fine Sandy, Silty CLAY (Residuum)	CH	321.2	28	10-12-16	
7.0	Firm to Stiff Tan Brown Fine to Coarse Sandy Clayey SILT (Residuum)	ML / MH	316.2	14	6-7-7	
			311.2	11	3-5-6	
			306.2	9	3-4-5	
			301.2	8	3-3-5	
			296.2	7	2-3-4	
						30.4'
			291.2	9	3-4-5	
	(Continued on next page)		286.2	5	2-2-3	

Penetration scale: 0, 10, 20, 40, 60, 100

JOB NUMBER ES 90-001
BORING NUMBER B-2
DATE 2/15/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
	(Continued from previous page)	286.2		
			10	3-4-6
		281.2		
			15	4-6-9
50.0		276.2		
	Boring Terminated at 50.0' Groundwater Encountered at 30.4' at Boring Termination. Boring Caved at 34.0' 2/26/91 Boring Grouted to Ground Surface 3/5/91			

JOB NUMBER ES 90-001
BORING NUMBER B-2
DATE 2/15/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	
0.0	Firm to Stiff Tan and Red Brown Slightly Micaceous, Slightly Clayey, Fine Sandy SILT	ML	318.2	15	4-6-9	
				10	4-4-6	
			313.2			
				8	2-3-5	
			308.2			
10.0	Stiff to Very Stiff Reddish Tan Brown Slightly Micaceous, Fine to Medium Sandy, Clayey SILT	MH		9	3-4-5	
			303.2			
				9	4-4-5	
			298.2			
21.0	Stiff Grey-Green and Reddish Brown Slightly Micaceous, Fine Sandy SILT	ML		17	3-8-9	
			293.2			
				14	4-6-8	29.2'
			288.2			
				15	4-6-9	
			283.2			
	(Continued on Next Page)			12	4-5-7	
			278.2			

Penetration scale: 0, 10, 20, 40, 60, 100

JOB NUMBER ES 90-001
BORING NUMBER B-3
DATE 2/20/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
40.0'	(Continued From Previous Page)	278.2		
			11	5-5-6
		273.2		
			11	4-5-6
		258.2		
50.0'	Boring Terminated at 50.0' Groundwater Encountered at 29.9' at Boring Termination . Piezometer Set to a Depth of 49.0' at Boring Termination			

JOB NUMBER ES 90-001
BORING NUMBER B-3
DATE 2/20/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.
0.0'	Stiff to Very Stiff Tan and Reddish Brown Fine Sandy, Clayey SILT (Residuum)	MH	330.6	11	3-5-6
				17	5-8-9
			325.6		
				16	5-8-8
			320.6		
11.5'	Firm Tan Slightly Silty, Fine to Medium SAND (Residuum)	SM		13	4-5-8
			315.6		
				13	5-5-8
			310.6		
21.0'	Firm to Very Stiff Red Grey Tan Slightly Fine Sandy, Clayey SILT (Residuum)	MH		9	4-4-5
			305.6		
				7	2-3-4
			300.6		
				9	3-4-5
			295.6		
				11	4-5-6
	(Continued on Next Page)		290.6		

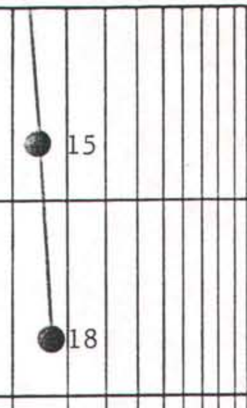
Penetration scale: 0, 10, 20, 40, 60, 100

JOB NUMBER ES 90-001
BORING NUMBER B-4
DATE 2/15/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
40.0'	(Continued From Previous Page)	290.6		
			15	7-7-8
		285.6		
			18	7-8-10
		280.6		
50.0'	Boring Terminated at 50.0' No Groundwater Encountered at Boring Termination. Boring Caved at a Depth of 13.0' 2/26/91 Boring Grouted to Ground Surface 3/5/91			



JOB NUMBER ES 90-001
BORING NUMBER B-4
DATE 2/15/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	
0.0'	Stiff Tan and Reddish Brown Slightly Fine Sandy SILT (Residuum)	MH	310.6	12	5-6-6	
				10	4-4-6	
5.0'			305.6			
	Stiff Grey Brown Fine to Medium Sandy SILT	ML		10	5-5-5	
			300.6			
				9	5-5-4	
			295.6			
				11	4-5-6	
19.0'	Stiff to Very Hard Grey Brown Slightly Micaceous Slightly Silty Fine to Coarse SAND	SM	290.6			
				12	4-5-7	23.0'
			285.6			
				11	6-5-6	
			280.6			
				11	5-5-6	
			275.6			
				22	6-10-12	
	(Continued on Next Page)		270.6			

JOB NUMBER ES 90-001
BORING NUMBER B-5
DATE 2/25/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.
40.0'	(Continued From Previous Page)	270.6		
			28	8-12-16
		265.6		
			52	13-19-33
		260.6		
50.0'	Boring Terminated at 50.0' Groundwater Encountered at 23.0' at Boring Termination Piezometer set to a Depth of 50.0' at Boring Termination			

X

JOB NUMBER ES 90-001
BORING NUMBER B-5
DATE 2/25/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.	
0.0'	Very Stiff Dark Reddish Brown Slightly Micaceous, Fine Sandy Clayey SILT (Residuum)	MH	296.8	16	3-7-9	
				23	9-11-12	
			291.8			
6.0'	Stiff Reddish Brown to Tan Slightly Micaceous Fine to Medium Sandy Clayey SILT (Residuum)	ML		13	4-6-7	
			286.8	11	4-5-6	
			281.8	9	3-4-5	
			276.8			
22.0'	Firm Pinkish Tan Slightly Micaceous Silty Fine to Coarse Sand (Residuum)	SM		13	3-6-7	24.3
			271.8			
	Stiff to Hard Black and Greyish Tan Micaceous Fine to Medium Sandy Clayey SILT (Residuum)	ML		14	3-6-8	
			266.8	11	3-5-6	
			261.8			
	(Continued on Next Page)			43	7-12-31	
40.0'			256.8			

JOB NUMBER ES 90-001
BORING NUMBER B-6
DATE 2/18/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.
40.0	(Continued from Previous Page)	256.8		
			20	9-9-11
		251.8		
			19	7-8-11
		246.8		
50.0'	Boring Terminated at 50.0' Groundwater Encountered At 24.3' at Boring Termination. Boring Caved at a Depth of 22.5' 2/26/91 Boring Grouted to Ground Surface 3/5/91			

JOB NUMBER ES 90-001
BORING NUMBER B-6
DATE 2/18/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.
0.0'	Firm Tan Slightly Micaceous Fine to Medium Sandy Clayey SILT*	ML	271.6	7	3-3-4
2.0'	Firm to Very Stiff Brownish Grey Slightly Micaceous Fine to Coarse Sandy Clayey SILT (Residuum)	ML		20	8-9-11
			266.6		5.4' (water level, handwritten, with "?")
				8	2-3-5
			261.6		
11.0'	Partially Weathered Rock When Sampled Becomes Grey Coarse SAND (Residuum)	SM		50/2	50/2
			256.6		
16.0'	Very Stiff to Hard Brown Fine to Coarse Sandy Clayey SILT with Rock Fragments (Residuum)	ML		30	12-17-13
			251.6		
				33	15-16-17
			246.6		
				22	8-11-11
			241.6		
				43	12-19-24
			236.6		
				33	
39.0'					
40.0'	(Continued on Next Page)		231.6	50/5	50/5

Penetration scale: 0, 10, 20, 40, 60, 100

JOB NUMBER ES 90-001
BORING NUMBER B-7
DATE 2/27/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
40.0'	Partially Weathered Rock When Sampled Becomes Tan and Grey Silty Fine to Coarse SAND (Residuum)	231.6	50/5	
		226.6	50/5	
50.0'	Boring Terminated at 50.0' Groundwater Encountered at 5.4' at Boring Termination Piezometer Set to a Depth of 50.0' at Boring Termination	221.6		

X

JOB NUMBER ES 90-001
BORING NUMBER B-7
DATE 2/27/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.	
0.0'	Firm to Hard Tan Brown Slightly Micaceous Fine to Medium Sandy Clayey SILT (Residuum)	ML	273.9	8	2-3-5	
				31	11-15-16	
			268.9	28		
9.0'	Partially Weathered Rock When Sampled Becomes Tan Slightly*		263.9	50/5	50/5	
11.0'	Very Stiff to Hard Grey Slightly Micaceous Fine to Coarse Sandy Clayey SILT (Residuum)	ML		30	10-13-17	14.0'
			258.9			
19.0'	Partially Weathered Rock When Sampled Becomes Tan Brown Slightly Micaceous Fine to Coarse SAND (Residuum) Auger Refusal @ 23.0'		253.9	50/4	50/4	
23.0'	Partially Weathered Rock When Sampled Becomes Dark Grey Slightly Micaceous SILT (Residuum)		248.9	50/5	50/5	
	Boring Terminated at 27.1' due to Tri-cone Refusal Groundwater Encountered at 14.0' Boring Termination Piezometer Set to a Depth of 27' at Boring Termination * Micaceous Fine to Coarse Sandy Clayey SILT (Residuum)					

JOB NUMBER ES 90-001
BORING NUMBER B-8
DATE 2/28/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.
0.0'	Stiff to Very Stiff Reddish Brown Slightly Micaceous Fine to Medium Sandy Clayey SILT (Residuum)	ML	314.6	12	4-5-7
				16	4-7-9
			309.6	18	8-8-10
			304.6	14	9-6-8
			299.6	9	3-4-5
20.0'	Stiff Dark Purple Slightly Micaceous Clayey SILT	MH	294.6	9	4-4-5
			289.6	9	3-4-5
31.0'	Stiff Tan Grey Slightly Micaceous Fine to Coarse Sandy Clayey SILT	MH	284.6	14	5-6-8
			279.6	9	4-4-5
	(Continued on Next Page)		274.6		

Penetration scale: 0, 10, 20, 40, 60, 100

Water level: 35.2'

JOB NUMBER ES 90-001
BORING NUMBER B-9
DATE 2/18/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
40.0'	(Continued From Previous Page)	274.6		
			15	4-6-9
		269.6		
			14	5-6-8
50.0'		264.6		
	Boring Terminated at 50.0' Groundwater Encountered at 35.2' at Boring Termination Piezometer Set at a Depth of 48.5' at Boring Termination			

JOB NUMBER ES 90-001
BORING NUMBER B-9
DATE 2/18/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.)	BLOWS PER SIX IN.
0.0'	Soft to Stiff Brown Slightly Micaceous Fine Sandy SILT (Posssible Fill)	ML	295.5	3	1-1-2
				11	4-5-6
4.0'	Stiff to Very Stiff Tan Brown with White Streaks Fine to Medium Sandy Clayey SILT (Residual)	ML	290.5		
				13	4-6-7
			285.5		
				12	5-5-7
			280.5		
				17	6-8-9
			275.5		
				9	3-4-5
			270.5		
				9	4-4-5
			265.5		
32.0'	Dense Slightly Micaceous Silty Fine to Medium SAND (Residuum)	SM		43	13-17-26
			260.5		
39.5'				50/4	
40.0'	(Continued on Next Page)		255.5		

Water level: 29.1'

JOB NUMBER ES 90-001
BORING NUMBER B-10
DATE 2/18/91

ENSCI CORPORATION

TEST BORING RECORD

DEPTH (FT.)	DESCRIPTION		ELEVATION (FT.)	PENETRATION (BLOWS/FT.) 0 10 20 40 60 100	BLOWS PER SIX IN.
40.0'	(Continued On Previous Page) Partially Weathered Rock When Sampled Becomes Tan Brown Slightly Micaceous Fine TO Medium Sandy SILT With Manganese Lenses		255.5 250.5	50/5	
46.0'	Hard Tan Brown Fine to Medium Sandy SILT (Residuum)	ML	245.5	49	12-20-29
50.0'	Boring Terminated at 50.0' Groundwater Encountered at 29.1' at Boring Termination Boring Caved at a Depth of 16.0' 2/26/91 Boring Grouted to Ground Surface 3/5/91				

JOB NUMBER ES 90-001
BORING NUMBER B-10
DATE 2/18/91

ENSCI CORPORATION

TABLE 6

SUMMARY OF FIELD PERMEABILITY TESTS
(SLUG TESTS)

BORING	BOUWER-RICE (PARTIAL DEPTH)	BOUWER-RICE (FULL DEPTH)	NAVFAC	HVORSLEV TIME-LAG
Sand B-1 38.5/48.5	1.0×10^{-4}	---	4.64×10^{-5}	3.64×10^{-5}
Silt B-3 39/49	8.72×10^{-6}	---	---	---
Sand B-5 40/50	4.81×10^{-5}	---	---	---
PWR-Sd B-7 39/49	2.85×10^{-5}	---	---	---
PWR Sd/Silt B-8 17/27	1.89×10^{-5}	2.29×10^{-5}	4.64×10^{-5}	8.40×10^{-6}
Silt B-9 38.5/48.5	1.00×10^{-5} 3.6×10^{-5}	---	---	---

ALL VALUES IN CM/SEC

NOTE: SEE LIST OF EQUATIONS AND FIGURES AND ACOMPANYING DATA AND CALUCULATIONS IN APPENDIX B.

screen intervals

soil types

ENSCI CORPORATION

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUNTY ASH MONOFILL

GROUND ELEVATION: 291.7

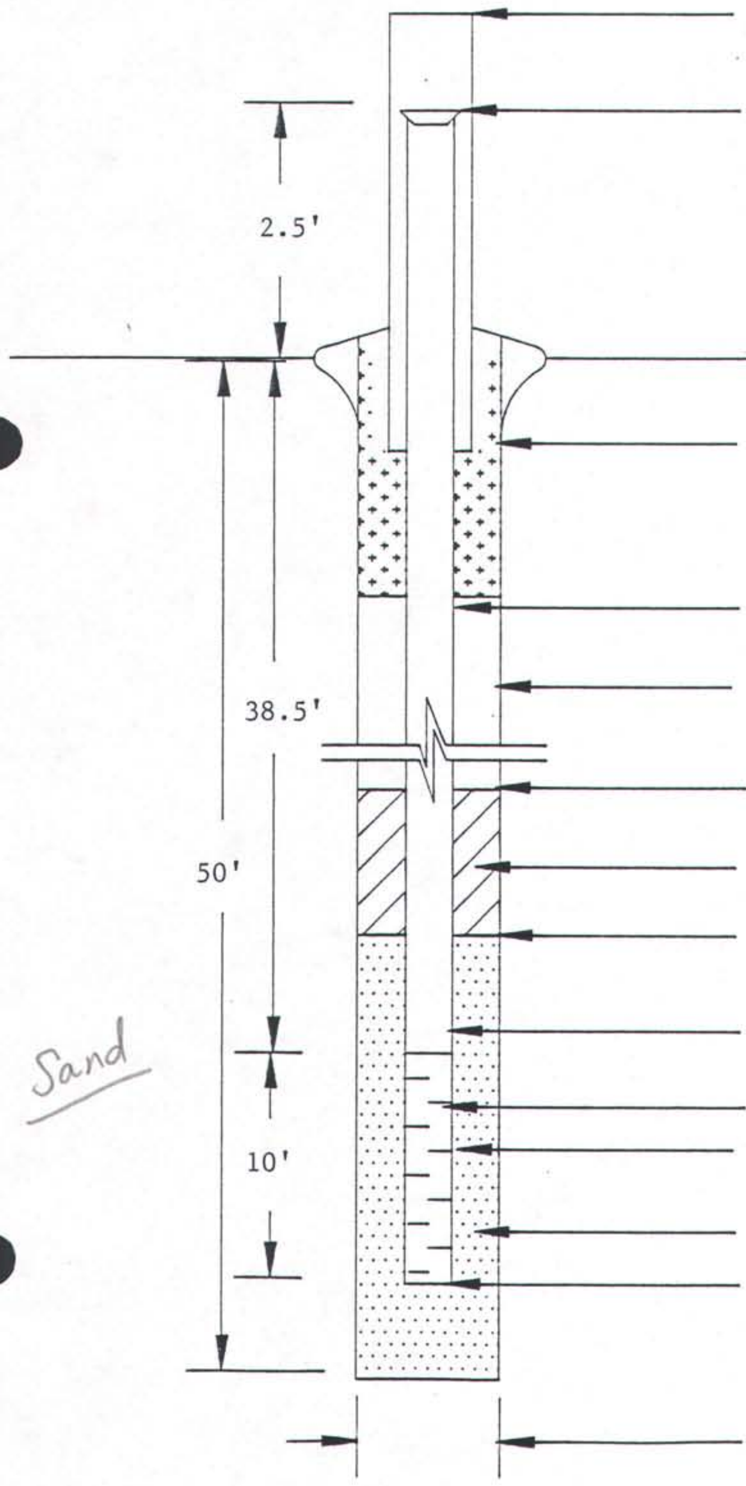
BENCH MARK DATA:

ELEVATION OF TOP OF PIEZOMETER: 294.2

PIEZOMETER NUMBER: MW 1 (B1)

DEPTH TO WATER LEVEL: 4.1'

ELEVATION OF WATER LEVEL: 287.6



PROTECTIVE BOX W/LOCKING CAP

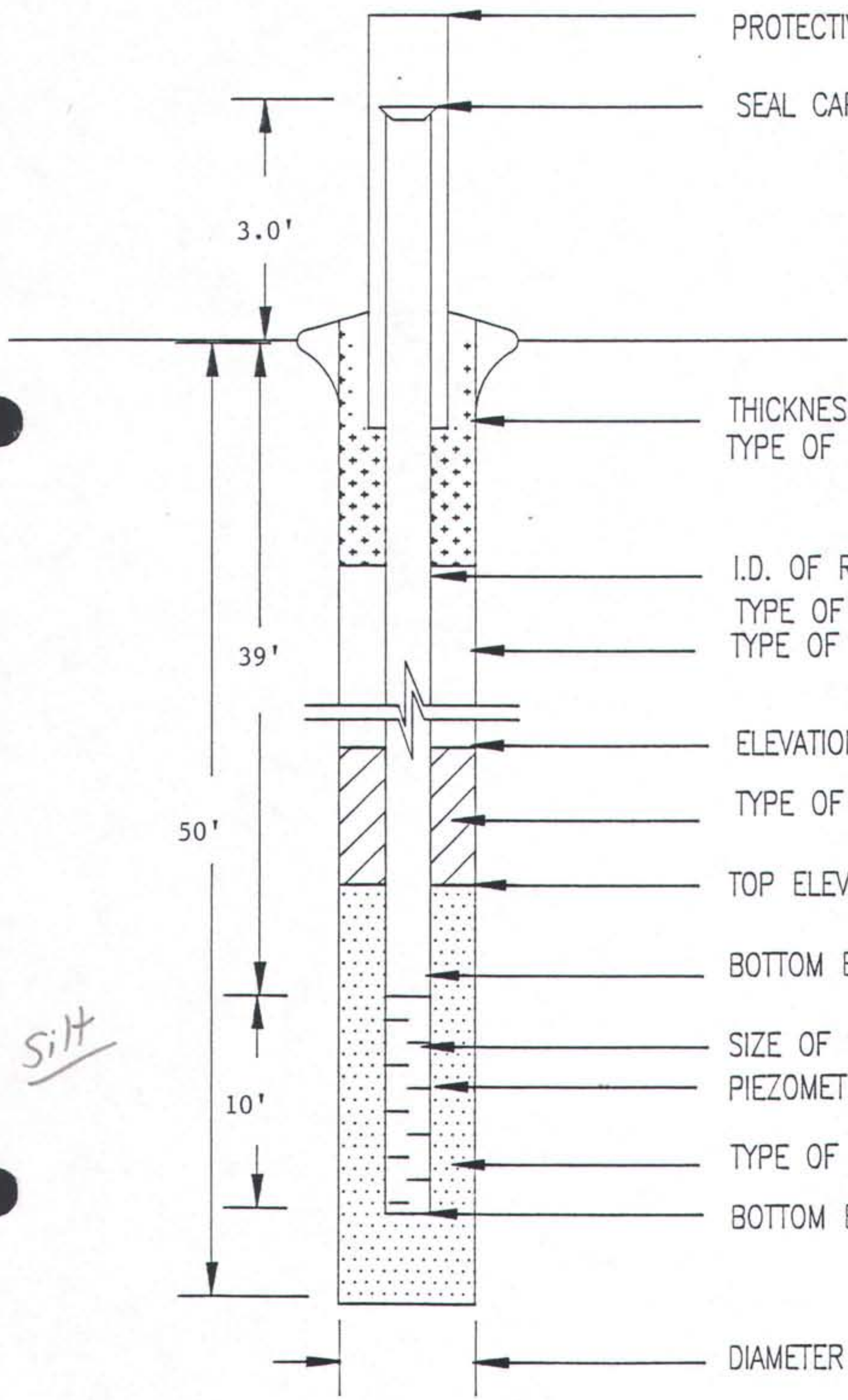
SEAL CAP

THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH. 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	255.2
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	254.2
BOTTOM ELEVATION OF RISER	253.2
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	243.2
DIAMETER OF BOREHOLE	7.75"

ENSCI
CORPORATION

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUNTY ASH MONOFILL
PIEZOMETER NUMBER: MW 3 (B-3)
GROUND ELEVATION: 318.2
DEPTH TO WATER LEVEL: 14.8'
BENCH MARK DATA:
ELEVATION OF WATER LEVEL: 303.4
ELEVATION OF TOP OF PIEZOMETER: 321.2

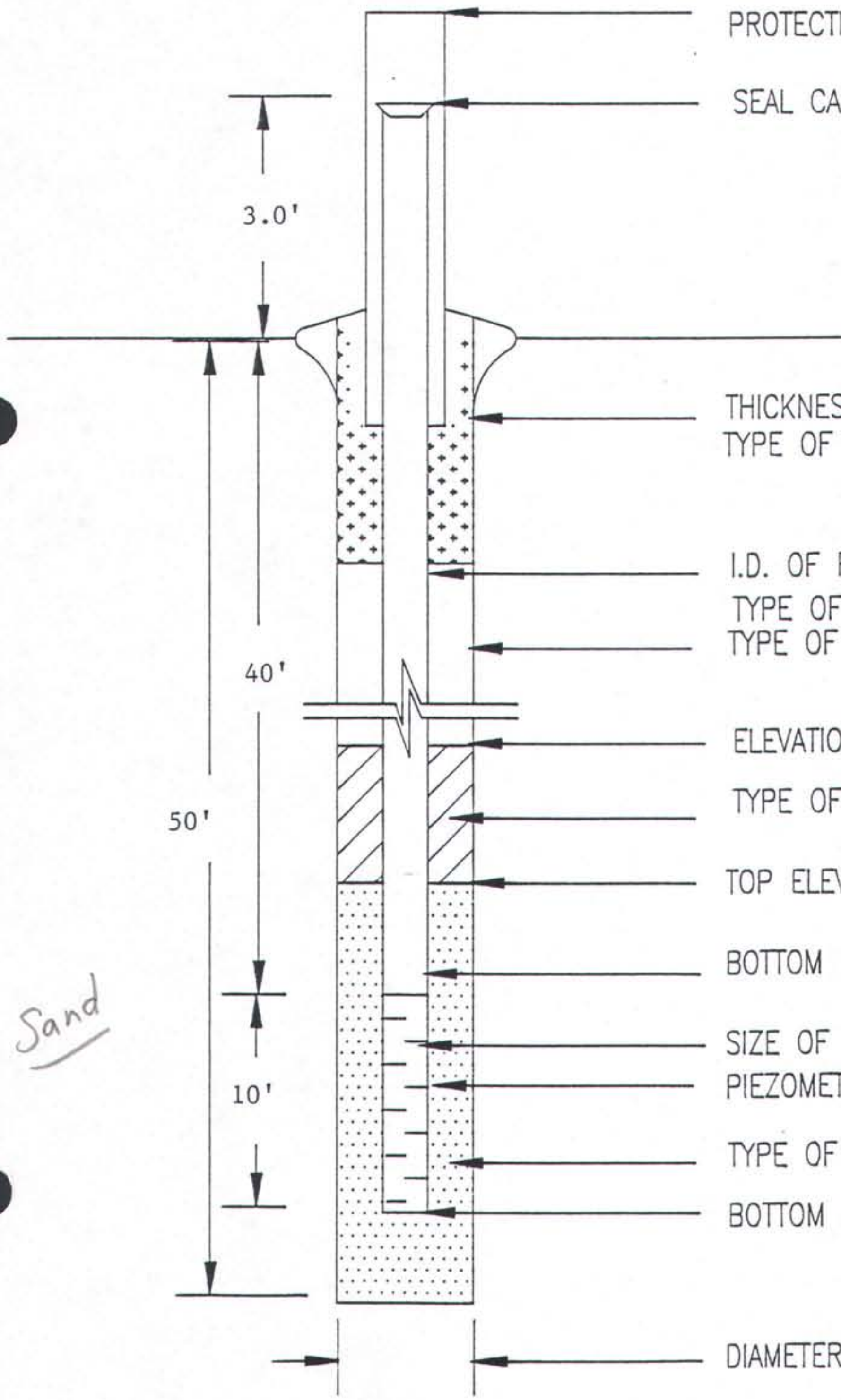


PROTECTIVE BOX W/LOCKING CAP	
SEAL CAP	
THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH. 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	281.2
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	280.2
BOTTOM ELEVATION OF RISER	279.2
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	269.2
DIAMETER OF BOREHOLE	7.75"

ENSCI CORPORATION

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUBTY ASH MONOFILL
PIEZOMETER NUMBER: MW 5 (B 5)
GROUND ELEVATION: 310.6
DEPTH TO WATER LEVEL: 21.4'
BENCH MARK DATA:
ELEVATION OF WATER LEVEL: 289.2
ELEVATION OF TOP OF PIEZOMETER: 313.6



PROTECTIVE BOX W/LOCKING CAP

SEAL CAP

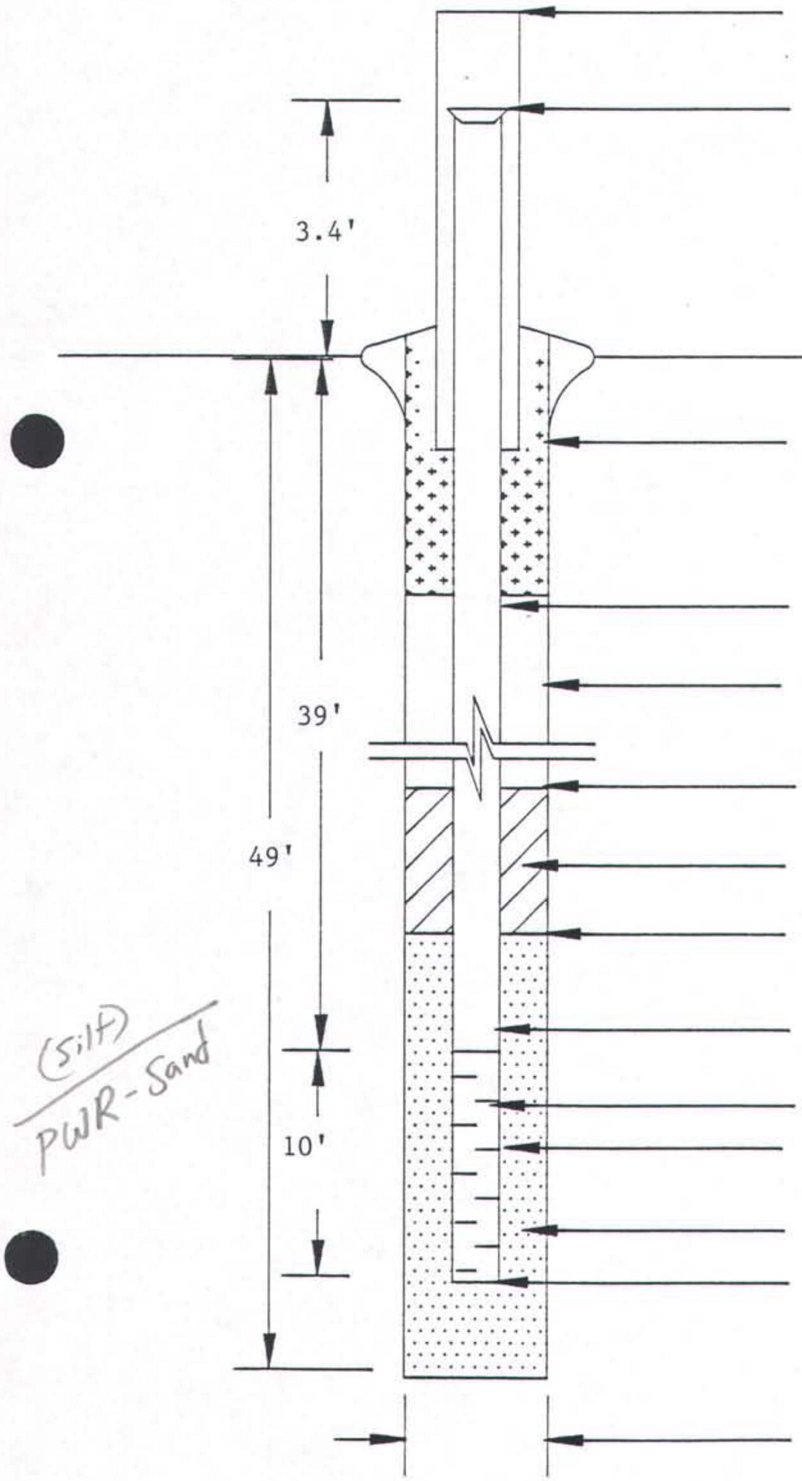
THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	272.6
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	271.6
BOTTOM ELEVATION OF RISER	270.6
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	260.6
DIAMETER OF BOREHOLE	7.75"

ENSCI CORPORATION

MONITORING WELL INSTALLATION SKETCH

PROJECT HALIFAX COUNTY ASH MONOFILL
GROUND ELEVATION 271.6
BENCH MARK DATA
ELEVATION OF TOP OF PIEZOMETER 275.0

PIEZOMETER NUMBER MW 7 (B 7)
DEPTH TO WATER LEVEL 2.8'
ELEVATION OF WATER LEVEL 268.8



PROTECTIVE BOX W/LOCKING CAP

SEAL CAP

THICKNESS OF SURFACE SEAL 2'
TYPE OF SURFACE SEAL PORTLAND CEMENT

I.D. OF RISER PIPE 2"
TYPE OF RISER PIPE SCH. 40 PVC
TYPE OF BACKFILL PORTLAND CEMENT

ELEVATION OF TOP OF SEAL 234.6

TYPE OF SEAL BENTONITE

TOP ELEVATION OF FILTER SAND 233.6

BOTTOM ELEVATION OF RISER 232.6

SIZE OF SCREEN OPENINGS .010"
PIEZOMETER SCREEN DIAMETER 2"

TYPE OF FILTER SAND C-33

BOTTOM ELEVATION OF PIEZOMETER 222.6

DIAMETER OF BOREHOLE 7.75"

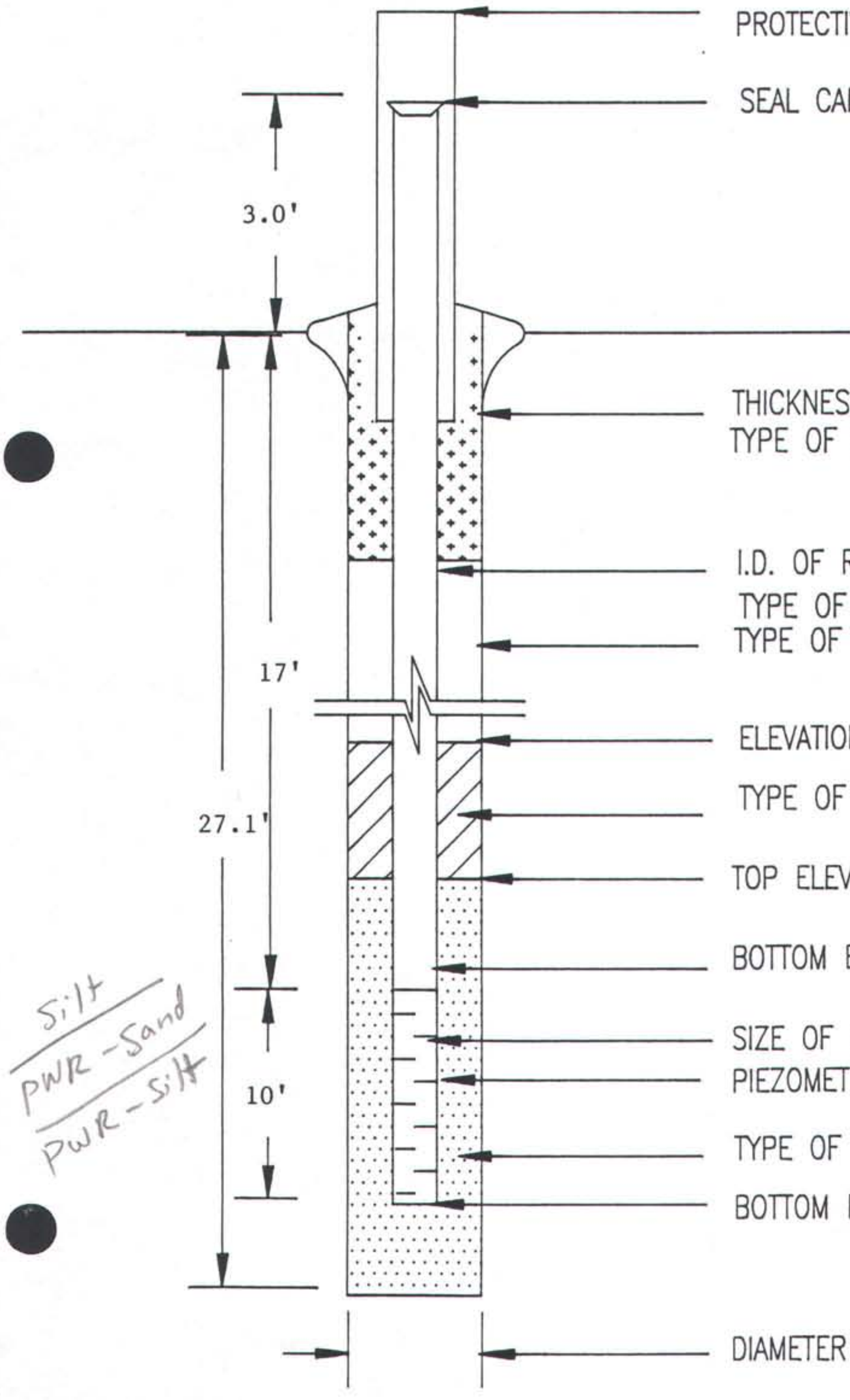
ENSCI CORPORATION

Corrected Copy
5-2-91

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUNTY ASH MONOFILL
GROUND ELEVATION: 273.9
BENCH MARK DATA:
ELEVATION OF TOP OF PIEZOMETER: 276.9

PIEZOMETER NUMBER: MW 8 (B 8)
DEPTH TO WATER LEVEL: 15.8'
ELEVATION OF WATER LEVEL: 258.0



PROTECTIVE BOX W/LOCKING CAP	
SEAL CAP	
THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	258.9
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	257.9
BOTTOM ELEVATION OF RISER	256.9
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	246.9
DIAMETER OF BOREHOLE	7.75"

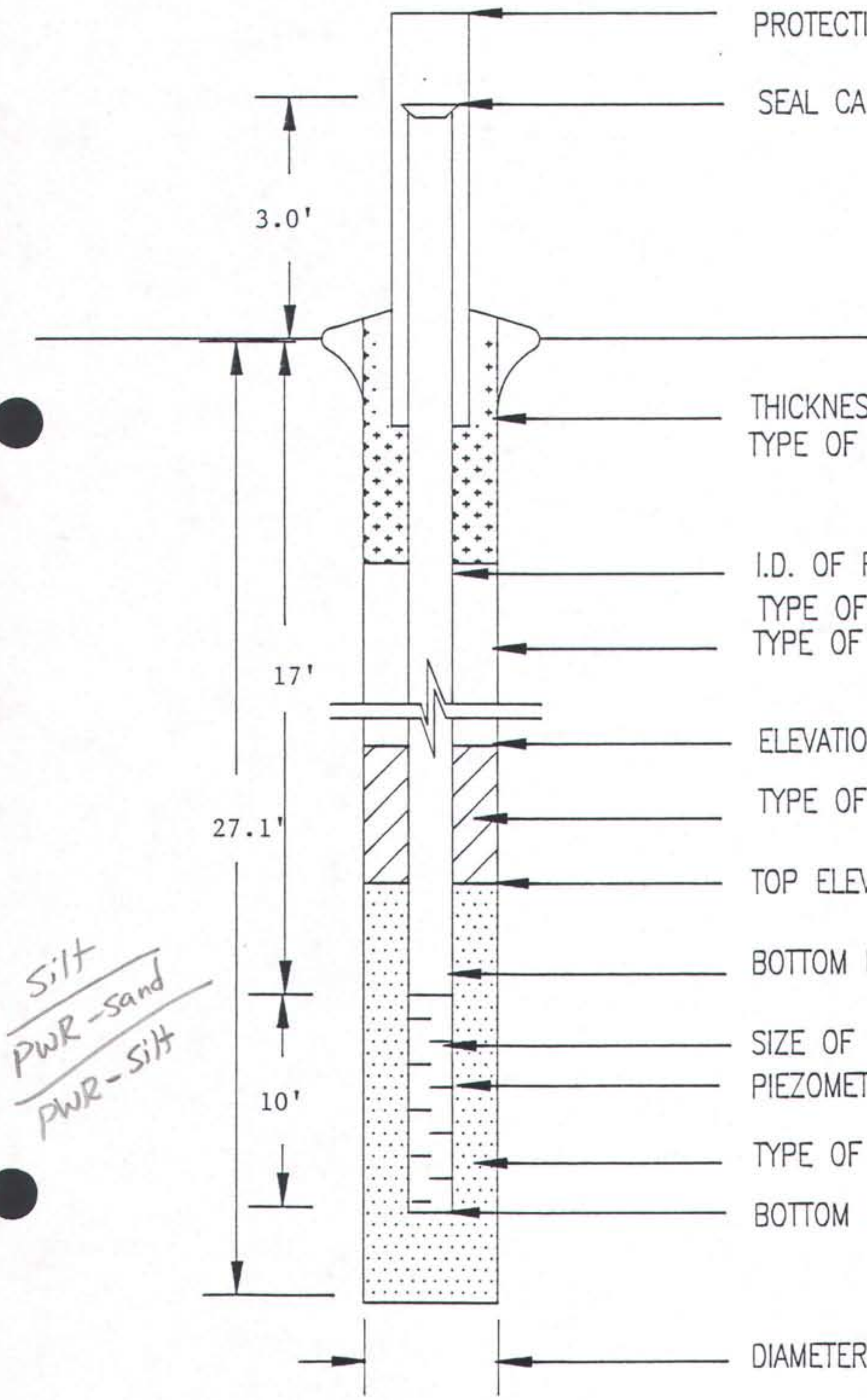
ENSCI CORPORATION

Original Submittal

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUNTY ASH MONOFILL
GROUND ELEVATION: 273.9
BENCH MARK DATA:
ELEVATION OF TOP OF PIEZOMETER: 276.9

PIEZOMETER NUMBER: MW 8 (B 8)
DEPTH TO WATER LEVEL: ~~31.7'~~
ELEVATION OF WATER LEVEL: 242.2 ?



PROTECTIVE BOX W/LOCKING CAP
SEAL CAP

THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	258.9
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	257.9
BOTTOM ELEVATION OF RISER	256.9
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	246.9
DIAMETER OF BOREHOLE	7.75"

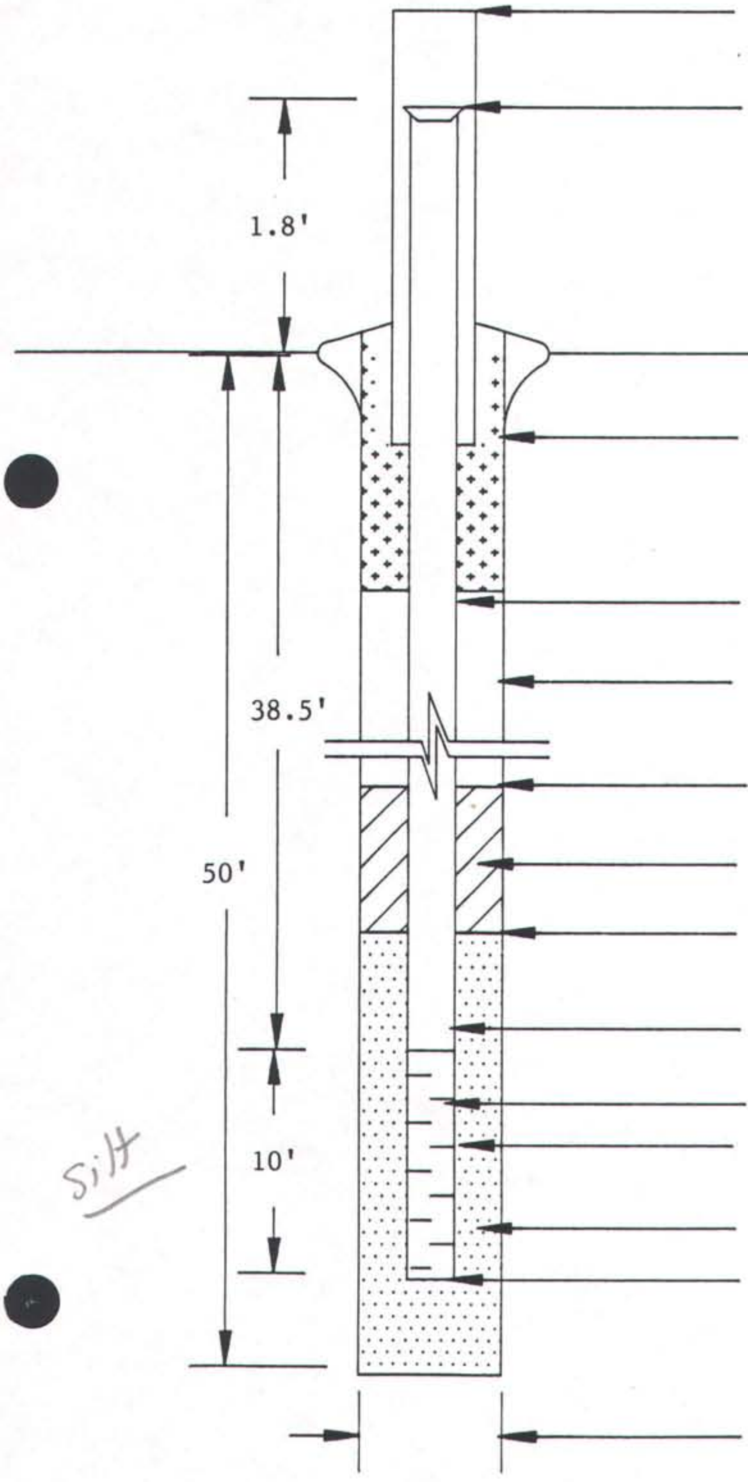
ENSCI CORPORATION

Corrected Copy
5-2-91

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUNTY ASH MONOFILL
GROUND ELEVATION: 314.6
BENCH MARK DATA:
ELEVATION OF TOP OF PIEZOMETER: 316.4

PIEZOMETER NUMBER: MW 9 (B 9)
DEPTH TO WATER LEVEL: 30.3'
ELEVATION OF WATER LEVEL: 284.3



PROTECTIVE BOX W/LOCKING CAP

SEAL CAP

THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH. 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	278.1
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	277.1
BOTTOM ELEVATION OF RISER	276.1
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	266.1
DIAMETER OF BOREHOLE	7.75"

ENSCI CORPORATION

original submittal

MONITORING WELL INSTALLATION SKETCH

PROJECT: HALIFAX COUNTY ASH MONOFILL

GROUND ELEVATION: 314.6

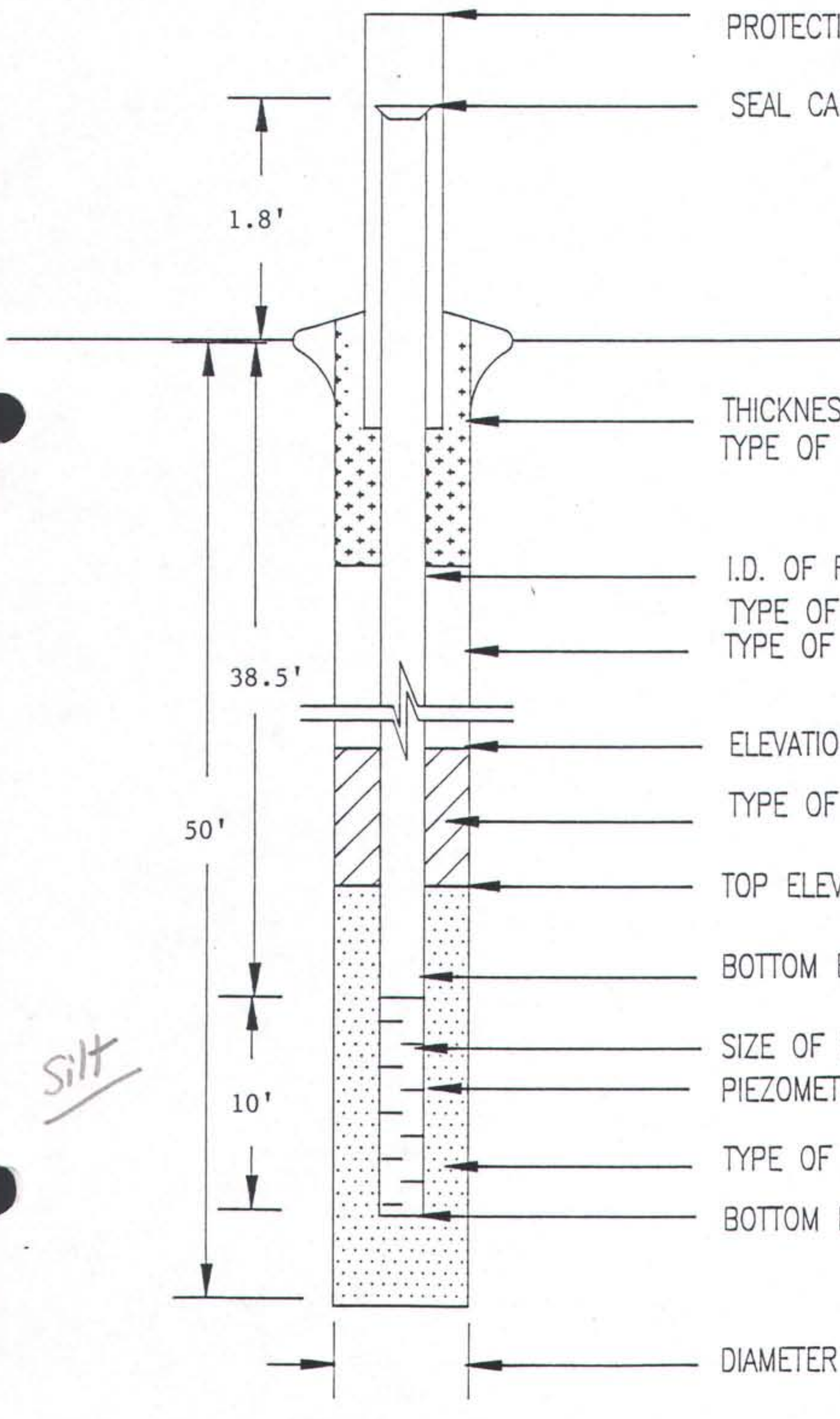
BENCH MARK DATA:

ELEVATION OF TOP OF PIEZOMETER: 316.4

PIEZOMETER NUMBER: MW 9 (B 9)

DEPTH TO WATER LEVEL: 31.7'

ELEVATION OF WATER LEVEL: 282.9 ?



PROTECTIVE BOX W/LOCKING CAP

SEAL CAP

THICKNESS OF SURFACE SEAL	2'
TYPE OF SURFACE SEAL	PORTLAND CEMENT
I.D. OF RISER PIPE	2"
TYPE OF RISER PIPE	SCH. 40 PVC
TYPE OF BACKFILL	PORTLAND CEMENT
ELEVATION OF TOP OF SEAL	278.1
TYPE OF SEAL	BENTONITE
TOP ELEVATION OF FILTER SAND	277.1
BOTTOM ELEVATION OF RISER	276.1
SIZE OF SCREEN OPENINGS	.010"
PIEZOMETER SCREEN DIAMETER	2"
TYPE OF FILTER SAND	C-33
BOTTOM ELEVATION OF PIEZOMETER	266.1
DIAMETER OF BOREHOLE	7.75"

B- Field Permeability

PROCEDURES FOR PERFORMING BOUWER AND RICE SLUG TEST

1. Obtain static groundwater level, standpipe diameter, depth of well, length of screen, borehole diameter and casing stickup for test well. Record on data sheet.

2. Indicate if the test will be a falling head (water added) or a rising head (water subtracted by bailing). Add or subtract water as needed and record water level at beginning of test as h_o.

3. Begin timing the rise or fall of the water level. Record the water level at even time increments (5 minute intervals, for instance). Adjust time increments as needed and record change in water level until equilibrium is established with static conditions.

4. Evaluate the head difference (Δh) for each time increment and plot on semi-log paper. Use appropriate Bouwer and Rice equations to determine permeability, k, for the aquifer near the well. Results can be checked with NAVFAC method.

5. Evaluate head ratio (h_t/h_o) and plot against time increments on semi-log paper if time-log method is to be used. Use appropriate equation referenced in Cedergren to evaluate k.

6. A list of equations for Bouwer and Rice, NAVFAC and time-log methods follow.

   REF: "The Bouwer and Rice Slug Test - An Update", by H. Bouwer, Groundwater, May-June, 1989, pp. 304-309.

SUMMARY OF PERMEABILITY
SLUG TESTS

BORING	BOUWER-RICE (PARTIAL DEPTH)	BOUWER-RICE (FULL DEPTH)	NAVFAC	HVORSLEV TIME-LAG
B-1	1.0×10^{-4}	-	4.64×10^{-5}	3.64×10^{-5}
B-3	8.72×10^{-6}	-	-	-
B-5	4.81×10^{-5}	-	-	-
B-7	2.85×10^{-5}	-	-	-
B-8	1.89×10^{-5}	2.29×10^{-5}	4.64×10^{-5}	8.40×10^{-6}
B-9	1.00×10^{-5}	-	-	-

ALL VALUES IN CM / SEC

SEE FOLLOWING LIST OF EQUATIONS & CALCULATIONS

SUMMARY OF GRADIENT AND
SEEPAGE VELOCITIES

BORING DATA	HORIZ. GRADIENT	VELOCITY ft / day	VELOCITY ft / yr	
B5 - B10	0.008	4×10^{-3}	(1.3)	1.46
B2 - B7	0.019	5×10^{-3}	1.9	
B9 - B8	0.017	3×10^{-3}	1.1	
AVG	0.015	4×10^{-3}	(1.4)	1.46

SLUG TEST EVALUATION

1. DATA COLLECTED IN FIELD AND RECORDED ON INDIVIDUAL RECORD FOR EACH BORING

2. DATA WAS REDUCED, PLOTTED (SEMI-LOG-VS-LOG) AND CALCULATION OF K PERFORMED FOR 3 METHODS AS FOLLOWS:

(I) BOUWER-RICE (REF. GROUND WATER, MAY-JUNE 1989)

EQ 3: $$K = \frac{(r_c)^2 \ln(R_e/r_w)}{2L_e} \cdot \frac{1}{t} \ln\left(\frac{Y_0}{Y_t}\right)$$

EQ 4: $$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{L_w}{r_w}\right)} + \frac{A + B \ln\left(\frac{H - L_w}{r_w}\right)}{(L_e/r_w)} \right]^{-1}$$

EQ 5: $$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{L_w}{r_w}\right)} + \frac{C}{(L_e/r_w)} \right]^{-1}$$

WHERE: A, C EVALUATED FR. FIG 2 FOR ~~PARTIAL~~ PENTRATION

B " " " FULL "

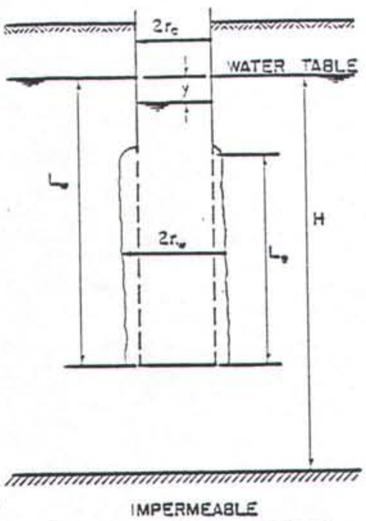


Fig. 1. Geometry and symbols for slug test on partially penetrating, partially screened well in unconfined aquifer with gravel pack and/or developed zone around screen.

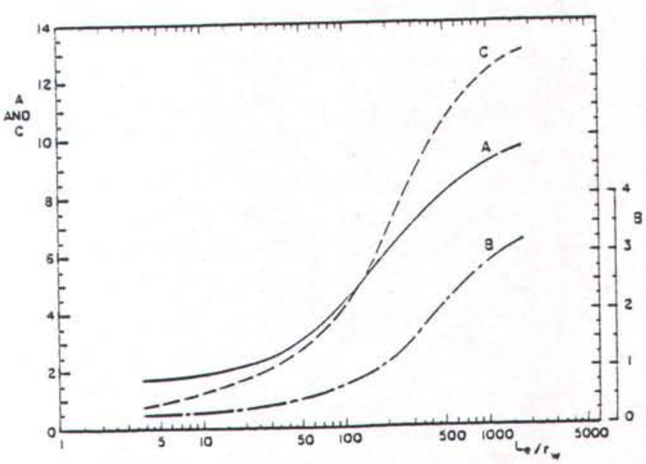
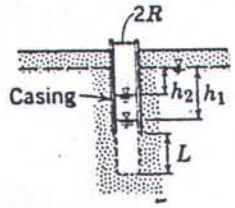


Fig. 2. Dimensionless parameters A, B, and C as a function of L_e/r_w for calculation of $\ln(R_e/r_w)$.

(II) NAVFAC (REF. CEDERGREN, 2nd Ed., p. 67)

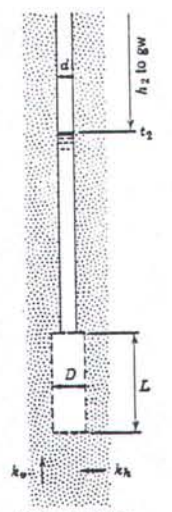
CASE C: CASED HOLE W/ SCREENED EXTENSION



$$k = \frac{R^2}{2L} \ln\left(\frac{L}{R}\right) \left[\frac{\ln(h_2/h_1)}{t_2 - t_1}\right]$$

(III) HVORSLEV TIME-LAG (REF. CEDERGREN, p. 75)

CASE E: WELL-POINT IN UNIFORM SOIL



Well point-filter in uniform soil
(e)

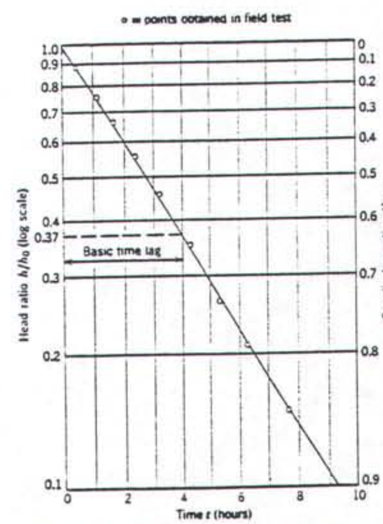


FIG. 2.19 Plot used for basic time lag determination.

SLUG TEST FIELD REPORT

JOB HALIFAX

BORING NO. B-1

DATE 3-4-91

PERFORMED BY JDE

WELL CASING DIAM. 2"

SCREEN LENGTH 10'

DEPTH TO BOTTOM 48.5' below ground

STICK UP LENGTH 2.5'

REFERENCE POINT:

( ) GROUND SURFACE

(✓) TOP OF CASING

(CHECK ONE)

TYPE OF TEST: (✓) FALLING HEAD/( ) RISING HEAD

STATIC WATER LEVEL BEFORE TEST 4.9' (59")

ELAPSED TIME (min.)*	WATER LEVEL (ft.)	HEAD DIFF. (Δh)	HEAD RATIO (h_t/h_o)
0	0 (h_o)	59"	1.0
5	49"	10"	.169
10	52"	7"	.119
15	57"	2"	.034
20	58"	1"	.017
25	"	1"	"
30	"	1"	"
40	59"	0"	0

CASING AREA

$A = \pi \frac{d^2}{4}$

$= 3.14 \text{ in}^2$

VOLUME

$V = A(\Delta h)$

= 0.107 ft³

X 7.48 gal/ft³

= 0.802 gal

Added

STATIC WATER LEVEL AFTER TEST 59"

*ADJUST TIMES AS NEEDED

100

LOG Y_t - VS - t

$t = 0$

$Y_0 = 59''$

BOUWER - RICE $r_c = 1.0''$ $L_e = 120''$

$r_w = 3.87''$ $L_w = 45.3' = 543.6''$

PARTIALLY PENETRATING; $H = 1200''$ $A = 2.5$, $B = 0.4$

$$\text{EQ 4;} \quad \ln\left(\frac{R_e}{r_w}\right) = \frac{1.1}{\ln\left(\frac{543.3}{3.87}\right)} + \frac{2.5 + 0.4 \ln\left(\frac{1200-543.6}{3.87}\right)}{\left(120/3.87\right)}$$

10

$$= 2.71$$

Y_t

$$\text{EQ 3:} \quad K = \frac{1.0^2(2.71)}{2(120)} \cdot \frac{1}{1750} \ln\left(\frac{59}{1}\right)$$

$$= 3.84 \times 10^{-5} \text{ in/s} = \underline{1.0 \times 10^{-4} \text{ cm/s}}$$

$t = 1200$ s

$Y_t = 1''$

1.0

STATIC

LOG H_t/H_o - VS - t

1.0

$t_1 = 0$

$h_1 = 59''$

NAVFAC $R = 1.0''$ $L = 120''$

.37 → $T = 300$ s

$$K = \frac{R^2}{2L} \ln\left(\frac{L}{R}\right)\left[\frac{\ln h_2/h_1}{t_2 - t_1}\right]$$

$$= \frac{(1.0)^2}{2(120)} \ln\left(\frac{120}{1.0}\right)\left[\frac{\ln 54/18}{1800-600}\right]$$

$\frac{H_t}{H_o}$

$$= 1.83 \times 10^{-5} \text{ in/s} = \underline{4.64 \times 10^{-5} \text{ cm/s}}$$

0.1

HVORSLEV $d = 1.0''$, $D = 3.87''$, $L = 120''$, $m = 1.0$

$$K = \frac{d^2 \ln\left(\frac{2mL}{D}\right)}{8LT} = \frac{(1.0)^2 \ln\left[\frac{2(1.0)(120)}{3.87}\right]}{8(120)(300)}$$

$t_2 = 1200$ s

$h_2 = 1.0''$

STATIC

$$= 1.43 \times 10^{-5} \text{ in/s} = \underline{3.64 \times 10^{-5} \text{ cm/s}}$$

.01

2 4 6 8 10 12

SLUG TEST FIELD REPORT

JOB HALIFAX

BORING NO. B-3 (MW-3)

DATE 3-4-91

PERFORMED BY JDB

WELL CASING DIAM. 2"

SCREEN LENGTH 10'

DEPTH TO BOTTOM 49'

STICK UP LENGTH 3.0'

REFERENCE POINT:

(✓) GROUND SURFACE

( ) TOP OF CASING

(CHECK ONE)

TYPE OF TEST: ( ) FALLING HEAD/(✓) RISING HEAD

STATIC WATER LEVEL BEFORE TEST 14.8'

ELAPSED TIME (min.)*	WATER LEVEL (ft.)	HEAD DIFF. (Δh)	HEAD RATIO (h_t/h_o)
0	45.5' (h_o)	30.7	
5	42.5	27.7	
10	39.2	24.4	
15	37.5	22.7	
20	35.8	21.0	
25	34.1	19.0	
30	32.5	17.7	
35	31.5	16.7	
40	28.5	13.7	
50	27.5	12.7	
60	25.5	10.7	
75	24.5	9.7	
90	22.5	7.7	
105	21.5	6.7	
120	20.1	5.3	
235	19.2	4.4	

CASING AREA

$A = \pi \frac{d^2}{4}$

= 3.14 in²

VOLUME

$V = A(\Delta h)$

= 0.99 ft³

X 7.48 gal/ft³

= 7.43 gal

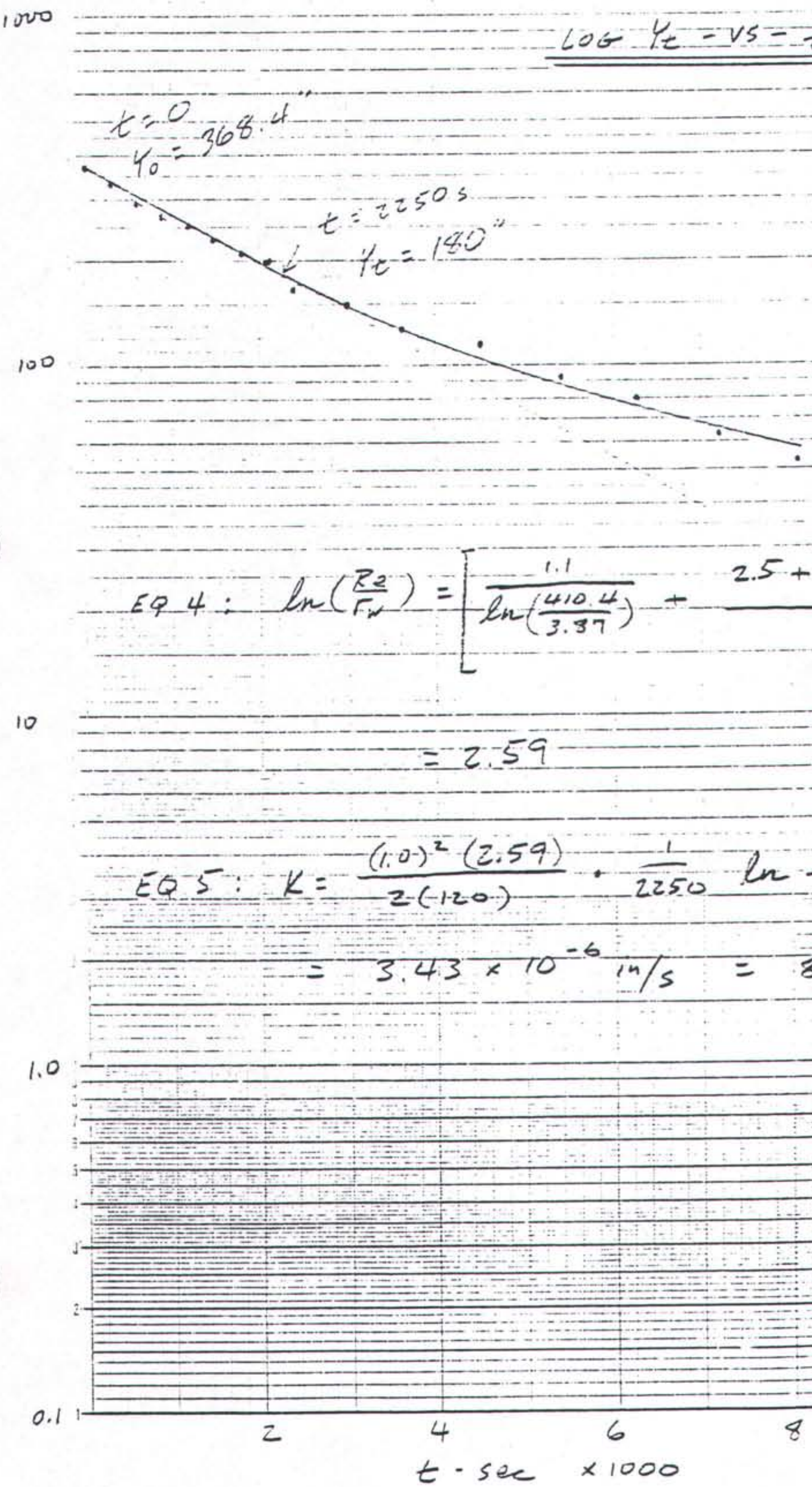
subtracted

STATIC WATER LEVEL AFTER TEST NA

*ADJUST TIMES AS NEEDED

E-3

LOG Y_t - VS - t



$r_c = 1.0''$

$r_w = 3.87''$

$L_e = 120''$

$L_w = 34.2' = 410.4''$

$A = 2.5, \; B = 0.4$

$H = 1200''$

EQ 4:

$$\ln\left(\frac{R_2}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{410.4}{3.87}\right)} + \frac{2.5 + 0.4\ln\left(\frac{1200 - 410.4}{3.87}\right)}{\left(\frac{120}{3.87}\right)}\right]^{-1}$$

$$= 2.59$$

EQ 5:

$$K = \frac{(1.0)^2\,(2.59)}{2\,(120)} \cdot \frac{1}{2250}\ln\frac{368}{180}$$

$$= 3.43 \times 10^{-6} \text{ in/s} = 8.72 \times 10^{-6} \text{ cm/s}$$

SLUG TEST FIELD REPORT

JOB HALIFAX

BORING NO. B-5

DATE 3-5-91

PERFORMED BY JDB

WELL CASING DIAM. 2"

SCREEN LENGTH 10'

DEPTH TO BOTTOM 50'

STICK UP LENGTH 3.0'

REFERENCE POINT:

(✓) GROUND SURFACE

( ) TOP OF CASING

(CHECK ONE)

TYPE OF TEST: (✓) FALLING HEAD/( ) RISING HEAD

STATIC WATER LEVEL BEFORE TEST 22.5'

ELAPSED TIME (min.)*	WATER LEVEL (ft.)	HEAD DIFF. (Δh)	HEAD RATIO (h_t/h_o)
0	+3.0 (h_o) Above Ground	30½" (25.5')	
5	21.1 below ground	17"	
10	22.1 below ground	5"	
15	22.25 below ground	3"	
20	22.3 below ground	2"	
25	22.4	1"	
30	22.5'	0	
35	"		
40	"		

CASING AREA

$A = \pi \frac{d^2}{4}$

= 3.14 in²

VOLUME

$V = A(\Delta h)$

= 0.56 ft³

X 7.48 gal/ft³

= 4.14 gal

STATIC WATER LEVEL AFTER TEST 22.5

*ADJUST TIMES AS NEEDED

B-5

$r_c = 1.0''$

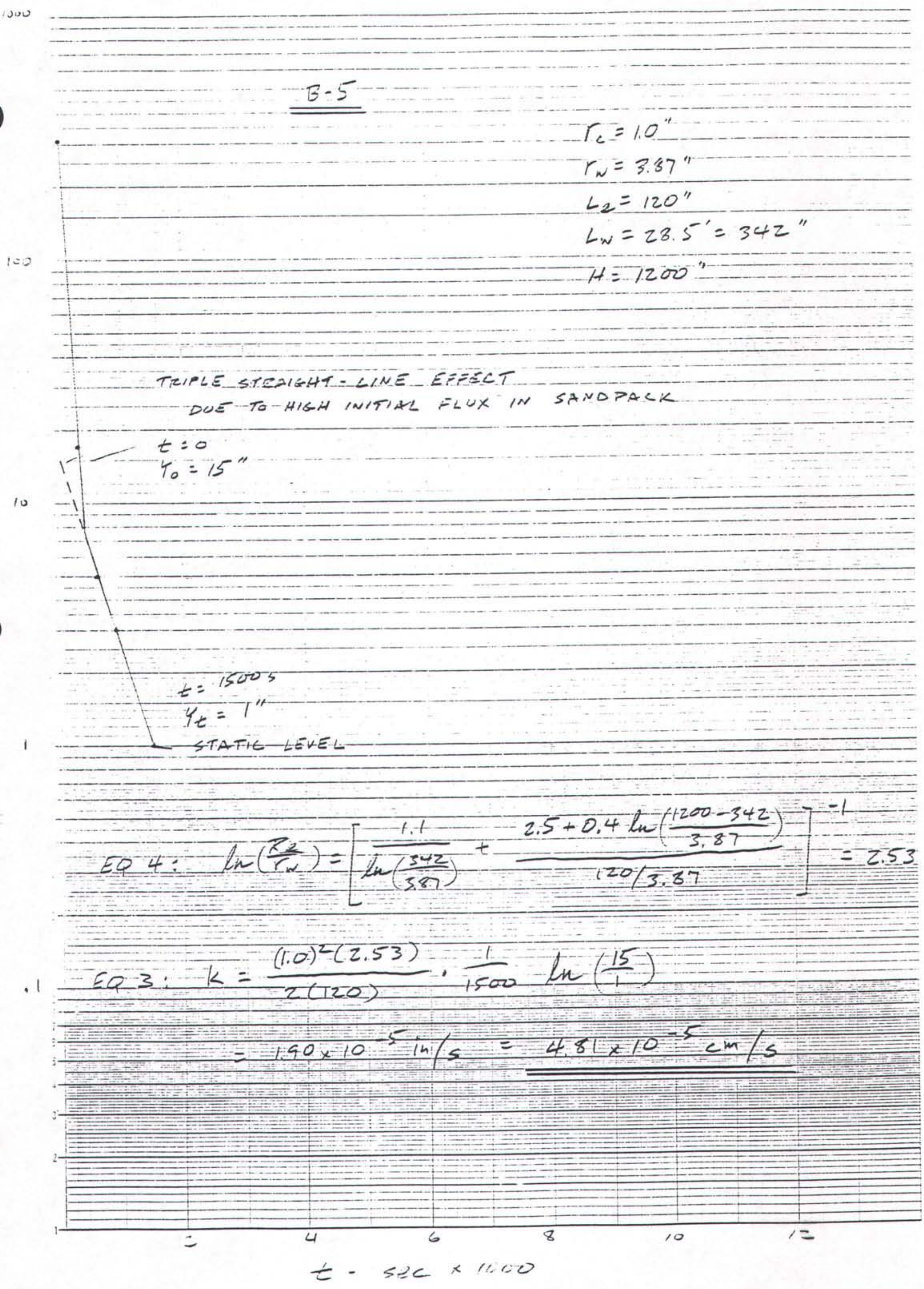
$r_w = 3.87''$

$L_e = 120''$

$L_w = 28.5' = 342''$

$H = 1200''$

TRIPLE STRAIGHT-LINE EFFECT DUE TO HIGH INITIAL FLUX IN SANDPACK



EQ 4: $$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{342}{3.87}\right)} + \frac{2.5 + 0.4\ln\left(\frac{1200-342}{3.87}\right)}{120/3.87}\right]^{-1} = 2.53$$

EQ 3: $$k = \frac{(1.0)^2(2.53)}{2(120)} \cdot \frac{1}{1500} \ln\left(\frac{15}{1}\right)$$

$$= 1.90 \times 10^{-5} \text{ in/s} = 4.81 \times 10^{-5} \text{ cm/s}$$

SLUG TEST FIELD REPORT

JOB HALIFAX

BORING NO. B-7

DATE 3-5-91

PERFORMED BY JDB

WELL CASING DIAM. 2"

SCREEN LENGTH 10'

DEPTH TO BOTTOM 49'

STICK UP LENGTH 3.4'

REFERENCE POINT:

( ) GROUND SURFACE

(✓) TOP OF CASING

(CHECK ONE)

TYPE OF TEST: (✓) FALLING HEAD/( ) RISING HEAD

STATIC WATER LEVEL BEFORE TEST 6.5

ELAPSED TIME (min.)*	WATER LEVEL (ft.)	HEAD DIFF. (Δh)	HEAD RATIO (h_t/h_o)
0	0 (h_o)	78"	
5	1.9'	56"	
10	2.25'	51"	
15	3.4'	31"	
20	4.5'	24"	
25	4.9'	21"	
30	5.5'	12"	
40	5.8'	8"	
45	6.2'	4"	
50	6.5'	0"	
60	6.5'	0	

CASING AREA

$A = \pi \frac{d^2}{4}$

$= 3.14 \text{ in}^2$

VOLUME

$V = A(\Delta h)$

$= 0.14 \text{ ft}^3$

X 7.48 gal/ft^3

= 1.06 gal

STATIC WATER LEVEL AFTER TEST 6.5

*ADJUST TIMES AS NEEDED

B-7

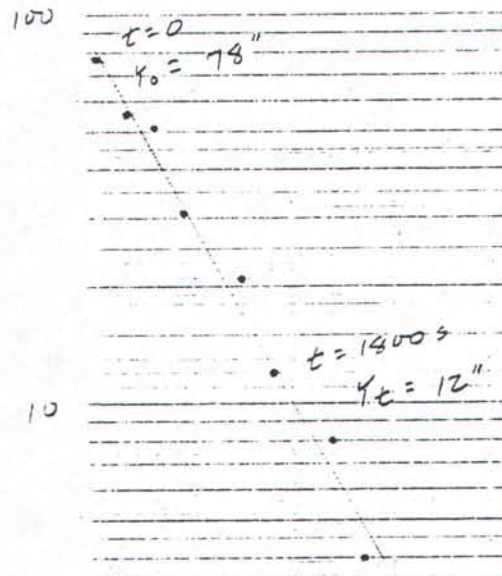
LOG Y_t -VS- t

$r_c = 1.0''$

$r_w = 3.87''$

$L_e = 120''$

$L_w = 45.5' = 546''$



EQ 4: $$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{546}{3.87}\right)} + \frac{2.5 + 0.4\ln\left(\frac{1200-546}{3.87}\right)}{\left(120/3.87\right)}\right]^{-1} = 2.59$$

EQ 3: $$k = \frac{(1.0)^2(2.59)}{2(120)} \cdot \frac{1}{1800} \ln\left(\frac{78}{12}\right)$$

$$= 1.12 \times 10^{-5} \text{ in/s} = \underline{2.85 \times 10^{-5} \text{ cm/s}}$$

1000

1

.1

2 4 6 8 10 12

t - sec × 1000

SLUG TEST FIELD REPORT

JOB HALIFAX

BORING NO. B-8

DATE 3-4-91

PERFORMED BY JDB

WELL CASING DIAM. 2"

SCREEN LENGTH 10'

DEPTH TO BOTTOM 27'

STICK UP LENGTH 3.0'

REFERENCE POINT:

(✓) GROUND SURFACE

( ) TOP OF CASING

(CHECK ONE)

TYPE OF TEST: ( ) FALLING HEAD/(✓) RISING HEAD

STATIC WATER LEVEL BEFORE TEST 15.3'

ELAPSED TIME (min.)*	WATER LEVEL (ft.)	HEAD DIFF. (Δh)	HEAD RATIO (h_t/h_o)
0	21.5' (h_o)	6.2'	1.0
5	20.1'	4.4'	0.77
10	19.8'	4.5'	0.73
15	18.8'	3.5'	.56
20	17.8'	2.5'	.40
25	17.1'	1.8'	.29
30	16.8'	1.5'	.24
40	16.5'	1.2'	.19
50	16.3'	1.0'	.16
60	"	"	"
75	"	"	"
90	16.2'	0.9'	.15
105	"	"	"
120	"	"	"

CASING AREA

$A = \pi \frac{d^2}{4}$

$= 3.14 in^2$

VOLUME

$V = A(\Delta h)$

$= 0.14$ ft³

X 7.48 gal/ft³

$= 1.01$ gal

subtracted

STATIC WATER LEVEL AFTER TEST 16.2'

*ADJUST TIMES AS NEEDED

BOUWER-RICE $r_c = 1.0''$ $L_e = 120''$

$r_w = 3.87''$ $L_w = 11.7' = 140.4''$

① PARTIAL PENETRATING : $H = 1200''$, $L_e/r_w = 31.0 \rightarrow A = 2.5,\ B = 0.4$

$$\text{EQ 4:}\quad \ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{140.4}{3.87}\right)} + \frac{2.5 + 0.4\ln\left(\frac{1200-140.4}{3.87}\right)}{\left(120/3.87\right)}\right]^{-1} = 2.18$$

$$\text{EQ 3:}\quad k = \frac{1.0(2.18)}{2(120)} \cdot \frac{1}{1750}\ln\left(\frac{80}{19}\right)$$

$$= 7.45\times10^{-6}\ \text{in/s} = \underline{1.89\times10^{-5}\ \text{cm/s}}$$

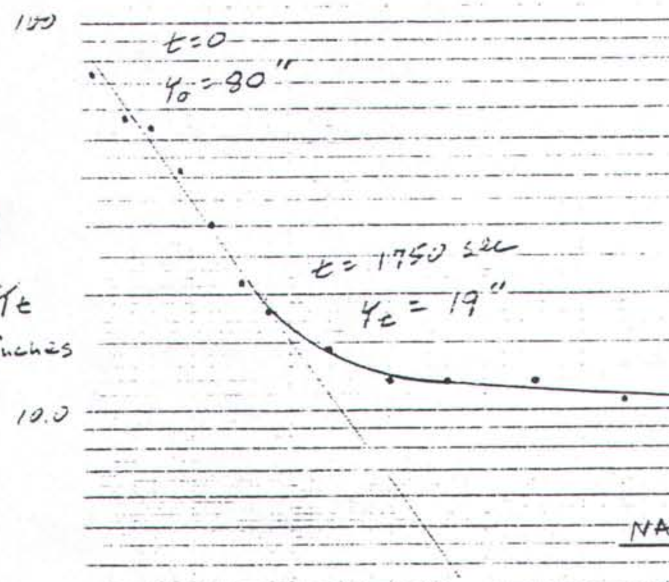
LOG Y_t - VS - t

② FULLY PENETRATING CASE : $H = L_w$

$c = 2.0$ (Fig 2)

EQ 5: $\ln\left(\frac{R_e}{r_w}\right) = 2.70$

EQ 3: 9.0×10^{-6} in/s $= \underline{2.29\times10^{-5}\ \text{cm/s}}$



NAVFAC

$$k = \frac{(1.0)^2}{2(120)}\ln\left(\frac{120}{1.0}\right)\left[\frac{\ln 54/18}{1800-600}\right]$$

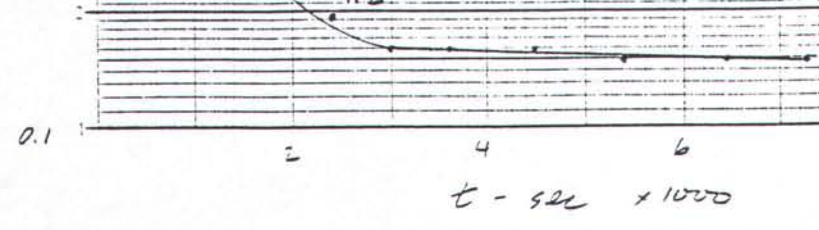
$$= 1.83\times10^{-5}\ \text{in/s} = \underline{4.64\times10^{-5}\ \text{cm/s}}$$

LOG $\left(\frac{h_t}{h_o}\right)$ - VS - t

HVORSLEV

$$k = \frac{(1.0)^2\ln\left(\frac{2(1.0)(120)}{3.87}\right)}{8(120)(1300)}$$

$$= 3.31\times10^{-6}\ \text{in/s} = \underline{8.40\times10^{-6}\ \text{cm/s}}$$



SLUG TEST FIELD REPORT

JOB HALIFAX

BORING NO. B-9

DATE 2-26-91

PERFORMED BY JDB

WELL CASING DIAM. 2"

SCREEN LENGTH 10'

DEPTH TO BOTTOM 48.5'

STICK UP LENGTH 1.8'

REFERENCE POINT:

(✓) GROUND SURFACE

( ) TOP OF CASING

(CHECK ONE)

TYPE OF TEST: ( ) FALLING HEAD/(✓) RISING HEAD

STATIC WATER LEVEL BEFORE TEST 30.3'

ELAPSED TIME (min.)*	WATER LEVEL (ft.)	HEAD DIFF. (Δh)	HEAD RATIO (h_t/h_o)
0	47.5' (h_o)	17.2'	
5	45.6'	15.3'	
10	45.3'	15.0'	
15	42.9'	12.6'	
30	39.3'	9.0'	
45	37.0'	6.7'	
60	35.3'	5.0'	
90	32.8'	2.5'	
120	31.6'	1.3'	
150	31.1'	0.8'	
240	30.7'	0.4'	
300	30.6'	0.3'	
360	30.6'	0.3'	

CASING AREA

$A = \pi \frac{d^2}{4}$

= 3.14 in^2

VOLUME

$V = A(\Delta h)$

= 0.38 ft^3

X 7.48 gal/ft^3

= 2.81 gal

subtracted

STATIC WATER LEVEL AFTER TEST 30.6'

*ADJUST TIMES AS NEEDED

B-9

LOG Y_t vs. t

$r_c = 1.0''$

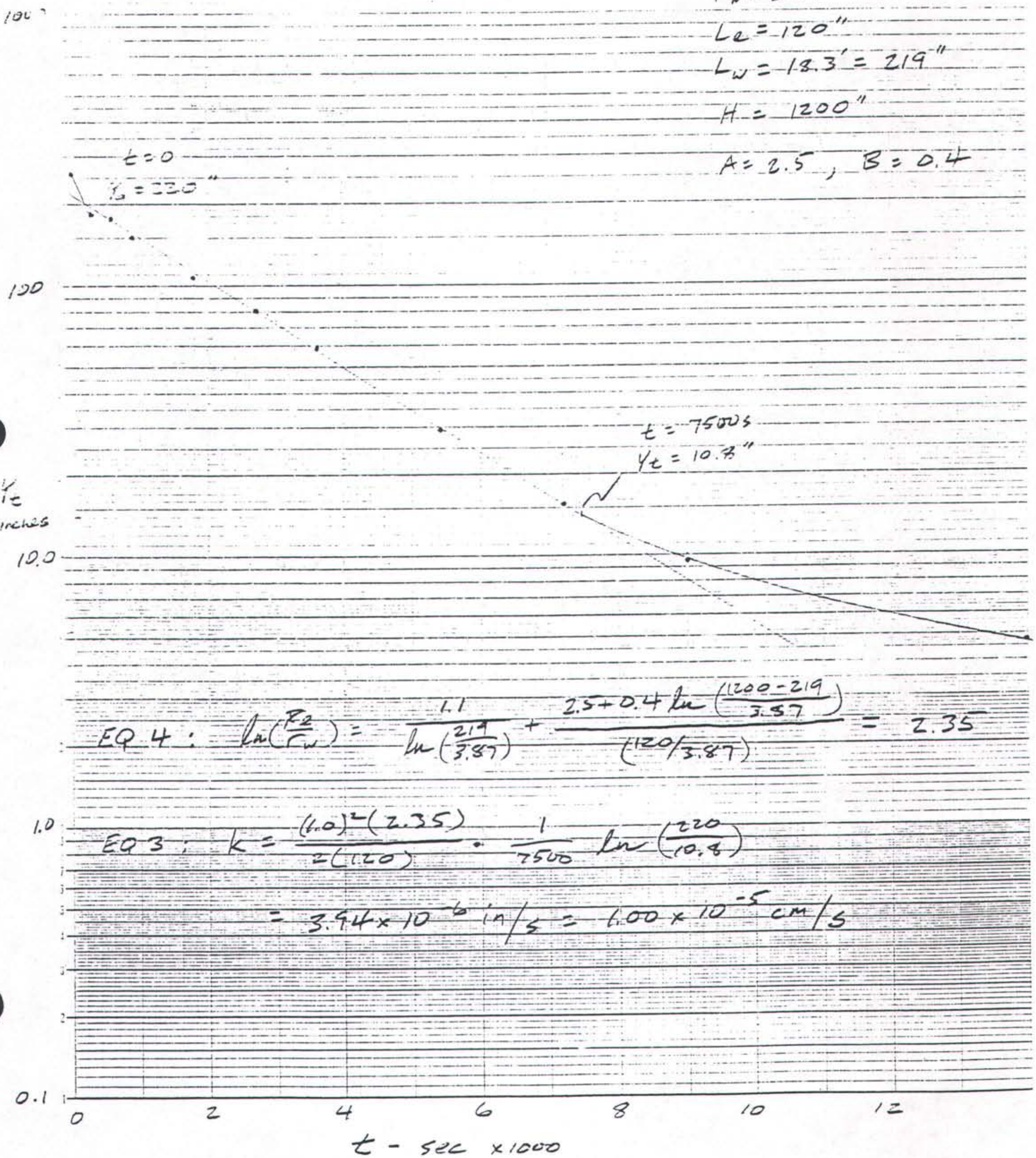
$r_w = 3.87''$

$L_e = 120''$

$L_w = 18.3' = 219''$

$H = 1200''$

$A = 2.5$, $B = 0.4$



EQ 4 : $$\ln\left(\frac{R_e}{r_w}\right) = \left[\frac{1.1}{\ln\left(\frac{219}{3.87}\right)} + \frac{2.5 + 0.4\ln\left(\frac{1200-219}{3.87}\right)}{(120/3.87)}\right]^{-1} = 2.35$$

EQ 3 : $$k = \frac{(1.0)^2(2.35)}{2(120)} \cdot \frac{1}{7500} \ln\left(\frac{220}{10.8}\right)$$

$$= 3.94 \times 10^{-6}\ \text{in/s} = 1.00 \times 10^{-5}\ \text{cm/s}$$

HORIZONTAL GRADIENT BETW. B-5 & B-10

L = horizontal distance = 1150'

h = groundwater elev. difference { B-5 - 288.7 ; B-10 - 279.5 } = 9.2'

i = gradient = $\frac{h}{L} = \frac{9.2}{1150} = 0.008$

SEEPAGE VELOCITY BETW. B-5 & B-10

$k \approx 4.81 \times 10^{-5}$ cm/s $\approx 9.62 \times 10^{-5}$ ft/min (B-5)

Assume $n_e = 0.30$

$V = ki/n_e = (9.62 \times 10^{-5})(.008)/0.30 = 2.57 \times 10^{-6}$ ft/min

CONVERSION FACTORS

1 ft/min = 1.44×10^{3} ft/day → 4×10^{-3} ft/day

1 ft/min = 5.25×10^{5} ft/yr → 1.3 ft/year

HORIZONTAL GRADIENT BETW. B-2 & B-7

$L = 1720'$

El. 301.5 (B-2)

El. 268.0 (B-7)

$h = 33.5$

$i = h/L = 0.019$

SEEPAGE VELOCITY BTW. B-2 & B-7

$k \approx 2.85 \times 10^{-5}$ cm/s $= 5.70 \times 10^{-5}$ ft/min (B-7)

Assume $n_e = 0.30$

$V = ki/n_e = 3.7 \times 10^{-6}$ ft/min

$= 5.0 \times 10^{-3}$ ft/day

$= 1.9$ ft/year

HORIZONTAL GRADIENT BETW. B-9 & B-8

EL 283.1 (B-9)

EL 268.0 (B-8)

$L = 900'$ $h = 15.1'$

$i = h/L = 0.017$

SEEPAGE VELOCITY BTW. B-9 & B-8

$k \approx 1.89 \times 10^{-5}$ cm/s $= 3.78 \times 10^{-5}$ f/min (B-8)

Assume $n_e = 0.30$

$V = ki/n_e = 2.1 \times 10^{-6}$ ft/min

$= 3 \times 10^{-3}$ ft/day

$= 1.1$ ft/year

C- Soil Laboratory

LABORATORY TEST PROCEDURES

Moisture Content: The moisture content of several samples were determined. The moisture content is the ratio, expressed as a percentage of the weight of the water in a given mass of soil to the weight of the solid particles. This test was conducted in accordance with ASTM Designation D-2216. The test results are presented on the attached Summary of Laboratory Test Data Sheet.

Soil Plasticity Tests (Atterberg Limits Test): Representative samples were selected for Atterberg Limits testing to determine the soil's plasticity characteristics. The Plastic Index (PI) is representative of this characteristic and is bracketed by the Liquid Limit (LL) and the Plastic Limit (PL). The Liquid Limit is the moisture content at which the soil will flow as a heavy viscous fluid. The Plastic Limit is the moisture content at which the soil begins to lose its plasticity. Both limits were determined in accordance with ASTM D-2487. The data obtained is presented on the attached Summary of Laboratory Test Data Sheet.

Grain Size: Representative samples were selected for grain-size and hydrometer testing to determine the size and distribution (gradation) of the soil particles in the soils. The gradation of the soil is an important index property of the soil which helps in verifying the visual classifications, and is an important engineering property of the soil. The grain size and hydrometer tests were performed in accordance to ASTM D-421. The data obtained is presented on the attached Grain Size Distribution Curves and is summarized on the Summary of Laboratory Test Data Sheets.

Compaction Test: Representative samples of the on-site soils were obtained from auger cuttings to examine their suitability as fill material. Standard Proctor Compaction Tests (ASTM D-698) were performed on these soils to identify the maximum dry density and optimum moisture content. The test results are presented on the attached Compaction Test Sheets.

Hydraulic Conductivity Testing: Representative samples were selected for hydraulic conductivity testing. The hydraulic conductivity test provides permeability values of the soils for use as an example in liner design, and determining seepage velocities. The hydraulic conductivity tests were performed on remolded bulk samples obtained from on-site. The samples were remolded to a specified density and moisture content and placed in a flexible wall permeameter. The soil was subjected to a confining pressure, and saturated by applying a backpressure to the pore water. A gradient is created across the sample by applying a large pressure on one side of the sample. The results of these tests are tabulated in the attached Summary of Laboratory Test Data sheets.

SUMMARY OF LABORATORY TESTS

BORING NUMBER	SAMPLE	DEPTH	NATURAL MOIST CONT	ATTERBURG LIMITS LL	PL	PI	AMOUNT OF SOIL (%) COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	USCS CLASS
B-1	BULK-A	0-3.5 } A-4	19.1	37	29	8	0	6.9	46	15.1	32	SM-ML
B-1	BULK-B	0-3.5 }	24.3	50	47	3	---	---	---	---	---	ML-MH
B-1	S-2	3.5-5 A-7	32.8	50	27	23	0	7.7	17	35.4	39.9	CL-CH
B-1	S-5	18.5-20	28									
B-1	S-7	28.5-30	20.3									
B-1	S-9	38.5-40	9.5									
B-2	S-2	3.5-5 A-7	23	61	25	36	0	2.2	39.4	14.3	44.1	CH
B-2	S-5	18.5-20	26.6									
B-2	S-7	28.5-30	39.2									
B-2	S-9	38.5-40	34.1									
B-3	S-2	3.5-5 A-5	26.6	47	37	10	0	2.2	30	48.8	19	ML
B-3	S-5	18.5-20 A-4	44.3	54	45	9	0	7.1	29.3	50.6	13	MH
B-3	S-7	28.5-30	34.7									
B-3	S-9	38.5-40	38.9									
B-4	S-2	3.5-5	19									
B-4	S-5	18.5-20	25.6									
B-4	S-7	28.5-30 A-7	68.6	99	68	31	0	0	4.3	67.7	28	MH
B-4	S-8	33.5-35	35.9									
B-5	S-2	3.5-5 A-7	34.6	69	44	25	0	1.1	24.1	40.8	34	MH
B-5	S-5	18.5-20	34.2	NP	NP	NP	0	19.1	31.7	42.2	7	SM-ML
B-5	S-7	28.5-30	22									
B-5	S-9	38.5-40	36.6									
B-6	S-2	3.5-5	37.6									
B-6	S-4	13.5-15	31.9	NP	NP	NP	0	3.1	44.1	44.8	8	ML-SM
B-6	S-6	23.5-25	29									
B-6	S-9	38.5-40	35.6									
B-7	S-11	48.5-50	12									
B-7	S-2	3.5-5	23.7									
B-7	S-5	18.5-20	26.5									
B-7	S-9	38.5-40	15.5									

SUMMARY OF LABORATORY TESTS

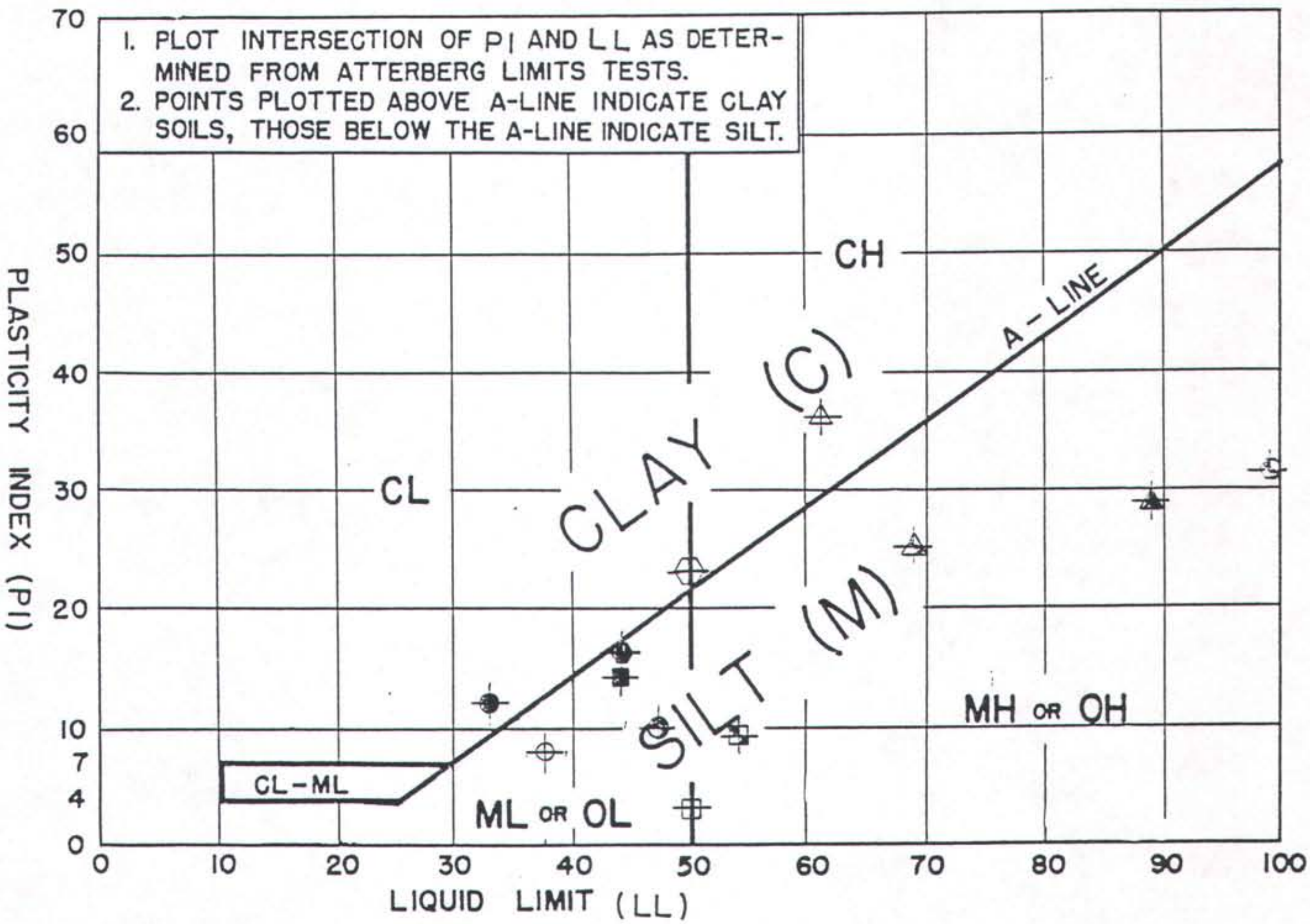
BORING NUMBER	SAMPLE	DEPTH	NATURAL MOIST CONT	ATTERBURG LIMITS LL	PL	PI	AMOUNT OF SOIL (%) COARSE SAND	MEDIUM SAND	FINE SAND	SILT	CLAY	USCS CLASS
B-8	BULK-A	0-5	9.8	NP	NP	NP	20.4	23.3	21.8	22.3	*	SM
B-8	BULK-B	5-10.0	16.1	33	21	12	---	---	---	---	---	ML
B-8	S-2	3.5-5	26.1									
B-8	S-5	18.5-20	11.4									
B-8	S-6	23.5-25	43.8									
B-9	BULK	0-10 A-7	---	44	30	14	0.6	14.8	28.1	56.5	*	ML
B-9	BULK	10-20 A-7	20	44	28	16	2	14.4	30.1	22.5	31	ML
B-9	S-2	3.5-5	20.2									
B-9	S-5	18.5-20	23									
B-9	S-7	28.5-30 A-7	59.8	89	60	29	0	0.3	6.5	70.2	23	MH
B-9	S-9	38.5-40	24									
B-10	S-10	43.5-45	18.2									
B-10	S-2	3.5-5	15.7									
B-10	S-5	18.5-20	29.2									
B-10	S-8	33.5-35	21.6									

* Total percentage of soil passing the #200 sieve.

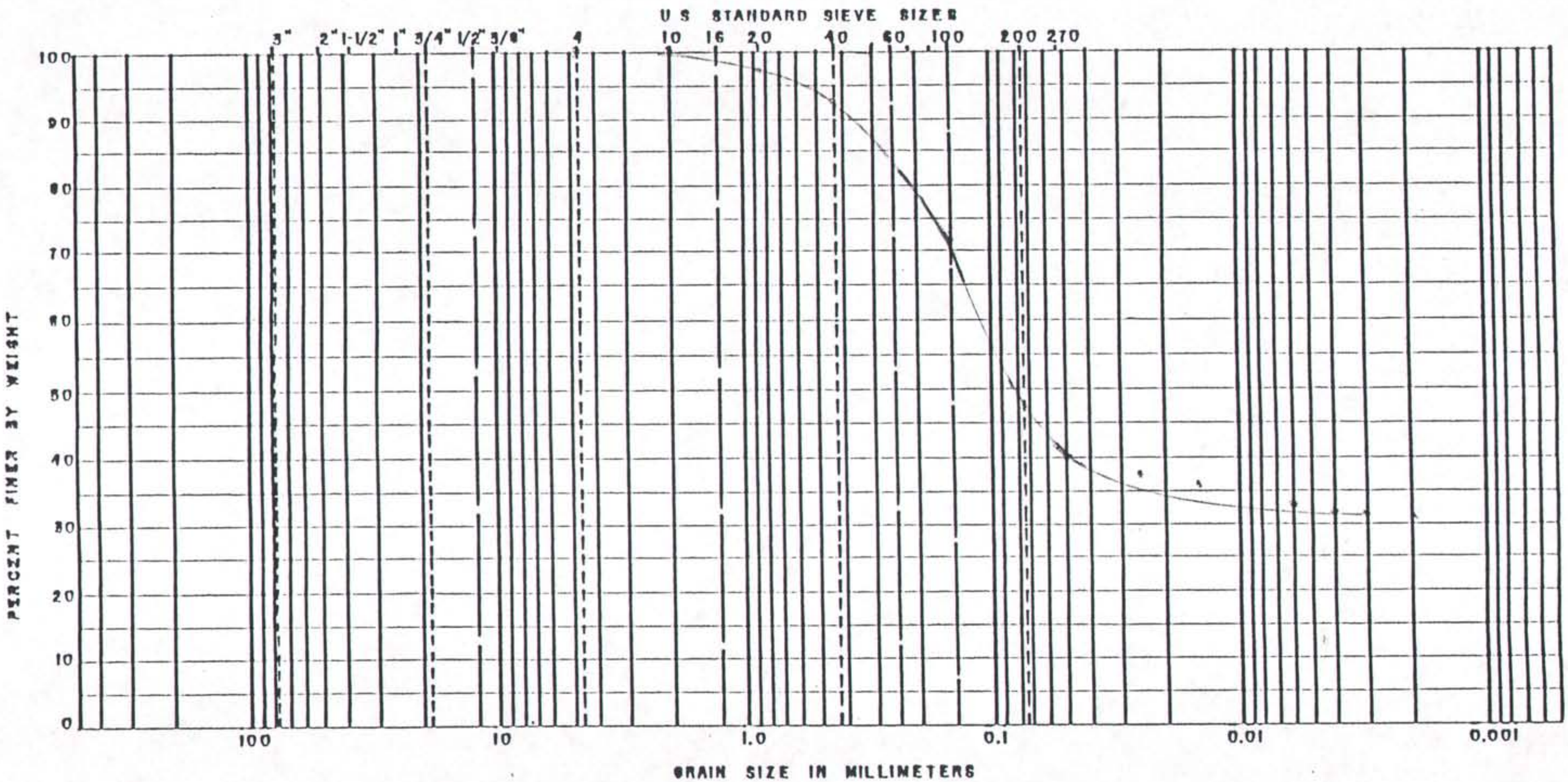
SUMMARY OF PERMEABILITY TEST RESULTS

SAMPLE NO.	DEPTH (FEET)	SPECIFIC GRAVITY	ASTM D 698 PROCTOR DATA MAX. DRY DENSITY (pcf)	ASTM D 698 PROCTOR DATA OPT. MOISTURE CONTENT (%)	ACTUAL SPECIMEN COMPACTION DATA DRY DENSITY (pcf)	ACTUAL SPECIMEN COMPACTION DATA MOISTURE CONTENT (%)	PERCENT COMPACTION	PERCENT MOISTURE CONTENT ABOVE OPTIMUM	HYDRAULIC CONDUCTIVITY k (cm/sec)	USCS CLASSIFICATION
B-1	3.5 - 5.0	2.65	102.4	21.0	100.7	23.0	98	2	2×10^{-8}	CL-CH
B-1	0 - 3.5	2.69	107.4	18.2	102.7	18.6	96	0.1	3.1×10^{-6}	SM-ML
B-8	5 - 10	2.65	117.0	12.7	111.1	12.8	95	0.1	1.7×10^{-5}	SM
B-9	0 - 10	2.71	106.4	18.8	105.5	19.2	99	0.4	1.6×10^{-7}	ML

ATTERBERG LIMITS TEST RESULTS



SYMBOL	BORING	DEPTH	USCS CLASSIFICATION
⊕ (circle)	B-1A	0-3.5'	ML-SM
⊞ (square)	B-1B	0-3.5'	ML-MH
⊕ (hexagon)	B-1	3.5-5.0'	CL-CH
△ (triangle)	B-2	3.5-5.0'	CH
half-filled circle	B-3	3.5-5.0'	ML
half-filled square	B-3	18.5-20.0'	MH
half-filled circle	B-4	28.5-30.0'	MH
half-filled triangle	B-5	3.5-5.0'	MH
● (filled circle)	B-8	5.0-10.0'	ML
■ (filled square)	B-9	0-10.0'	ML
filled circle	B-9	10.0-20.0'	ML
▲ (filled triangle)	B-9	28.5-30.0'	MH



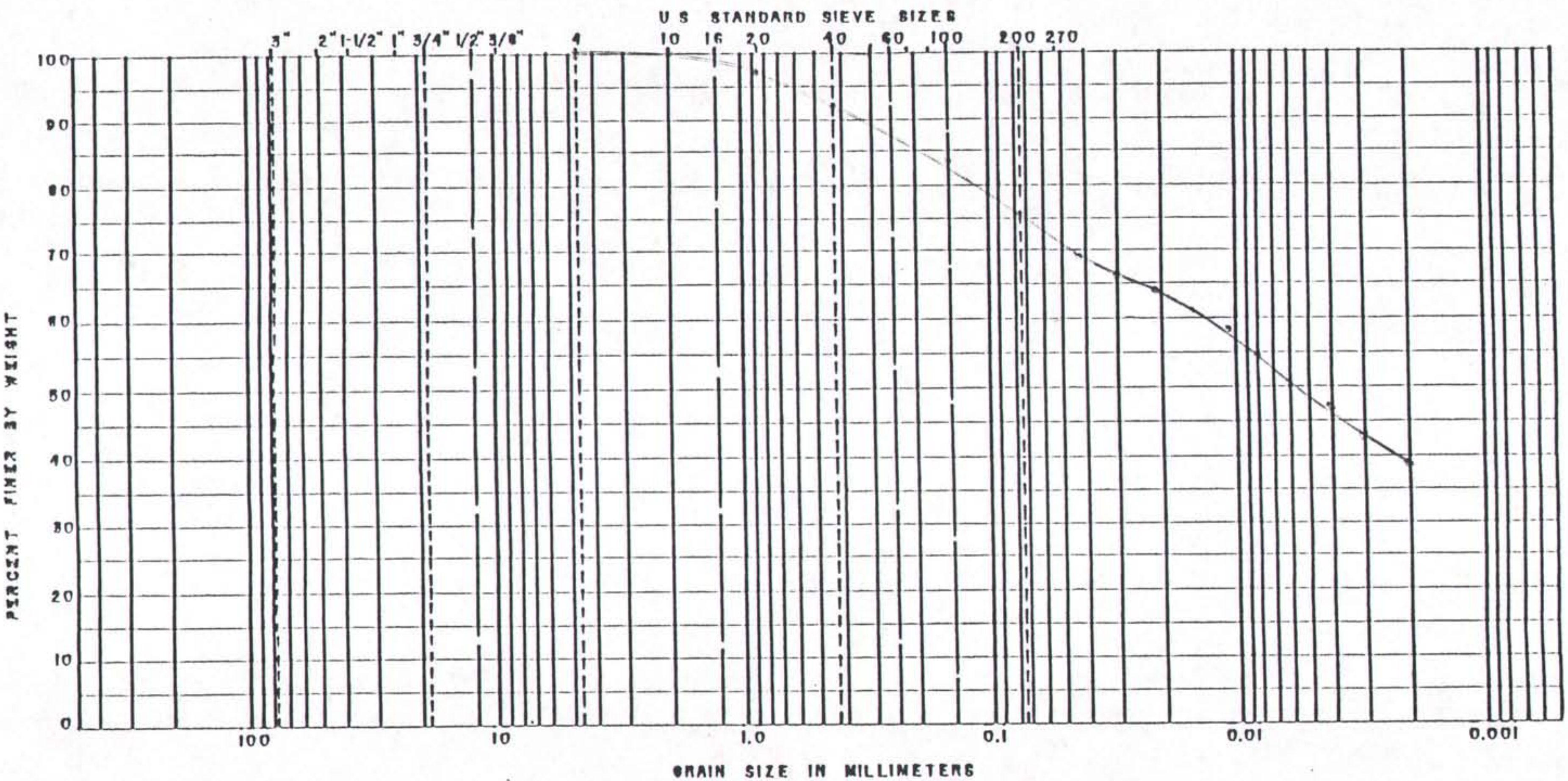
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-1	0-3.5	19.1	37	29	8	Tannish Brown Fine Sandy Silt

A-4

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION



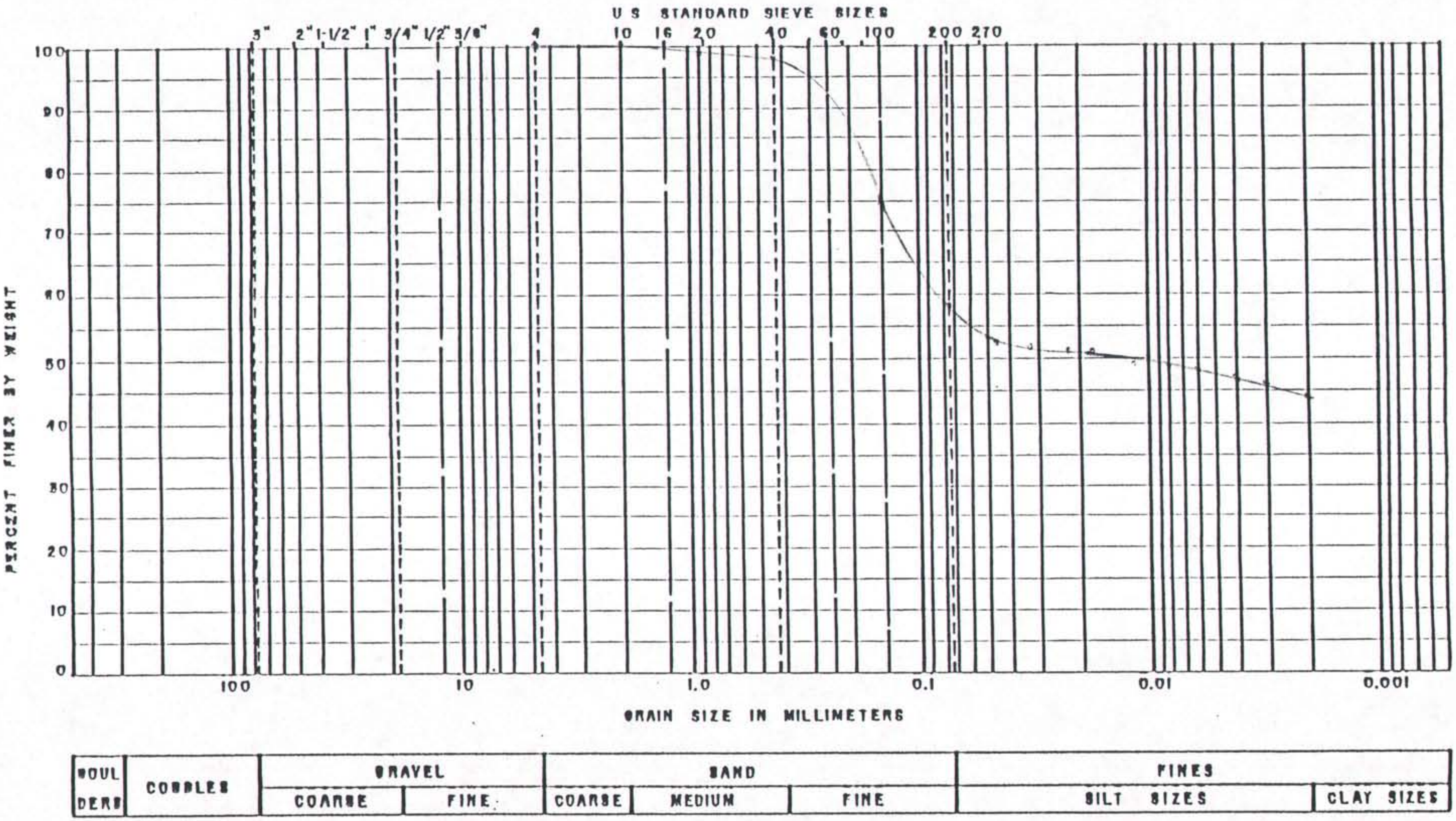
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-1	3.5-5.0	32.8	50	27	23	Brownish Grey Fine Sandy Clay

A-7

GRAIN SIZE DISTRIBUTION

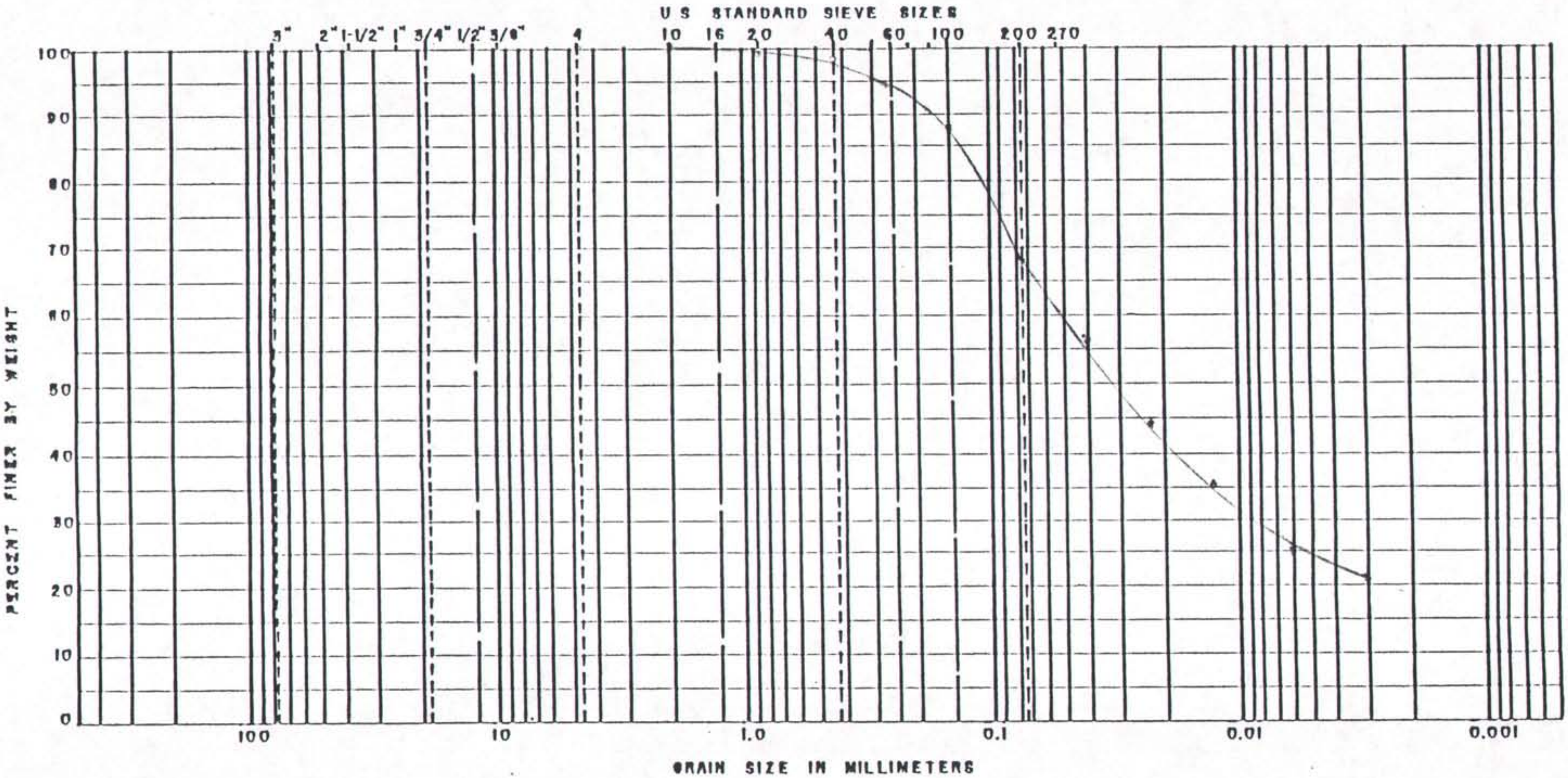
ENSCI CORPORATION



BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-2	3.5-5.0	23	61	25	36	Brown Silty Clay A-7

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION

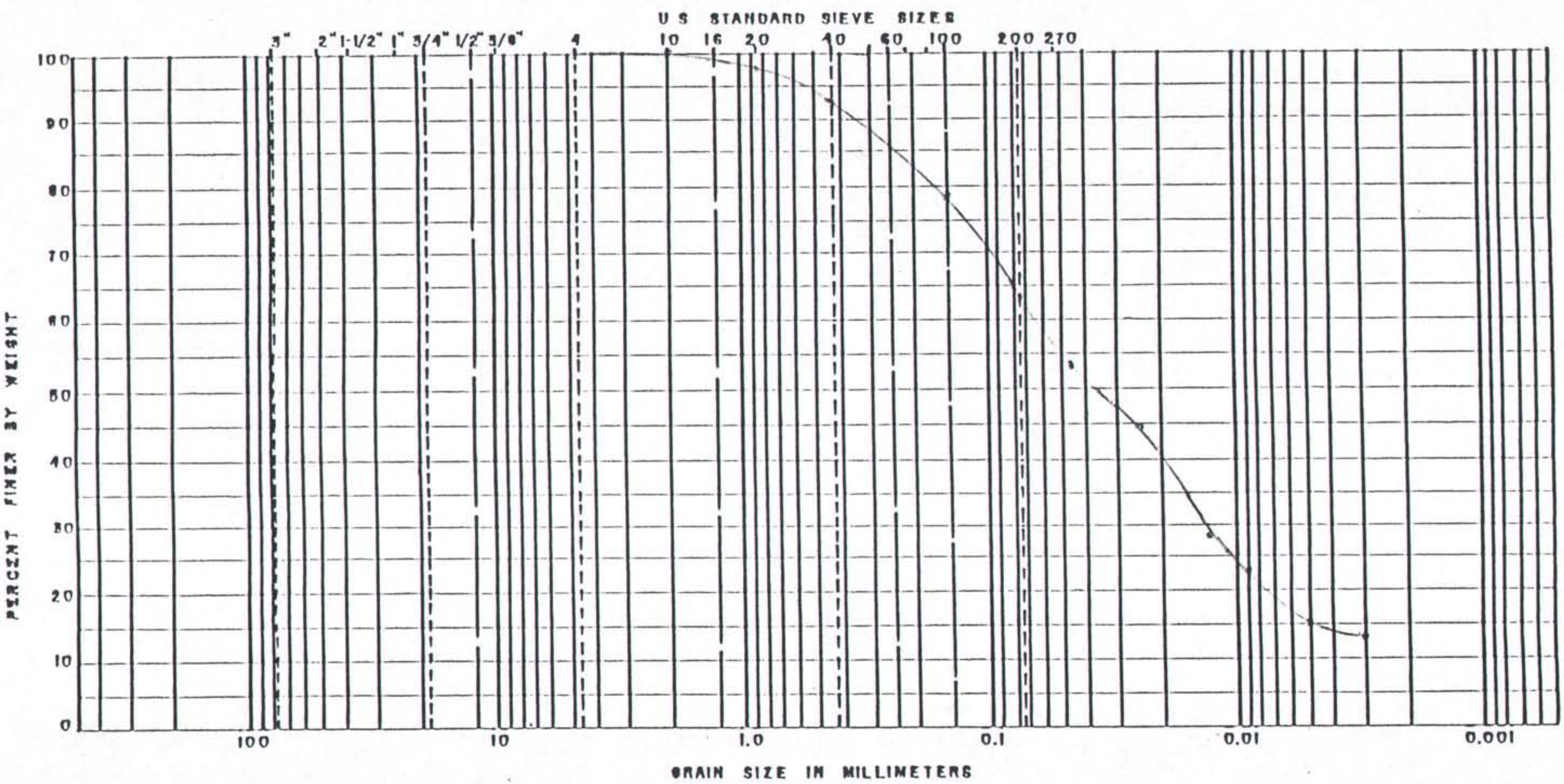


BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-3	3.5-5.0	26.6	47	37	10	Reddish Brown Fine Sandy Silt A-5

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION

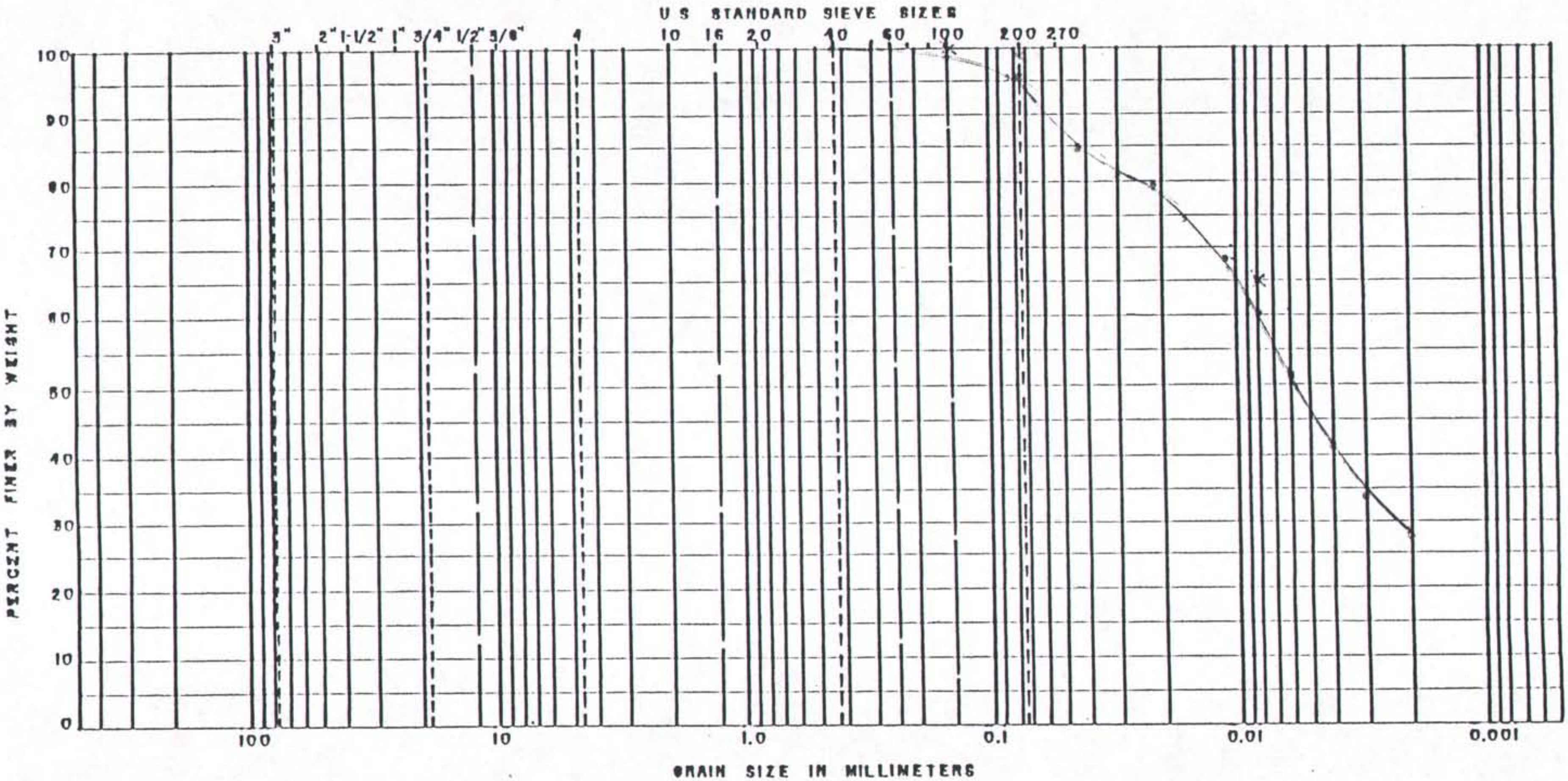


BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-3	18.5- 20	44.3	54	45	9	Reddish Tan Medium Clayey Silt A-4

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION



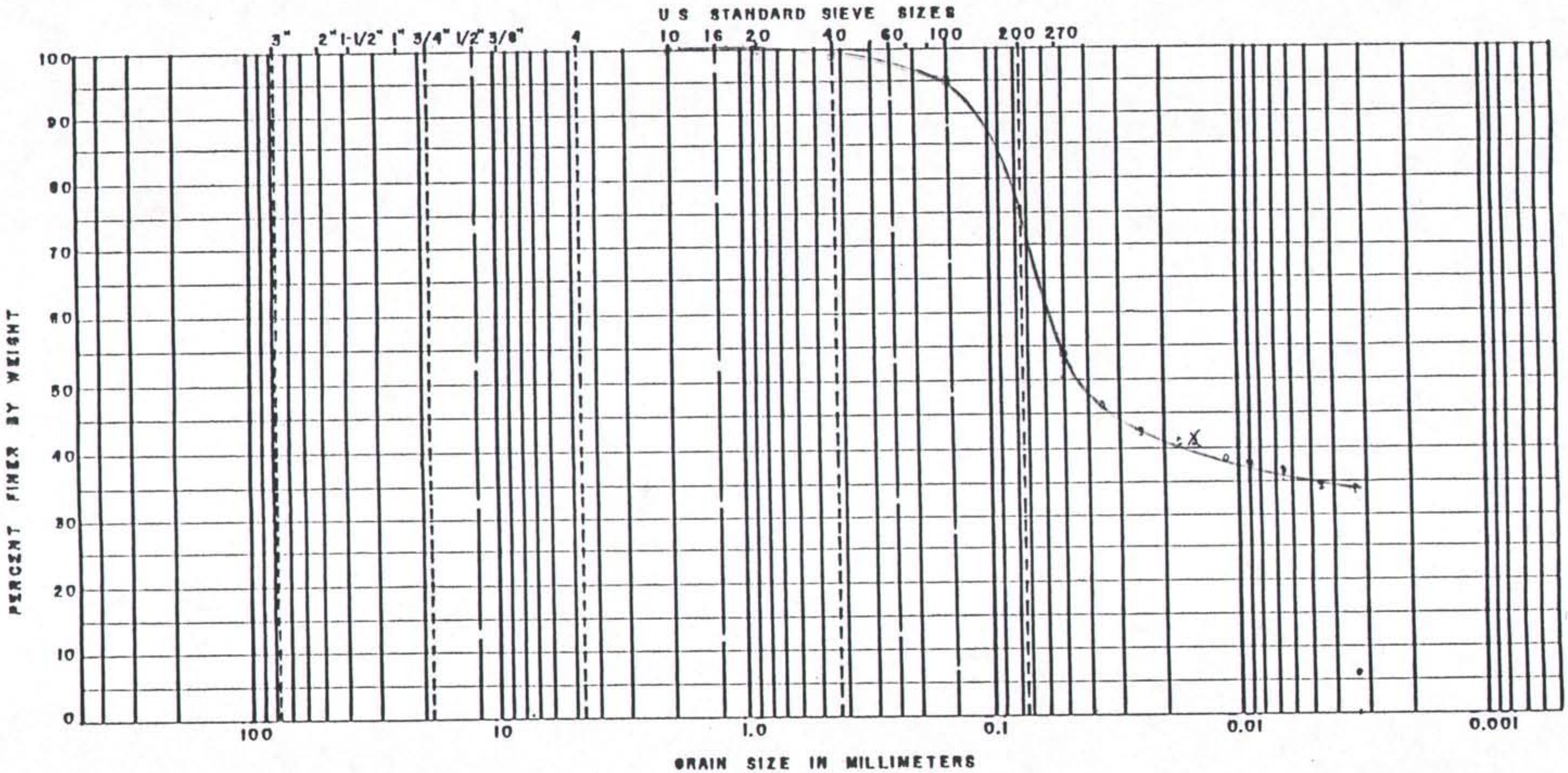
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-4	28.5-30.0	68.6	99	68	31	Reddish Grey Tan Clayey Silt

A-7

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION



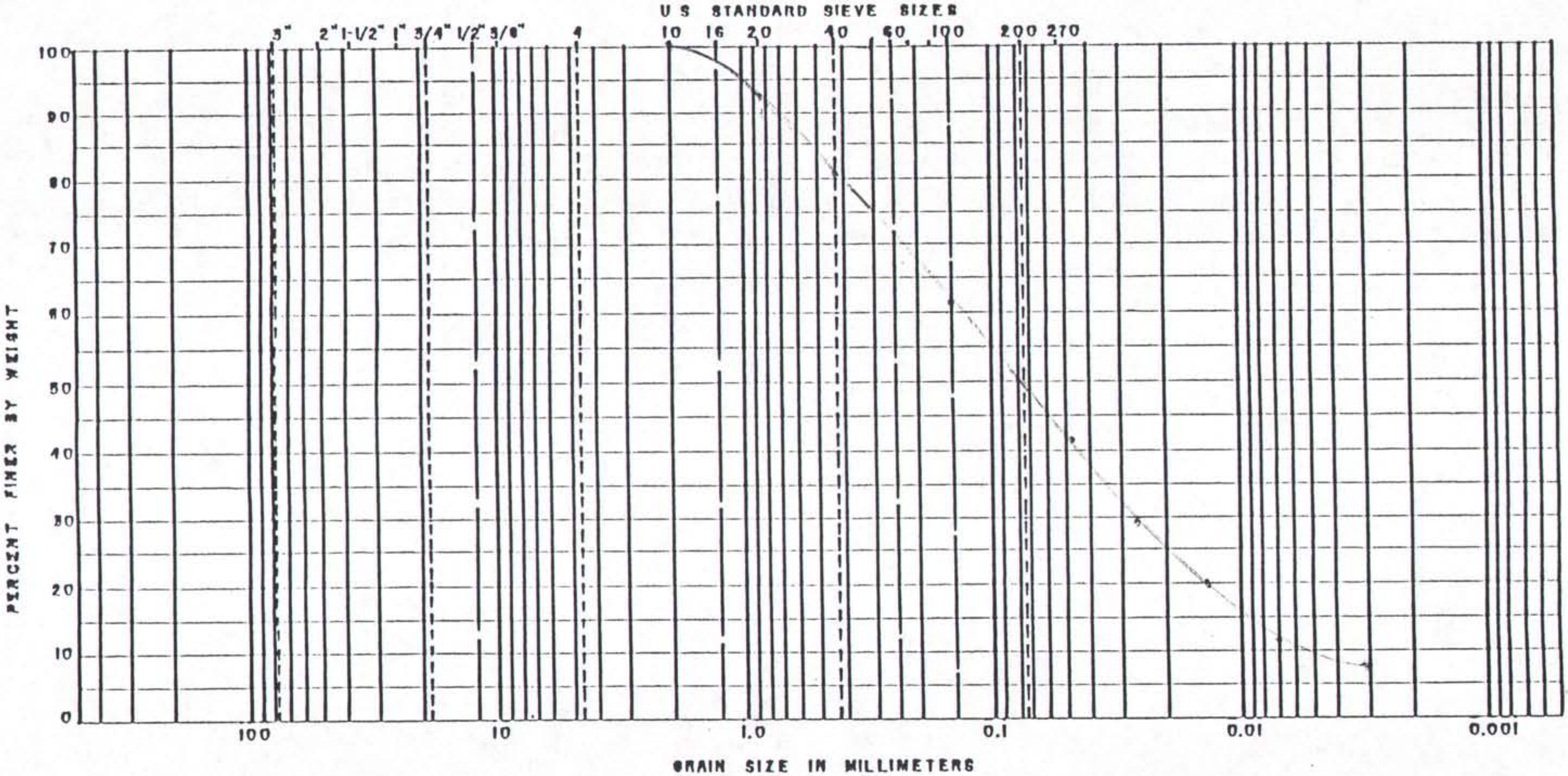
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-5	3.5-5	34.6	69	44	25	Reddish Brown Fine Sandy Silt

A-7

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION



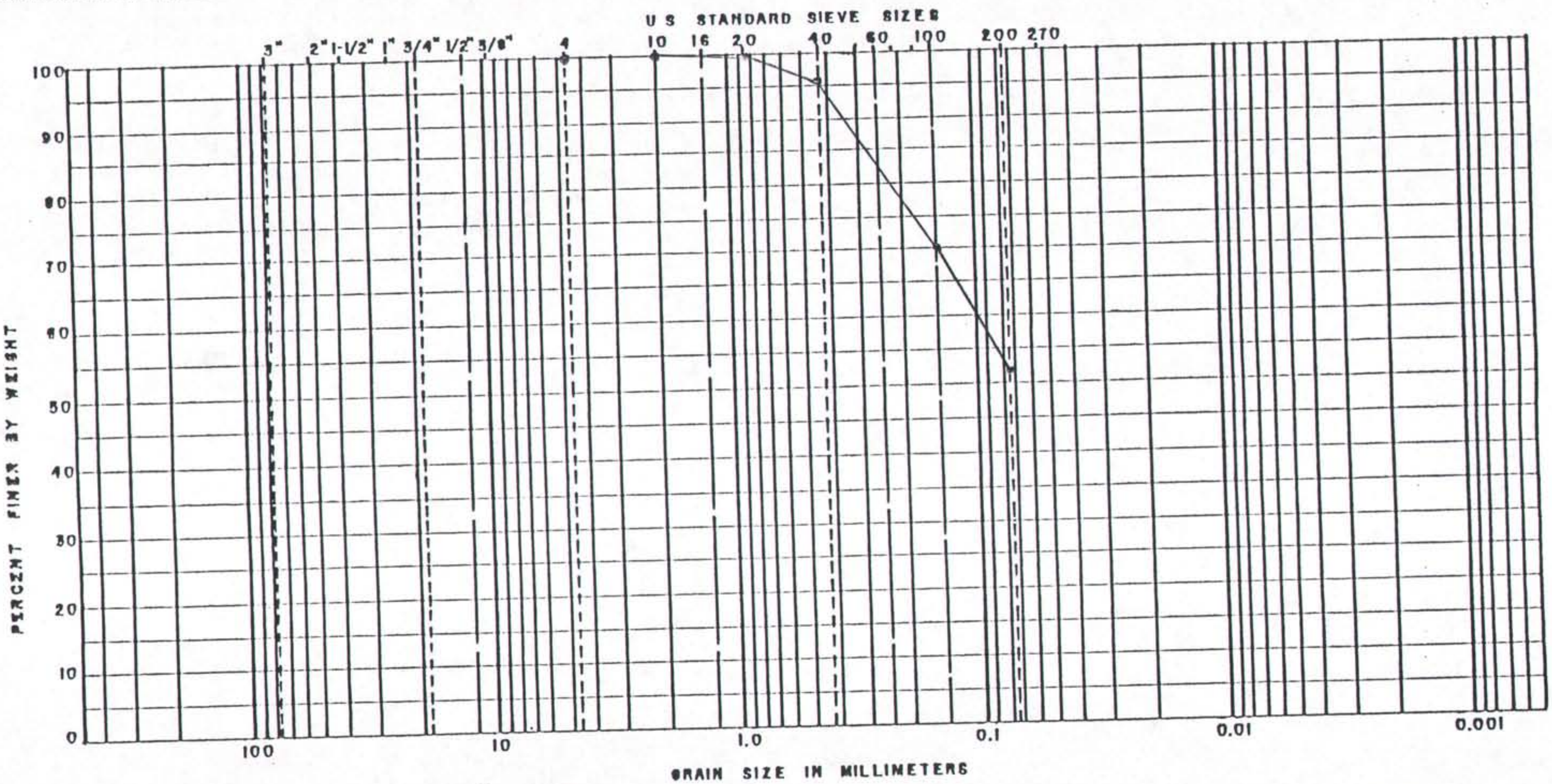
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-5	18.5-20.0	34.2	NP	NP	NP	Greyish Brown Medium Sandy Silt ?

GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION

SM-18



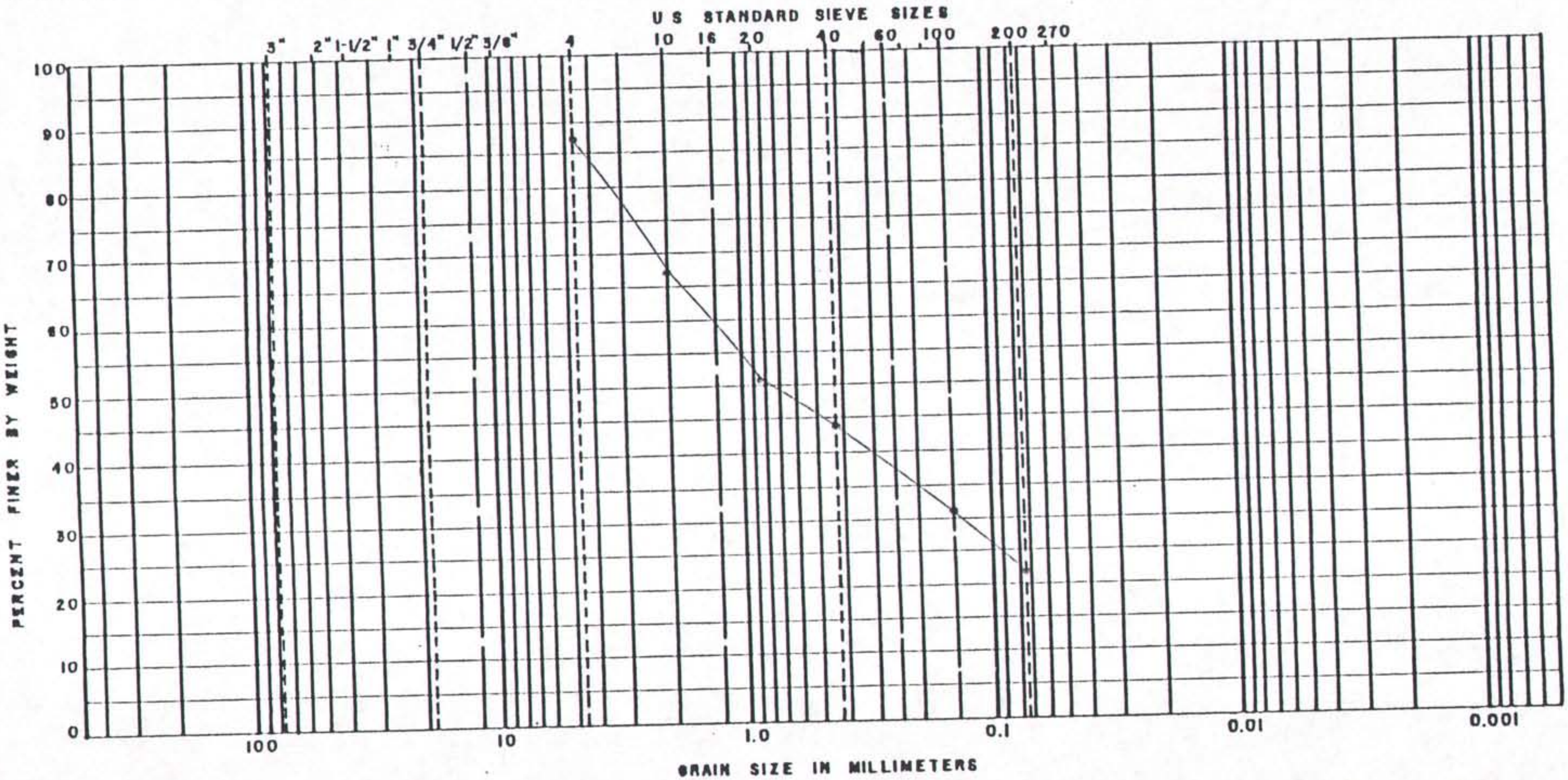
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-6	13.5-15.0	31.9	NP	NP	NP	Reddish Brown Sandy Clayey Silt ?

GRAIN SIZE DISTRIBUTION

JOB NO. ES90-001

ENSCI



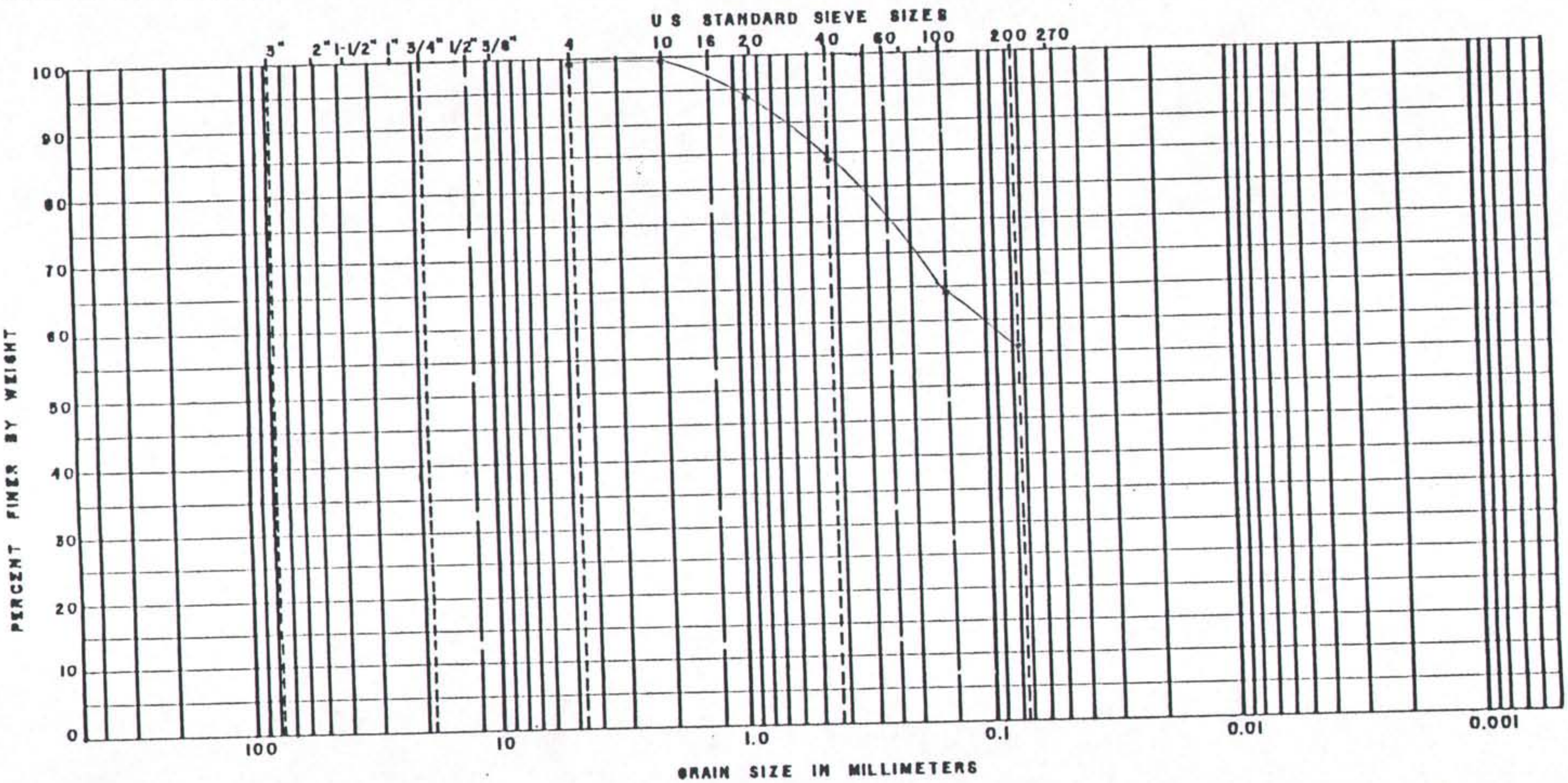
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-8	0-5	9.8	NP	NP	NP	Tannish Brown Sandy Clayey Silt ?

GRAIN SIZE DISTRIBUTION

JOB NO. ______

ENSCI



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

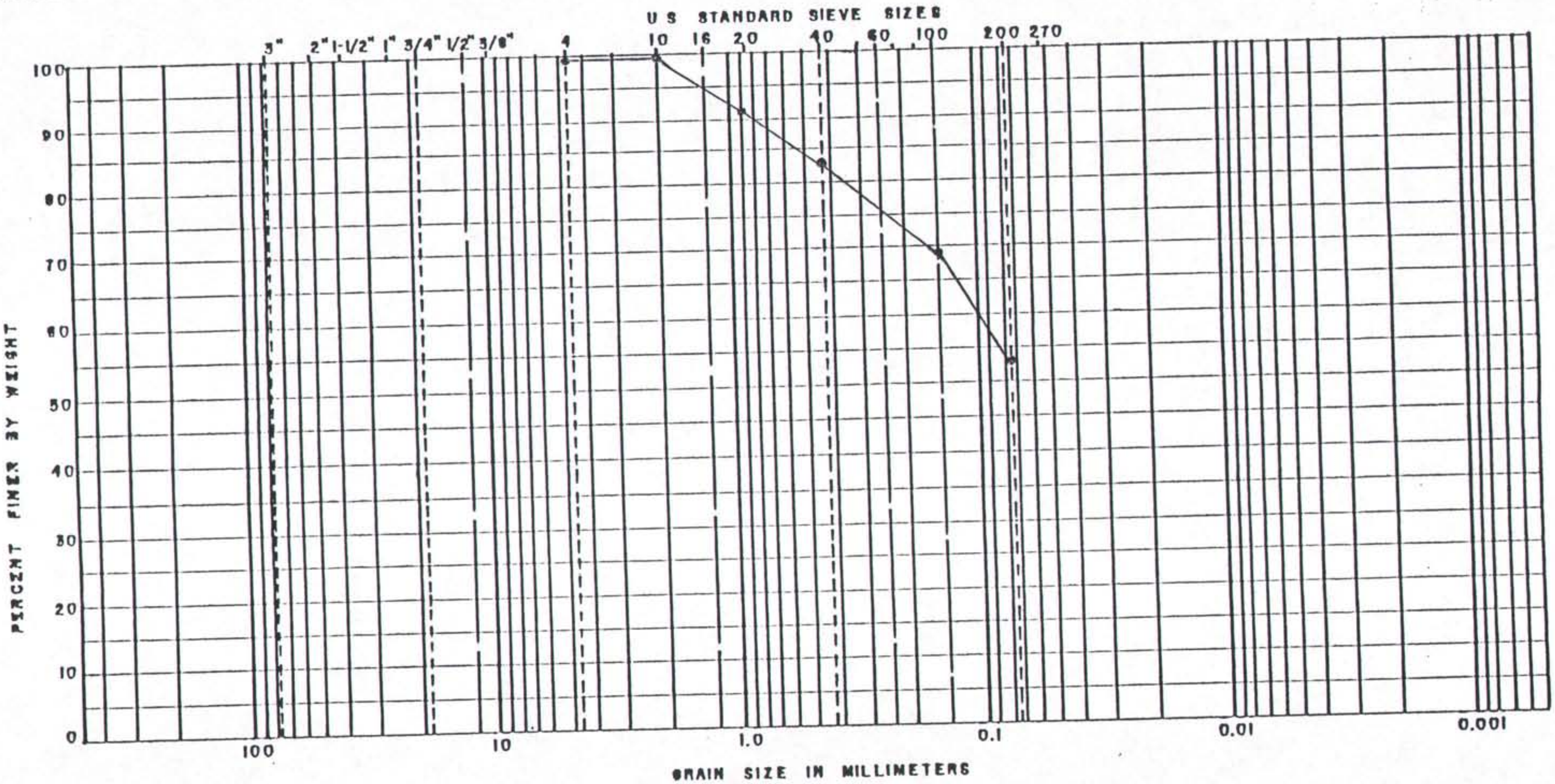
BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-9	0-10.0	--	44	30	14	Reddish Brown Fine to Medium Sandy Clayey Silt

A-7

GRAIN SIZE DISTRIBUTION

JOB NO. ES90-001

ENSCI



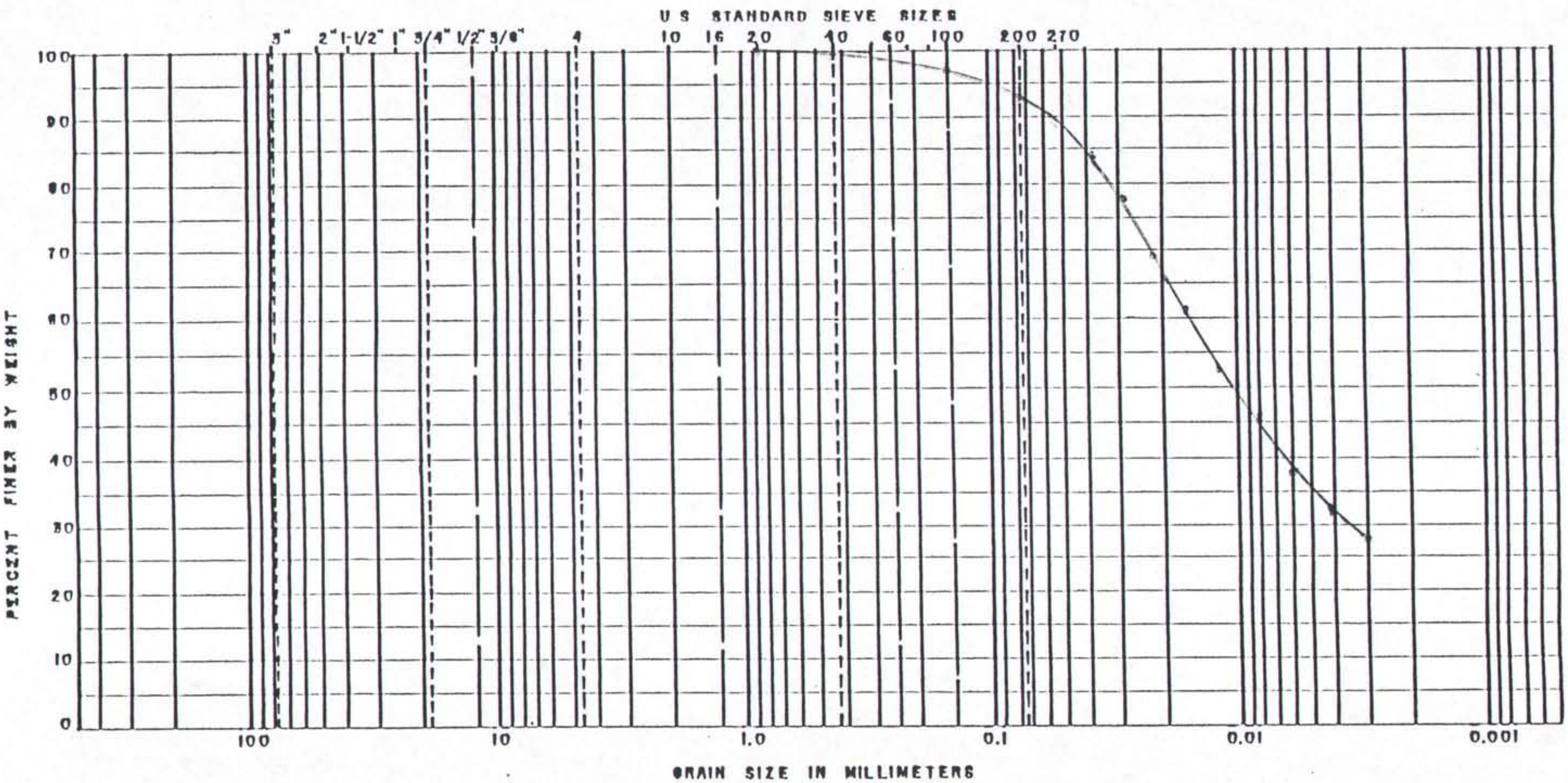
BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-9	10-20	20	44	28	16	Reddish Brown Clayey Silt A-7

GRAIN SIZE DISTRIBUTION

JOB NO. ES90-001

ENSCI



BOULDERS	COBBLES	GRAVEL		SAND			FINES	
		COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

BORING NO	ELEV. OR DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-9	28.5-30.0	59.8	89	60	29	Dark Purple Clayey Silt A-7

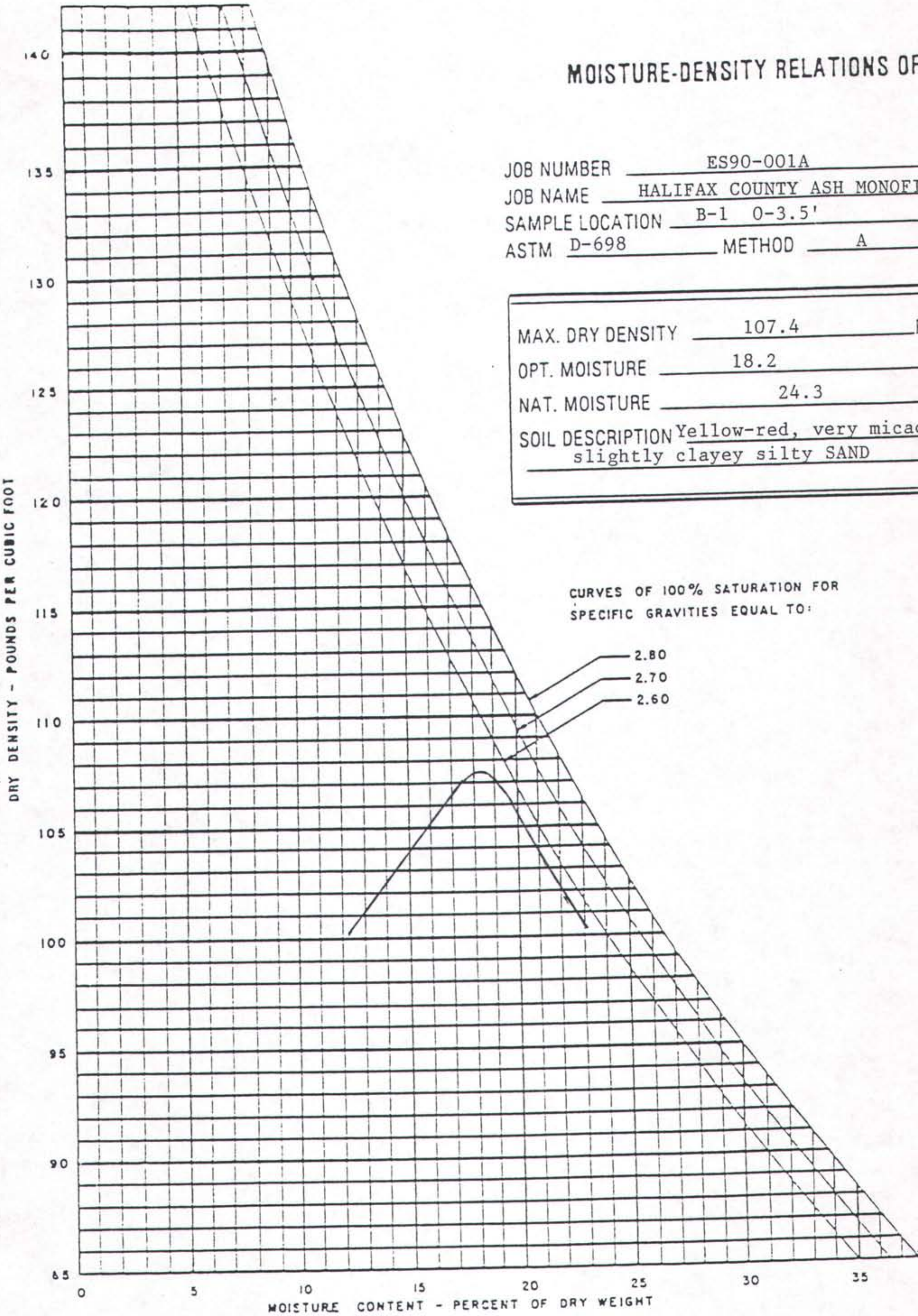
GRAIN SIZE DISTRIBUTION

ENSCI CORPORATION

MOISTURE-DENSITY RELATIONS OF SOIL

JOB NUMBER ES90-001A
JOB NAME HALIFAX COUNTY ASH MONOFILL
SAMPLE LOCATION B-1 0-3.5'
ASTM D-698 METHOD A

MAX. DRY DENSITY 107.4 PCF
OPT. MOISTURE 18.2 %
NAT. MOISTURE 24.3 %
SOIL DESCRIPTION Yellow-red, very micacious slightly clayey silty SAND

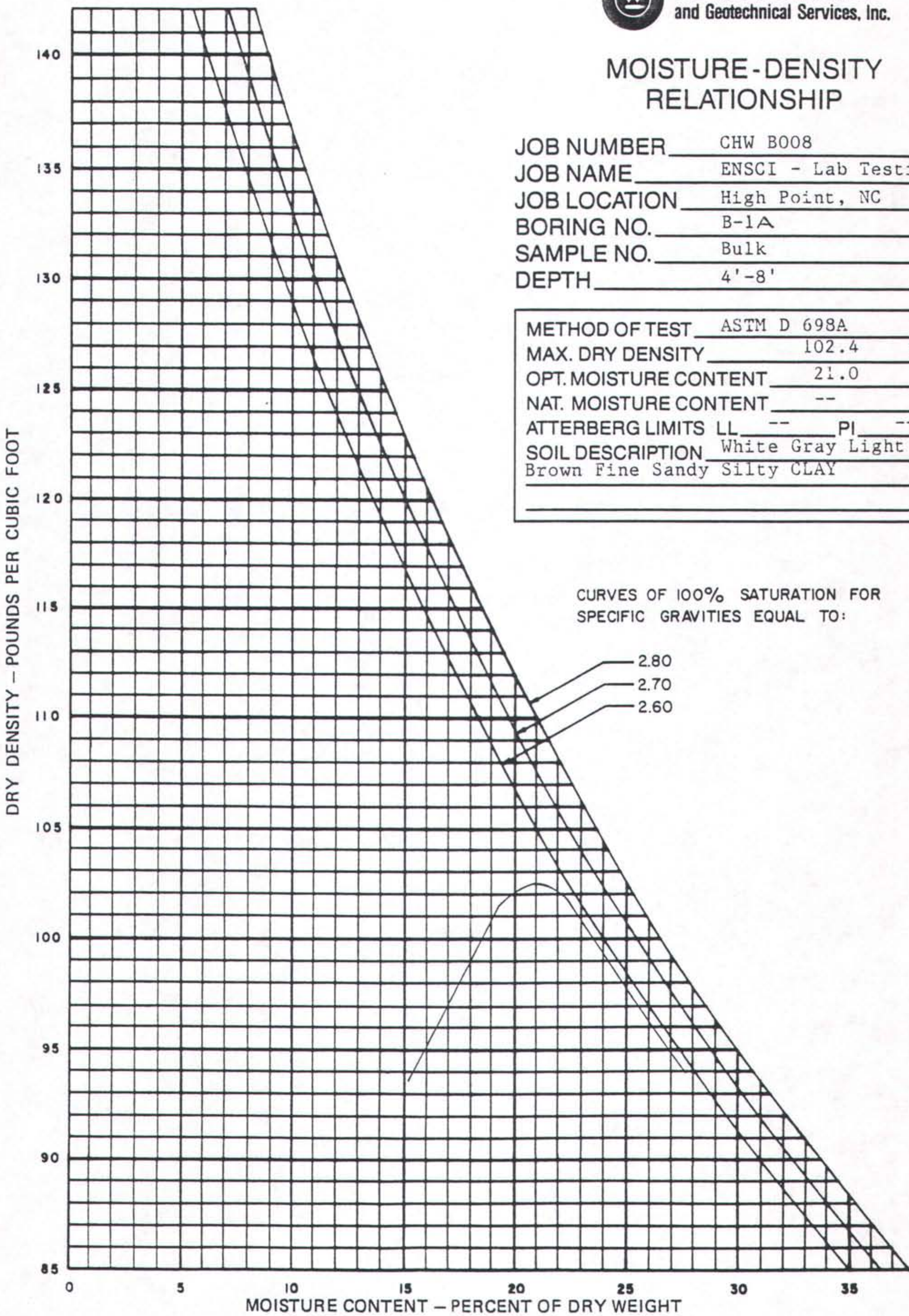


Westinghouse Environmental and Geotechnical Services, Inc.

MOISTURE-DENSITY RELATIONSHIP

JOB NUMBER CHW B008
JOB NAME ENSCI - Lab Testing
JOB LOCATION High Point, NC
BORING NO. B-1A
SAMPLE NO. Bulk
DEPTH 4'-8'

METHOD OF TEST ASTM D 698A
MAX. DRY DENSITY 102.4 PCF
OPT. MOISTURE CONTENT 21.0 %
NAT. MOISTURE CONTENT -- %
ATTERBERG LIMITS LL -- PI --
SOIL DESCRIPTION White Gray Light Brown Fine Sandy Silty CLAY



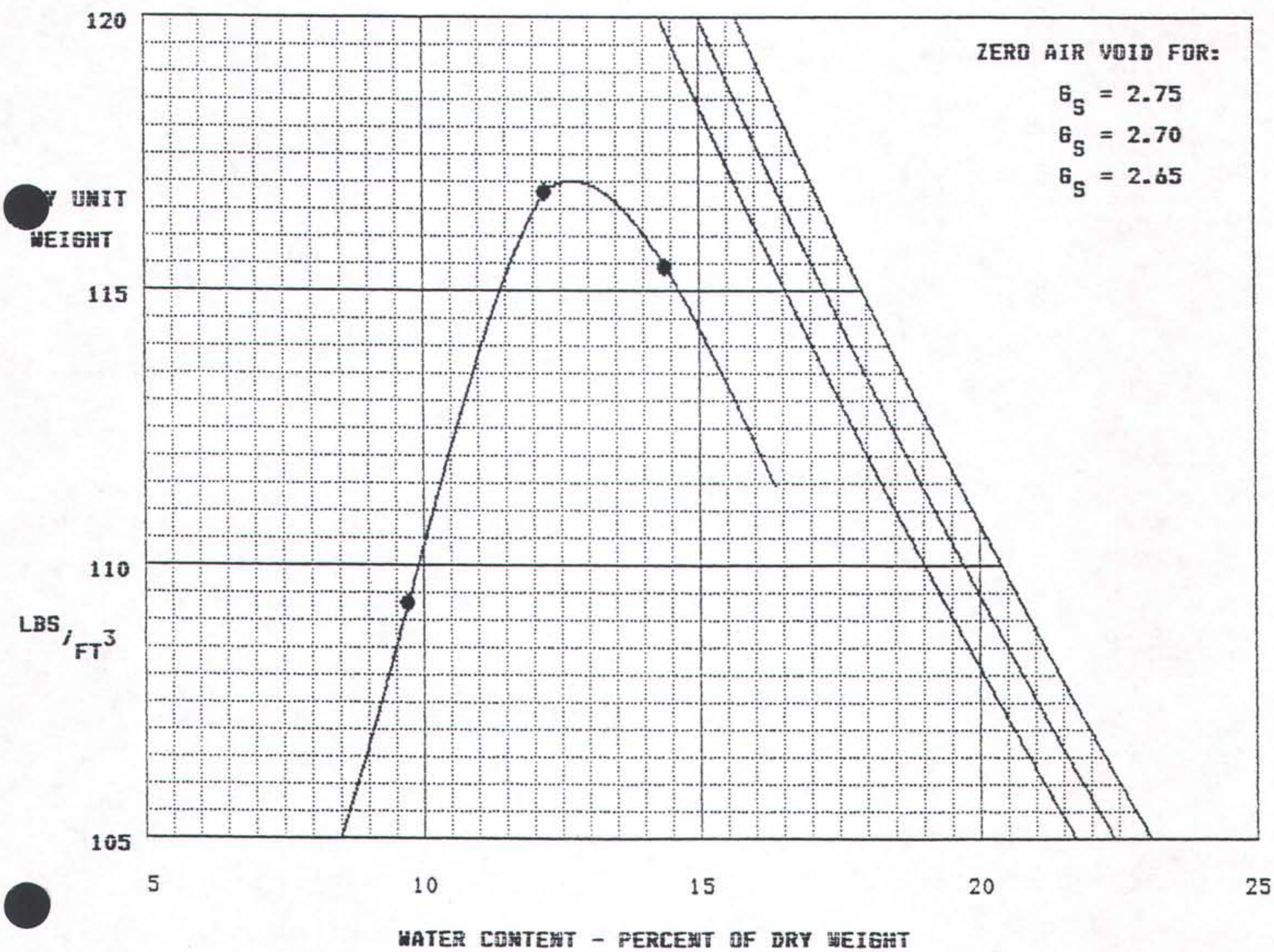
LAW ENGINEERING

STANDARD PROCTOR REPORT
ASTM D698 C

DATE: MARCH 7, 1991
PROJECT NUMBER: J-6479
PROJECT NAME: ENSCI
CLIENT: ENSCI
SAMPLE NUMBER: #1
FIELD MOISTURE: 16.1%

SOIL DESCRIPTION:
(VISUAL) YELLOW BROWN GRAVELLY SAND AND CLAY
PROPOSED USE:
FILL MATERIAL
SOURCE LOCATION:
ON SITE: B-8, 5′-10′

MOISTURE – DENSITY RELATIONSHIP



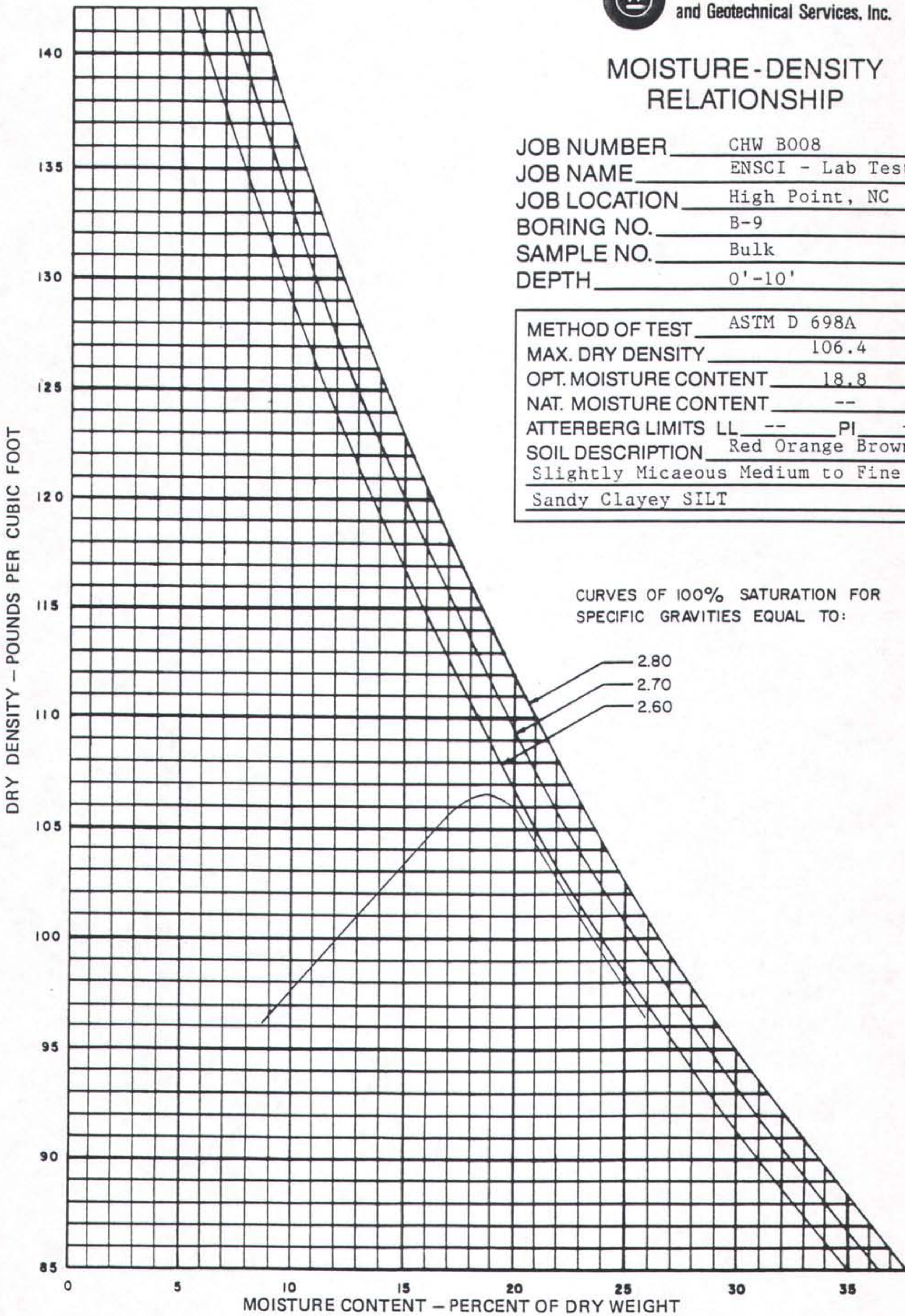
OPTIMUM MOISTURE CONTENT 12.7 **MAXIMUM DRY DENSITY** 117.0

Westinghouse Environmental and Geotechnical Services, Inc.

MOISTURE - DENSITY RELATIONSHIP

JOB NUMBER CHW B008
JOB NAME ENSCI - Lab Testing
JOB LOCATION High Point, NC
BORING NO. B-9
SAMPLE NO. Bulk
DEPTH 0'-10'

METHOD OF TEST ASTM D 698A
MAX. DRY DENSITY 106.4 PCF
OPT. MOISTURE CONTENT 18.8 %
NAT. MOISTURE CONTENT -- %
ATTERBERG LIMITS LL -- PI --
SOIL DESCRIPTION Red Orange Brown Slightly Micaeous Medium to Fine Sandy Clayey SILT



THE SHARPE CO 65542

WE–3

D- Environment-N- Archeology

United States Department of the Interior
FISH AND WILDLIFE SERVICE

Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

TAKE PRIDE IN AMERICA

TO:

Ms. Teri Corrington
ATTN: Ensci Corporation
1108 Old Thomasville Rd.
High Point, NC 27260

INSTANT REPLY

Please excuse this form. We thought you would prefer a speedy reply to a formal letter. This form serves to provide U.S. Fish and Wildlife Service recommendations pursuant to Section 7 of the Endangered Species Act, as amended (16 U.S.C. 1531-1543).

Re: Proposed landfills in Lee & Halifax Counties, NC
Project Name

3/6/91 Telephone Conversation
Date of Incoming Letter

____ Based on our records, there are no Federally-listed endangered or threatened species which may occur within the project impact area.

✓ The attached page(s) list(s) the Federally-listed species which may occur within the project impact area.

✓ If the proposed project will be removing pines greater than or equal to 30 years of age in pine or pine/hardwood habitat, surveys should be conducted for active red-cockaded woodpecker cavity trees in appropriate habitat within a 1/2 mile radius of project boundaries. If red-cockaded woodpeckers are observed within the project area or active cavity trees found, the project has the potential to adversely affect the red-cockaded woodpecker, and you should contact this office for further information.

____ Concur - Is not likely to adversely affect Federally-listed endangered or threateded species.

✓ Staffing limitations prevent us from conducting a field inspection of the project site. Therefore, we are unable to provide you with site specific recommendations at this time.

Questions regarding this form letter may be directed to the biologist who is handling this project.

Debbie C Scruggs 3/6/91
Biologist Date

CONCUR: DCScruggs 3/6/91
Acting Supervisor Date

REVISED SEPTEMBER 11, 1989

Halifax County

Red-cockaded woodpecker (_Picoides borealis_) - E

There are species which, although not now listed or officially proposed for listing as endangered or threatened, are under status review by the Service. "Status Review" (SR) species are not legally protected under the Act, and are not subject to any of its provisions, including Section 7, until they are formally proposed or listed as threatened or endangered. We are providing the below list of status review species which may occur within the project area for the purpose of giving you advance notification. These species may be listed in the future, at which time they will be protected under the Act. In the meantime, we would appreciate anything you might do for them.

Carolina madtom (_Noturus furiosus_) - SR
Bachman's sparrow (_Aimophila aestivalis_) - SR
Lewis' heartleaf (_Hexastylis lewisii_) - SR

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Parks and Recreation
512 North Salisbury Street • Raleigh, North Carolina 27611

James G. Martin, Governor
William W. Cobey, Jr., Secretary

Dr. Philip K. McKnelly
Director

December 11, 1990

John D. Barnard
ENSCI Corporation
1108 Old Thomasville Rd.
High Point, NC 27260

Dear Mr. Barnard:

The Natural Heritage Program has reviewed its topographic maps and database for locations of 1) endangered or threatened species and 2) locations of State Parks or State Recreation Areas in the vicinity of two projects of concern to ENSCI Corporation. Neither the proposed landfill site near Bilboa in Durham County nor the proposed landfill site near Aurelian Springs in Halifax County lies within 2-3 miles of such rare species or State Park/Recreation Areas. The proposed site in Durham County lies 5 to 10 river miles above Jordan Lake, which is a State Recreation Area. No impact to the recreation area would be expected from a properly-maintained landfill this far upstream from the lake.

If you have further questions about this response, please let me know.

Sincerely,

Harry E. LeGrand, Jr.

Harry E. LeGrand, Jr.
Zoologist, N.C. Natural Heritage Program

ENSCI
CORPORATION

March 22, 1991

Mr. Eric Alsmeyer
U. S. Army Corps of Engineers
Regulatory Field Office
11413 Falls of the Neuse Road
Wake Forest, NC 27587-9408

Dear Mr. Alsmeyer:

In response to our conversation Monday, March 18, 1991, I am forwarding a topographic map of the Halifax County site evaluated by you on February 12, 1991. As discussed during our meeting, the wetland areas are protected by the required buffer zones for the proposed landfill and will not be impacted by landfilling operations. I have delineated the wetlands at the proposed site as a 25 foot offset from the watercourse, per your recommendations. Additionally, I have enclosed an aerial photograph of the proposed landfill site.

If additional information is requested from your office concerning the wetland area as delineated, please do not hesitate to contact me.

Very truly yours,

ENSCI CORPORATION

Jeryl W. Covington

Jeryl W. Covington
Staff Engineer

JWC/few

Enclosure

North Carolina Department of Cultural Resources

James G. Martin, Governor
Patric Dorsey, Secretary

Division of Archives and History
William S. Price, Jr., Director

January 31, 1991

John D. Barnard, Staff Engineer
ENSCI corporation
1108 Old Thomasville Road
High Point, N.C. 27260

Re: Proposed solid waste landfill,
Halifax County, GS 91-0055

Dear Mr. Barnard:

Thank you for your letter of January 8, 1991, concerning the above project.

There are no known recorded archaeological sites within the project boundaries. However, the project area has never been systematically surveyed to determine the location or significance of archaeological resources. Based on the hydrologic and topographic characteristics of the proposed landfill area, it is likely that small specialized activity campsites dating from the Archaic and Woodland prehistoric periods are located within this vicinity.

We recommend that a comprehensive survey be conducted by an experienced archaeologist to identify the presence and significance of archaeological remains that may be damaged or destroyed by the proposed project. Potential effects on unknown resources should be assessed prior to the initiation of construction activities.

Enclosed is a list of archaeological consultants who have conducted or expressed an interest in conducting contract work in North Carolina. Individual files providing additional information on the consultants may be examined at the State Historic Preservation Office's Office of State Archaeology, 421 North Blount Street, Raleigh. If additional names are desired, you may consult the current listing of the members of the Society of Professional Archeologists, or contact the society's current secretary/treasurer, J. Barto Arnold, III, P.O. Box 13265, Austin, Texas 78711-3265. Any of the above persons, or any other experienced archaeologist, may be contacted to conduct the recommended investigation.

John D. Barnard
January 31, 1991, Page Two

We have conducted a search of our files and are aware of no structures of historical or architectural importance located within the planning area.

These comments are made in accord with G.S. 121-12(a) and Executive Order XVI. If you have any questions regarding them, please contact Ms. Renee Gledhill-Earley, environmental review coordinator, at 733-4763.

Sincerely,

David Brook
Deputy State Historic Preservation Officer

DB:slw

Enclosures

A PHASE-I CULTURAL RESOURCE STUDY OF THE PROPOSED 55-ACRE HALIFAX COUNTY LANDFILL EXTENSION

?

by:

David M. Van Horn, Ph.D.

ARCHAEOLOGICAL ASSOCIATES, LTD.
P.O. Box 180
Sun City, CA 92381

(714) 244-1783
FAX 244-0084

March 9, 1991

TABLE OF CONTENTS

MANAGEMENT SUMMARY

The Halifax County landfill extension project will add a 55-acre area to the eastern side of the existing County landfill facility. Plans call for the additional space to be used for ash disposal. The ash will be generated by the Hadson-Westmoreland cogenerating plant to be built in Weldon. The purpose of the study described in this report was to determine whether the addition to the landfill could adversely affect potentially significant archaeological or historical resources. The study has no clearinghouse number at this time.

Fieldwork for the project was conducted by Dr. David M. Van Horn and Ruth Ann Van Horn. It consisted of two parts: (1) a walk-over survey of the entire parcel and (2) shovel-testing of those areas regarded as having a relatively high probability of containing cultural resources. The walk-over survey, which was conducted in parallel transects at 15-20 m. intervals where practicable, resulted in an inspection of the remains of a burned down farmhouse with accompanying corrugated metal service building and privy. The remainder of the property, which lacks historical features of any kind, was divided into the following areas:

Area A: Northerly field which is in an undrained swale.

Area B: Southerly field which comprises a ridgetop; this is the principal highland portion of the parcel.

Area C: A wooded area on the eastern edge of the property. A small ridge and drainage are situated in Area C.

Area D: The riparian zone along the creek which runs parallel to the southern property boundary. Two areas thought to be of possible interest along the creek include its confluence with the Area C drainage and its passage through a small granite boulder outcrop.

Area E: This is a small "panhandle" which provides access from the existing landfill on the west to the study area. Area E is in a drainage swale and the topography is irregular.

Area F: Area F comprises wooded south-facing slopes between the ridgetop and riparian zone.

Surface visibility was good in some areas of the fields but poor in others due to weeds. Visibility was generally nil in wooded areas where fallen leaves blanketed the ground. Therefore, shovel-testing of high probability portions of these areas was conducted. Generally, shovel-testing was performed by excavating small pits 18-24 inches in diameter to the substratum. All backdirt was successfully passed through a shaker screen fitted with 1/4-inch mesh. Shovel test pits were dug at 30, 50, and 100 ft. intervals (depending upon location--see report for specific details). Five locations were shovel tested:

(1) Small north-south trending ridge in Area C (pits A1 - A4).
(2) Ungraded area in front of the farmhouse (B1 - B3).
(3) Area B, the property's central highland ridge (B4 - B9).
(4) Small terrace at the confluence of two drainages in Area D (C1 - C3).
(5) Small granite boulder outcrop along southerly stream (D1 - D2).

Insofar as prehistoric material is concerned, the results of the field investigation were entirely negative, not so much as a flake being found anywhere on the parcel. We were not surprised by this result since the streams on the property are small and since the area is topographically obscure (i.e. it lacks any kind of distinction relative to the surrounding rolling hills in the region).

Interviews of local individuals were conducted in order to identify the age and occupants of the burned down farmhouse. Mr. Edward Butts, whose family has resided in Aurelian Springs for many generations, told us that the farm had been occupied by a Mr. Ray Stansbury whose family has also lived in the community since sometime in the 19th century. However, the farmhouse in question had not been built until the 1930's or 1940's. Inspection of the materials around the house seemed to confirm the information acquired from Mr. Butts. A dilapidated corrugated metal service building still stands south of the house. The privy building may be found southwest of the house where it lies on its side. In the opinion of the author, it is not even remotely possible that any of these structures or their location might be eligible for the National Register of Historic Places. This statement is based upon the relatively recent age of the farm as well as its lack of historical significance or association with prominent historical persons.

A reasonably thorough field study in conjunction with interviews and a literature review have failed to show that the planned landfill extension will affect potentially significant archaeological or historical resources. Therefore, it is recommended that the project be permitted to proceed without additional measures in connection with cultural resources.

I. INTRODUCTION

This report describes the results of a cultural resources investigation of the proposed Hadson-Westmoreland cogenerating plant ash disposal site near Aurelian Springs in Halifax County, North Carolina (figs. 1-3). The planned disposal site will comprise a 55-acre extension to the existing Halifax County solid waste disposal landfill which is situated adjacent to the study area on the west. The additional landfill area is needed as a location for disposal of ash which will be generated by a new cogenerating plant to be built in Weldon. North Carolina Solid Waste Management Rules require that a solid waste disposal site ..."shall not damage or destroy an archaeological or historical site ..." (Section .0503 (b) (iii).

The existing land fill and the proposed extension are situated on the south side of Highway 1417 about 1 mile northeast of the small community of Aurelian Springs (fig. 3). Technically, the irregularly shaped 55-acre extension consists of parcel 10 as shown on Map No. 233, Butterwood Township, Halifax County. The northern boundary of the parcel fronts on the southern side of Highway 1417 while the western boundary is contiguous with the existing County landfill. The southern boundary more or less follows the alignment of a creek while fields and wooded areas lie to the east.

The survey of the subject property was conducted by Archaeological Associates, Ltd. at the verbal request of the Westmoreland-Hadson partners Charlottesville and Fairfax, Virginia. Work was conducted for the sole purpose of determining whether development of the landfill extension would adversely affect significant archaeological or historical resources. The project was directed and conducted by the author who was assisted by Ruth Ann Van Horn. Fieldwork was performed during two separate days. On February 12, 1991, the author spent the entire day conducting a walk-over survey of the property. Shovel testing of high probability areas with poor surface visibility was conducted on February 14, 1991. The reader is referred to the discussion of methods presented below for full details. Specific test locations are shown in Figure 5.

II. PHYSICAL ENVIRONMENT

The study area is situated in a region of rolling hills which is typical of North Carolina's Piedmont physiographic province. Slopes vary from gentle to moderately

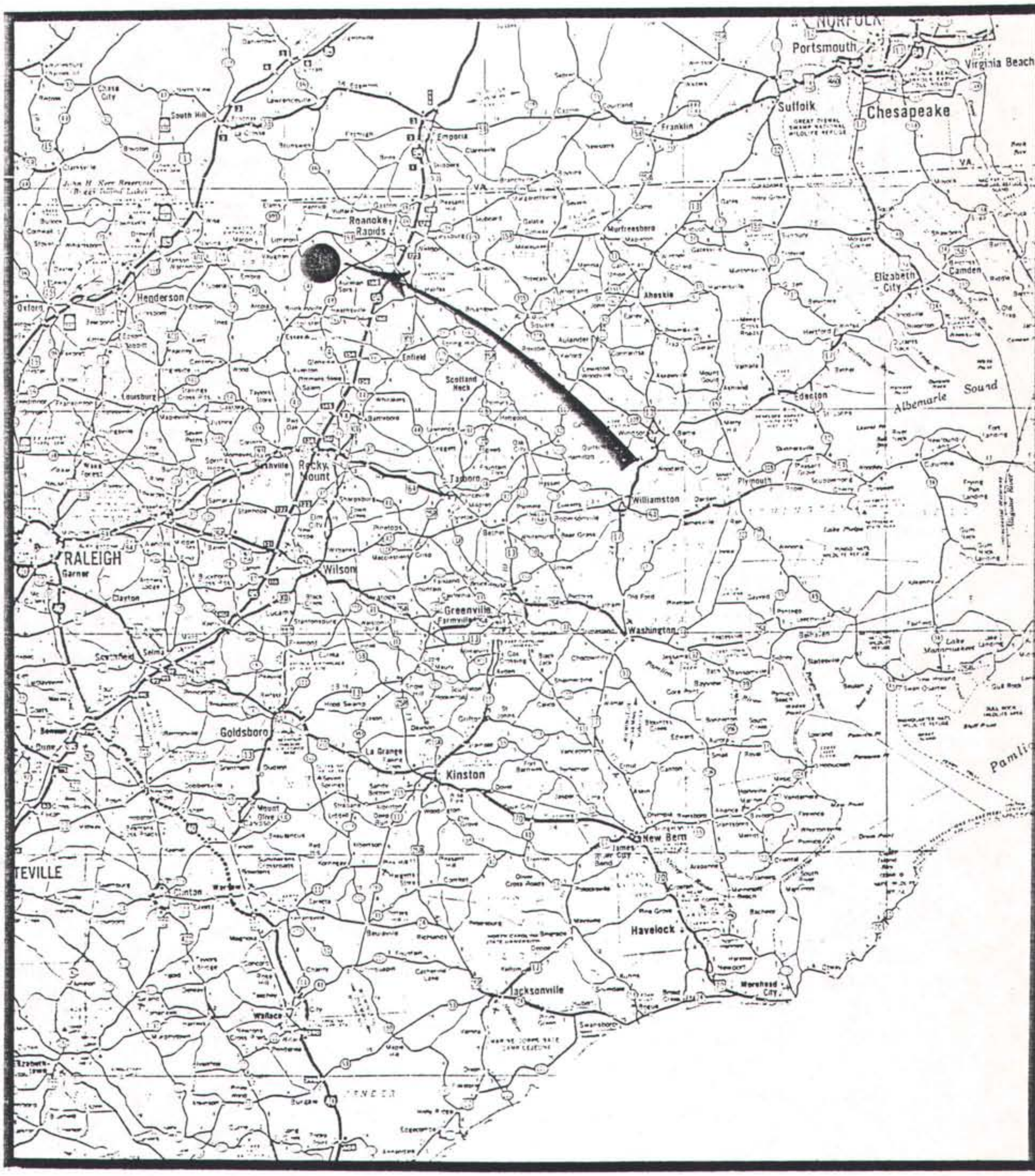


Figure 1. General location of study area shown on map of a portion of eastern North Carolina.

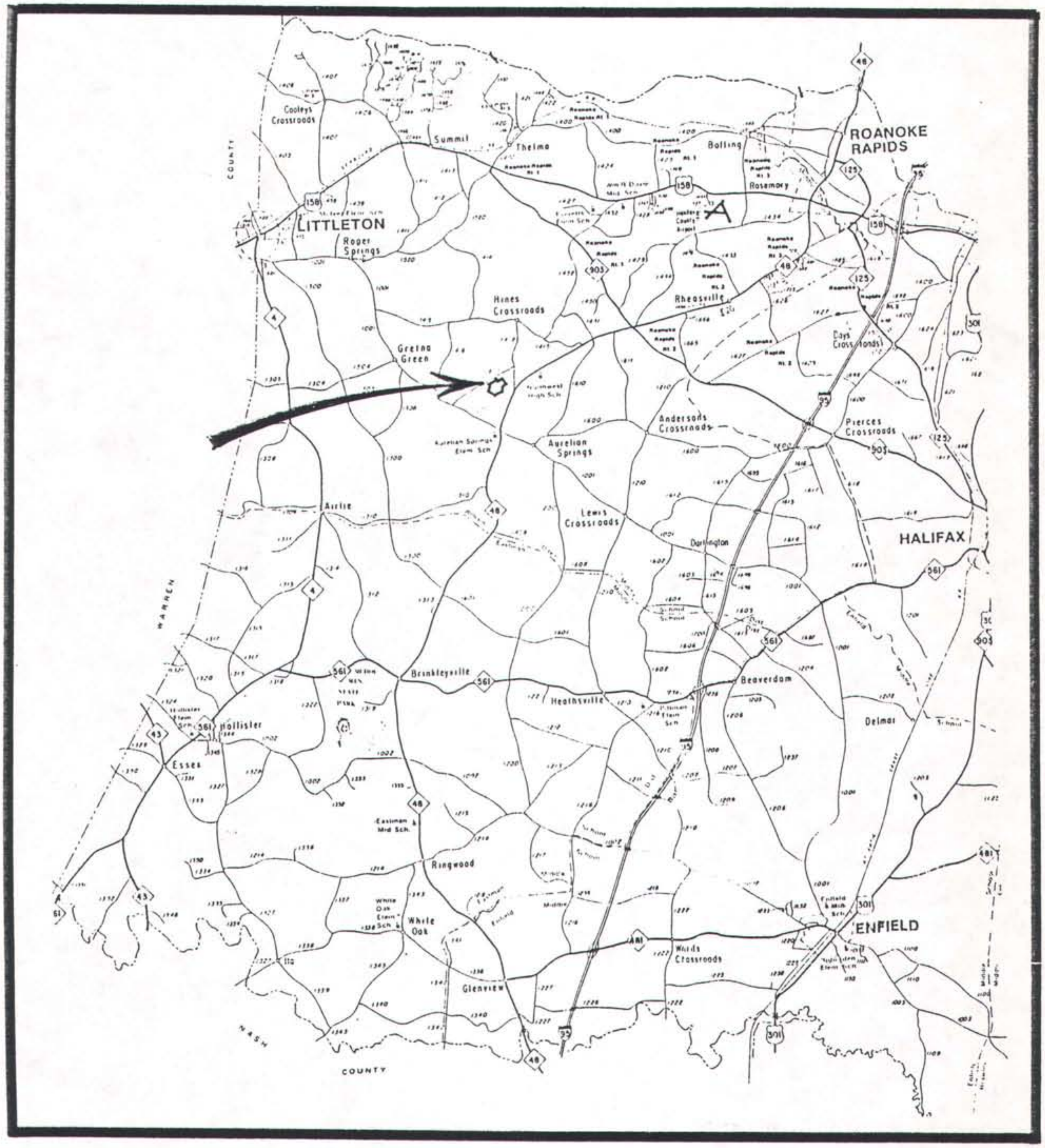


Figure 2. Location of study area shown on a map of Halifax County.

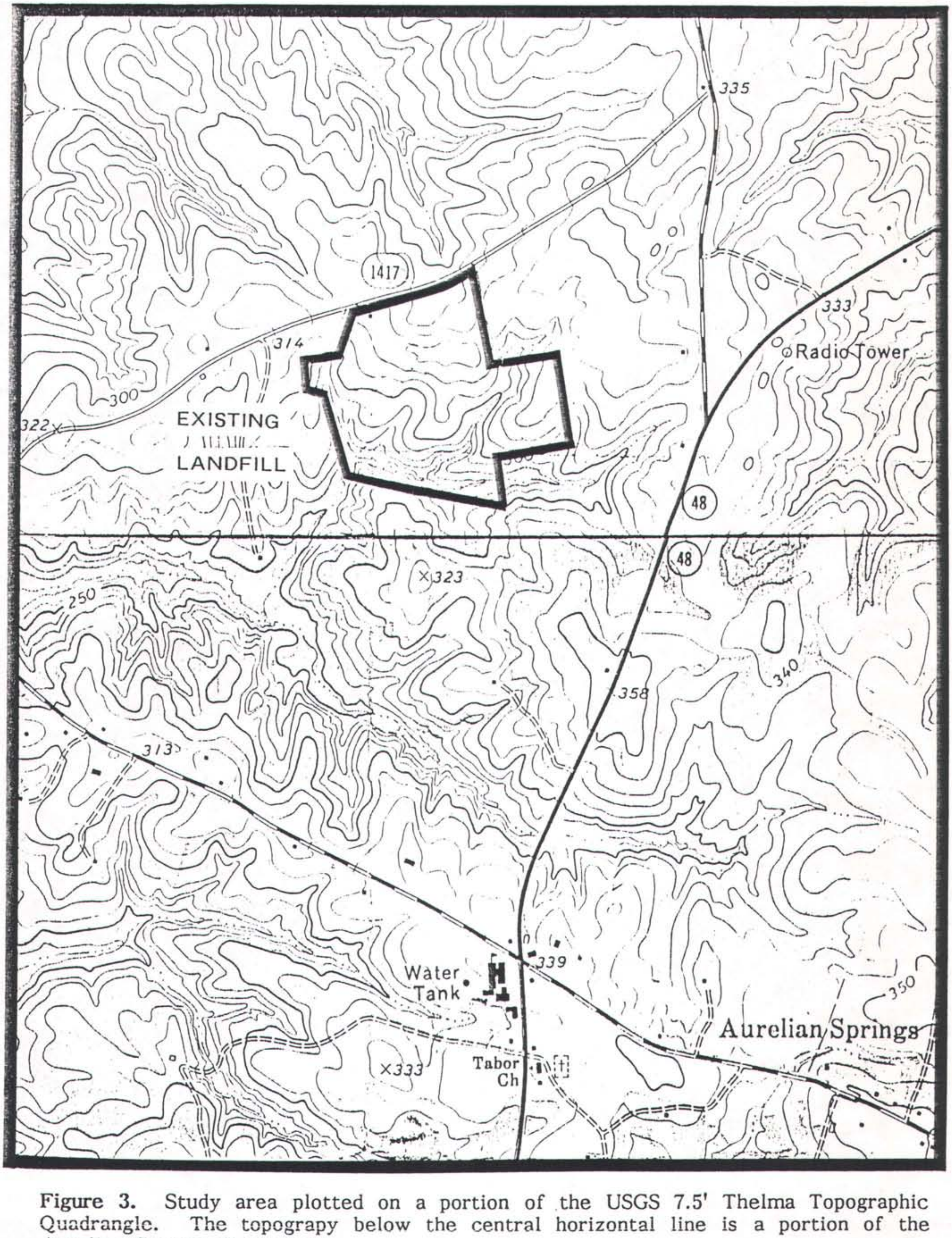


Figure 3. Study area plotted on a portion of the USGS 7.5' Thelma Topographic Quadrangle. The topograpy below the central horizontal line is a portion of the Aurelian Springs Quadrangle.

steep in the Piedmont topography. The bedrock geology of the region has been described as follows:

> Geologically, the vicinity of the site consists of an eroded peneplain which exhibits numerous broad flat-topped ridges dissected by a dendritic drainage pattern of streams and dry swales. This portion of Halifax County is underlain by a late Paleozoic-age coarse grained granite formation, which is part of a large complex of crystalline igneous rocks which comprises the so-called Eastern Piedmont geologic province. This formation forms large rounded outcrops and boulders within the lower lying portions of the site...(Ensci Corp 1991:n.p.).

The principal topographic feature of the subject property is a northwest trending ridge which transects the north-central portion of the parcel. The property generally drains to the north and south of this ridge which has an elevation of about 360' above msl. The area to the north drains into a swale which probably collects a good deal of water during rainy periods. The slope to the south, which can become moderately steep (10% - 15% grade), drains into a small creek which generally follows the southern boundary of the parcel. However, the southern slope also includes a second small

Figure 4. Granite boulders in area of dense young trees along southern Creek. Area of shovel-test D1 (see fig. 10 for location).

drainage which empties into the first. A second small ridge is located east of this secondary drainage (fig. 3).

Bedrock outcrops are absent over most of the parcel. However, several large, rounded granite boulders are situated along the southern creek in the southwestern quadrant of the study area (fig. 4). These boulders may be found to either side of the creek but their distribution is quite restricted so that they seem to represent a discrete area.

Most of the study area is covered with Wedowee soil which is characterized as a yellow clay. However, we found that most of the A-horizon soil on the property could be more accurately characterized as a red sandy clay overlying a B-horizon consisting of yellow or beige sandy clay. The local soils are said to be poor for agricultural purposes although much of the region, including parts of the study area, is farmed.

Doubtless during late prehistoric time the study area was entirely covered with mixed forest vegetation. Dominant species on uncleared portions of the higher elevations include white oak and American elm while river birch, soft rush, and various sedges are found along the drainages. Dense thickets of briar occupy much of the

Figure 5. A bulldozer cut through Area F (see fig. 9). Cuts such as this provided access for soil testing equipment but also facilitated our survey.

disturbed margins around the fields. Deer inhabit the property today as they were observed during our survey.

As noted above, most of the northern half of the property has been farmed for many years. The entire length of the major ridge has been cleared in addition to the swale to the north. The ruins of a burned farmhouse stand near Hwy. 1417 at the northeastern corner of the property (fig. 6). A badly deteriorated shed and turned over privy are located south of the house (figs. 7-8).

The small ridge on the east and the south-facing slopes below the major ridge are generally wooded and relatively undisturbed. However, a series of bulldozer cuts now connect the ridge with the southerly creek at several locations (fig. 5). These cuts, which were apparently made to facilitate soil testing, provided access to areas which could otherwise be visited only with difficulty.

III. ARCHAEOLOGICAL & HISTORICAL BACKGROUND

A. ARCHAEOLOGICAL BACKGROUND

(1) Culture History: Paleo-Indian to Early Archaic

Most culture histories for reports such as this begin with the observation that prehistoric man is generally believed to have entered North America via the "Bering Land Bridge." The hypothetical land bridge was a strip of land which connected present-day Alaska with Siberia. For some inscrutable reason, students of the subject have tended to assume that the people of the last ice age, generally referred to as the Pleistocene epoch, lacked the technical skill to construct a boat. However, recent, evidence from San Clemente Island off of the coast of California all but proves that the prehistoric inhabitants of that island built water craft capable of deep water ocean navigation almost 10,000 years ago:

> Geologic evidence indicates that San Clemente Island has never had a land connection with the mainland or its nearest neighbor, Santa Catalina Island. A very deep channel exists between the two islands and between Santa Catalina Island and the mainland. Watercraft, therefore, had to have been present on San Clemente Island at least 9,775 years ago.
>
> The watercraft technology of these early mariners appears to have been much more advanced than has been previously believed. The marine basins between the southern Channel Islands are dangerous and unpredictable and require extremely seaworthy watercraft for their

> navigation. It is speculated that the channels were probably first crossed in reed boats as these craft ..., are probably among the most the most seaworthy ships ever devised by man...(Salls 1990:71).

Since the Pleistocene is generally regarded as having ended circa 12,000-10,000 B.P. on the west coast, the recent data from San Clemente Island suggest that the earliest inhabitants of North America arrived by boat.

In any event, there is reason to believe that these early people were nomadic hunters who spread across the North American continent following game. Archaeologically, they are recognized by a particular long spear point with parallel sides, a slightly concave base, and a narrow channel or "flute" extending from the base up toward the mid-section of the point. The points, and, by implication, the people, have come to be known as "Clovis" after the City of Clovis, New Mexico, where one of the earliest discoveries of fluted points occurred.

No Clovis sites have ever been found in North Carolina although there are reports of fluted points having been found on the surface in Carburrus County near Rimer (east of Kannapolis), near Union Grove and Lookout Shoals Dam in Iredell County, and near Lake Norman in Mecklenburg County (Perkinson 1973:38, 40, 42). The oldest archaeological deposit investigated in North Carolina appears to be the Hardaway site on the Yadkin River in Stanley County. It is the finds from this Piedmont site which provided most of the data used to develop the North Carolina Paleo-Indian and Early Archaic cultural phases (Coe 1964). However, no Clovis points were uncovered at the Hardaway site and the Paleo-Indian phase in North Carolina remains sketchy to say the least.

Equally sketchy are the reasons for the termination of the Paleo-Indian phase. However, it is generally held that climatic changes (end of the ice age) caused floral and faunal changes which, in turn, necessitated changes in the lifestyle of the early big game hunters. In North Carolina, it is believed that nut-producing or deciduous trees became dominant over the formerly prevalent conifers (evergreens), thereby eliminating the habitat of certain Pleistocene fauna such as mammoth:

> When many large game animals disappeared, native Americans turned to smaller animals, shellfish, and wild plants for subsistence. Other changes accompanying the shift are significant enough to distinguish this new culture from that of the Paleo-Indians. Archaeologists call the more recent cultural tradition Archaic. Archaic peoples were far more confined to particular regions than Paleo-Indians had been... (Perdue 1964:6).

The archaic cultures were aceramic (i.e., they did not know pottery) but are well-known for their groundstone vessels and axes. These people also used the atlatl (spear thrower) although the bow and arrow remained unknown. The frequency of fire-cracked rock at Archaic sites suggests that Archaic people may have dropped heated stones into water for cooking purposes. The early Archaic Period in North Carolina has been divided into the Palmer and Kirk Periods (ca. 8,000 B.C. and 7-6,000 B.C. respectively), both of which are characterized by corner notched points (Ward and Coe 1976:11-12).

Insofar as we are aware, no evidence of the presence of either the Paleo-Indian or Early Archaic peoples has ever been found in the immediate vicinity of our study area. However, most of the remaining cultural phases are locally known.

2. Culture History: The Gaston Site & Middle Archaic to Woodland Cultural Phases in Halifax County

A records check was conducted at the Office of State Archaeology, Raleigh, with the kind assistance of Dolores A. Hall, state archaeologist. The results showed that a series of prehistoric archaeological sites have been recorded along the Roanoke River about eight miles to the north of the subject property. Most of these sites were recorded in connection with the Roanoke Rapids Dam project which took place during the 1950's. Since the impending formation of Roanoke Rapids Lake would result in inundation of some of these sites, the University of North Carolina petitioned the Virginia Electric and Power Company for permission to conduct investigations. Permission was received and excavations ensued. The most important of these excavations took place on a small (3 acre) alluvial plain next to the river at a location called Eaton's Falls. The site is situated near the entrance to the old Roanoke River Navigation where the old town of Gaston was once located (Coe 1964; this and most of the information which follows is based upon Coe 1964). Hence the name "Gaston site" for the archaeological deposit.

The Gaston site, which comprised alluvial sediments nearing nine feet in depth, was found to contain cultural material in the upper 5 1/2 feet (with the exception of an isolated hammerstone uncovered at a depth of about 6 feet). The earliest cultural phase identified at the Gaston site is known as the Guilford (after the type site in Guilford County) and is believed to date circa 4500-3500 B.C. based upon radiocarbon assays for the succeeding Halifax cultural phase. Prominent Guilford phase artifact types include long lanceolate points and chipped stone axes.

The next phase in the sequence represented at the Gaston site is called "Halifax." The Halifax people manufactured points with slender blades and shallow side notches which are often formed by grinding as opposed to chipping. Most Halifax points are made from quartz as opposed to Carolina slate which was favored for point manufacture by many other groups. Coe (1964) believed that the Halifax people may have come from the north. In any event, they are thought to have been nomadic hunters who came to the area periodically.

At the Gaston site, the Halifax people were followed by the Savannah River culture (3,000 - 1,000 B.C.). The Savannah River people, who represent the end of the Archaic Period, left a greater variety and quantity of artifacts behind than any of their predecessors. Consequently, it is thought that they may have occupied the site in greater numbers than did the earlier peoples. These Savannah River artifacts include Carolina slate points, hammerstones, ground stone vessels and grooved stone axes.

The Gaston site was apparently abandoned for about 1500 years following the departure of the Savannah River people. Then, about 500 A.D., a new people appear on the scene. Known as the Vincent Culture, the new population had technology not seen before including pottery and the bow and arrow. These introductions are the harbingers of the outset of the Woodland Period which lasted throughout the remainder of the region's prehistory. The local early pottery, called Vincent ware, is typically sand tempered and decorated by paddling with a cord-wrapped paddle or impression with a wicker type fabric (Coe 1964). Clay pipes found at the Gaston site seem to indicate that smoking of tobacco had begun.

By about 1200 A.D., sufficient changes in the material culture had occurred to justify the desingation of a new phase -- the Clements Culture. These changes include variations in pottery style, an increase in the frequency of smoking pipes, apparent complete abandonment of the atlatl in favor of the bow and arrow, and manufacture of bone points and other tools. The regional Woodland or latest prehistoric era ends with the termination of the Clements culture.

The final Indian occupation of the Gaston site commenced at circa 1600 A.D., or at about the same time as the Jamestown settlement. Known as the "Gaston Occupation," it consisted of a compact village with a stockade. The people of the Gaston Occupation may have been the historically known Tuscarora who are said to have controlled all of the land and smaller tribes between the Roanoke and Neuse River Valleys.

3. The Ethnographic Period: The Tuscarora War

European trade with the Indians began as early as the 16th century when explorers discovered that large profits were waiting to be made (most of the information which follows is from Perdue 1964).

> The first group of Englishmen whom Raleigh dispatched to Carolina in 1584 discovered that a handsome profit could be made in the Indian trade. Arthur Barlowe, captain of one of the ships sent on the expedition, reported to Raleigh: 'We exchanged our tin dish for twenty skins, worth twenty crowns or twenty nobles, and a copper kettle for fifty skins worth fifty crowns. They offered us good exchange for our hatchets and axes and for knives, and would have given anything for swords, but we would not depart with any.' (Perdue 1964:26).

The second most important Indian trade item was slaves taken as war captives. The white plantation owners purchased Indian slaves to work alongside their black slaves. The Tuscarora tribe, which was the most important in northeastern North Carolina, was among the groups active in these forms of trade. In fact, the upper Tuscarora, those living north of the Pamlico River, enjoyed the comfortable position of being middlemen in the trade taking place between the North Carolina Indian traders and the Virginia merchants operating out of the port cities.

By the early 18th century, the southern Tuscarora, living between the Roanoke and Neuse Rivers, began to feel the pressure from developing white settlements. This caused the normally independant Tuscarora villages to confederate together with some of the small displaced coastal tribes. The confederation, which I shall refer to collectively as the southern Tuscarora, was led by Chief Hancock while the upper Tuscarora were under the leadership of Chief Tom Blunt.

In 1710, a group of Swiss and German colonists built the town of New Bern near the southern Tuscarora. Convinced that hostilities were the only way to preserve the Indian domain, Chief Hancock planned an attack on New Bern for September, 1711. Just prior to the attack, the southern Tuscarora captured and executed John Lawson, an early explorer who provided some of the earliest descriptions of Piedmont cultures. The attack took place on September 22, 1711 and resulted in the deaths of some 120 colonists. Other colonists were taken captive, houses and barns were burned, and cattle and crops were seized.

The colonists retaliated and hostilities continued until finally, in 1712, Colonel John Barnwell was dispatched from South Carolina to subdue the southern Tuscarora.

Although he was able to take Fort Narhantes, a major Tuscarora fortification, Barnwell was unable to take Fort Hancock. Nonetheless, the Indians agreed to a truce.

> During a subsequent conference, however, Barnwell's troops killed 50 Tuscarora men and seized about 200 women and children as slaves. This act of treachery led to renewed hostilities which raged throughout the summer. The desparate Carolina colonists promised Tom Blunt of the northern Tuscarora control over the entire tribe in exchange for his collaboration. Blunt accepted the offer and captured Hancock, whom the colonists executed. In the spring of 1713 Colonel James Moore of South Carolina captured more than 900 Tuscarora ... the surviving southern Tuscarora were forced onto a reservation near Lake Mattamuskeet in Hyde County, but throughout the eighteenth century, groups of Tuscarora moved north to join the Iroquois, a powerful confederacy of related tribes in New York and southern Canada. (Ibid. 30).

Those Tuscarora who remained in North Carolina continued to feel the pressure of colonial expansion. Even worse, they were hated and despised as a result of the former hostilities. Finally, in 1803, the Tuscarora abandoned all land in North Carolina and followed their predecessors to reservations in New York and Canada.

4. Modern Indians: The Haliwa Tribe

The Haliwa are the only Indian tribe which exists in Halifax County today. The name "Haliwa" is not traditional--rather, it is a synthesis of the words "Halifax" and "Warren," the two counties where the tribal members reside. The tribe, which is made up of some 3,000 - 4,000 individuals, was officially recognized by the State of North Carolina on April 15, 1965. The Tuscarora, Saponi, and Cherokee are all represented among the Haliwa. W.R. Richardson is currently chief of the Haliwa, most of whom live in the towns of Hollister and Essex in Halifax County, and in Warren County (Richardson as told to Wheeler and Elias 1976:66).

B. HISTORICAL BACKGROUND

1. Halifax County

Most of the early English settlers in Halifax County were farmers from Virginia. The plantation system gradually developed as a result of their agrarian activities. The plantation owners used slave labor to grow various crops including wheat, corn, peas, and tobacco for out-of-state markets (Dept. of Cult. Resources n.d.:1). Completion of the Dismal Swamp Canal and the Roanoke River Navigation in the early 1800's provided a practical means of transporting agricultural goods to Virginia port cities.

The town of Halifax was founded on the bank of Roanoke River in 1760. It served as the seat of Halifax County as well as comprising an important trade center:

> The new town was ... at the intersection of major north-south and east-west roads. Falls and rapids were just upriver, making Halifax the head of river navigation. With these advantages, the small town quickly became a trading center and river port for goods moving between the backcountry, the plantations, and Virginia. (Ibid.).

Halifax is probably best known for its "Resolves" whereby North Carolina became the first American colony to formerly advocate overthrow of English control. This event occurred in April of 1776 when the Fourth Provincial Congress met at Halifax. The representatives at the congress were so unhappy with recent events that they authorized assembling four new Continental regiments and approved issuance of 500,000 pounds in currency to finance the war effort. They then turned to the matter of the resolves:

> The most significant action of the congress came on April 12, 1776, when a committee reported on the state of conflict with the resolution. Prefaced with a statement on the British destruction of property and lives in the colonies, the resolve firmly declared that the delegates from North Carolina to the Continental Congress 'be impowered to concur with the delegates of the other Colonies in declaring Independency, and forming foreign alliances.' (Butler 1976:65).

Halifax continued to prosper after the revolution as its agricultural-based economy flourished. But by 1835, certain changes in the State Constitution eliminated some of the County's political authority. A second blow was dealt to the City's prominence when the railroads arrived in 1839. They not only by-passed Halifax but provided a new means of transportation which soon rendered river navigation obsolete. The final blow to the area's economy resulted from the emancipation of slaves during the Civil War. Without slaves to do the work, the plantation system broke down completely.

2. Notes on Aurelian Springs

Research at the Halifax and Roanoke Rapids libraries failed to produce any documentary history of the community of Aurelian Springs. Interviews of several individuals who are familiar with Halifax County and its history also failed to produce any information (Akers 1991:pers. comm.). Consequently, we were compelled to depend upon the recollections of local residents. One such resident, Mr. Edward Butts Jr., is a student of the local genealogy and provided most of the useful information which we were able to acquire.

The small community of Aurelian Springs has its roots in colonial times era when it comprised an area of small plantations (Butts 1991:pers. comm.). The earliest name for the area, if indeed there was a name, is not known. At some time prior to the latter part of the 19th century, a teacher named Webb ran a boarding school at the intersection west of the springs. At that time, the area was known as "Webb's Crossroads."

Sometime about 1880, a man named Brinkley moved to the area. He decided to develop the springs as a health resort and it was he who named them "Aurelian Springs" or golden springs -- the name being intended to suggest the health benefits of the springwater. Local residents also came to believe that the springs conferred health benefits and it was said that they were "magical" because they moved around alot (i.e. the exact spring locations were ephemeral; Jones 1991:pers. comm.). Mr. Brinkley eventually moved away, selling the springs to a Mr. Walter Harris. Mr. Harris discontinued the resort business and returned the land to its former agrarian use. However, the community has retained the name Aurelian Springs ever since the late 19th century resort era.

3. Comments on Anticipated Cultural Resources Based upon Background Research

Aside from the well-known sites along the Roanoke River, virtually no prehistoric archaeological sites have been recorded within many miles of the subject property. Thus, there is little basis for speculation with regard to what types of prehistoric sites might be anticipated within the study area. In fact, the generalities presented in the culture history are about the only available basis for prediction.

Given these constraints, I might comment that I would not anticipate finding a Woodland era occupation site on the property since its soils are regarded as poor for agricultural purposes (Kelly 1991:pers. comm.) and the drainage channels are too narrow to accomodate fields. The prominent ridge in the north-central area of the property might seem to offer some potential for an earlier site, however.

With regard to historical sites, a prominent old farmhouse would seem to be about the only possibility. The Aurelian Springs community is very small and obscure and, with the exception of the late 19th century resort around the springs themselves, has always had an agricultural economic base. Since industry, transportation routes, and political importance are all lacking, it would be surprising to encounter an important historical site on the subject property.

IV. METHODS

The subject property was surveyed using two methods: (1) systematic walk-over inspection and (2) shovel testing. The entire property was covered by the author using the walk-over method on February 12, 1991. Each procedure is described in detail below.

1. Systematic Walk-Over Inspection

The survey began in the area of the former farmhouse (fig. 4) which was intensively reconnoitered by moving from one feature to the next. First, the area of the burned down farmhouse was examined followed by the metal shed and finally the fallen down privy. These are the only historical features visible within the study area.

Figure 6. Ruins of the Ray Stansbury farmhouse believed to have been built in the 1930's or 1940's.

The field in the swale north of the ridge was then inspected by walking in parallel transects spaced 20-30 meters apart (Area "A" in fig. 9). Although tall weeds

Figure 7. Wood and corrugated metal service building located south of farmhouse (see fig. 10 for location). Looking west.

Figure 8. Fallen down privy structure (see fig. 10 for location). Looking west.

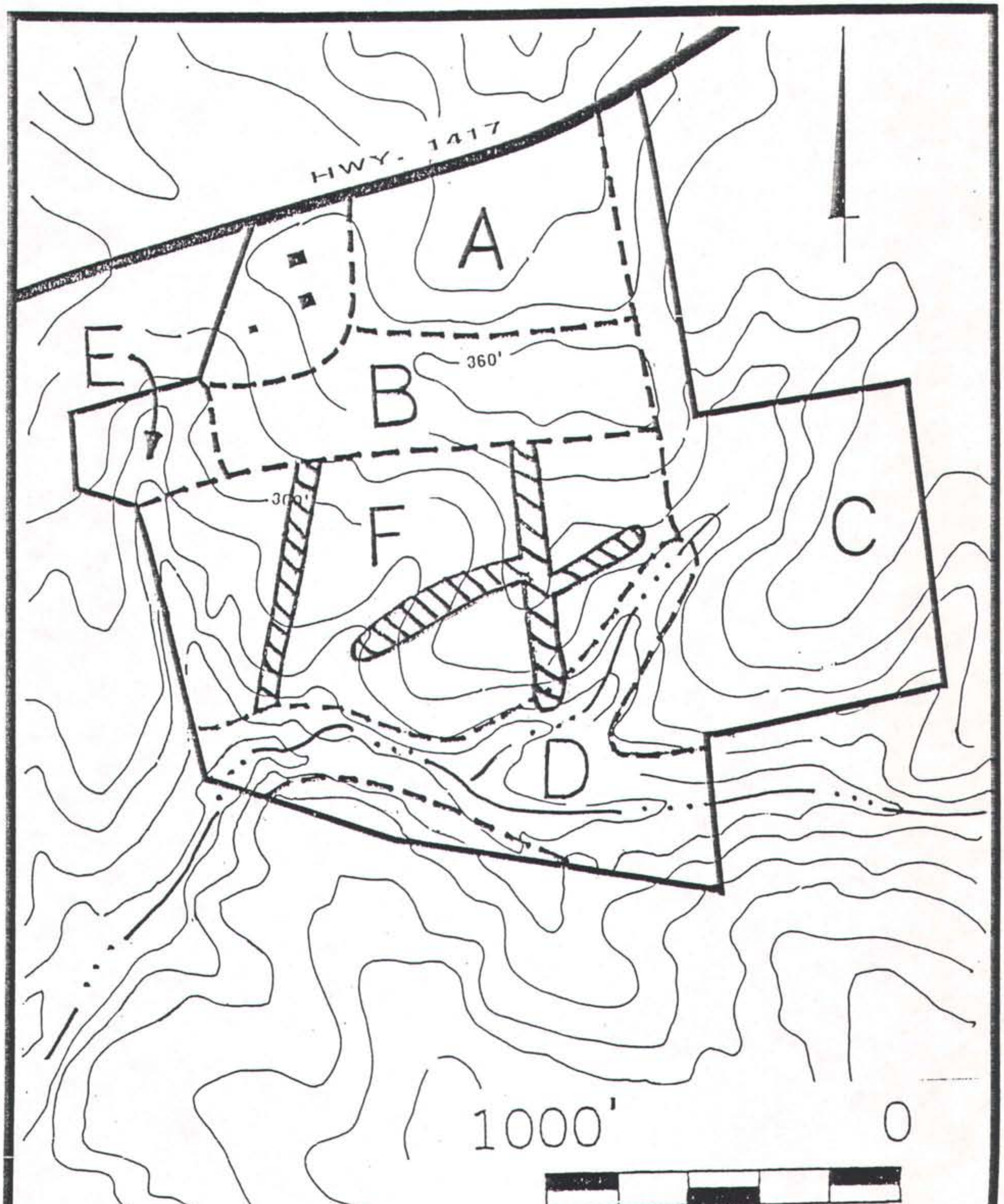


Figure 9. Study area divided into zones A through F. The hatched areas represent bulldoze cuts through wooded Area F. The farmhouse, service building, and privy are at upper left.

populate the abandoned field, it had been disced with sufficient frequency to afford some surface visibility. Soils consist of red sandy clay mixed with abundant small stream-rolled pebbles. The swale in which this northern field is situated is very poorly drained and was regarded as a low-probability location for that reason.

The ridgetop fields to the south were then inspected using a similar transect pattern (Area "B" in fig. 9). Some parts of the southern field had been recently disced affording excellent surface visibility. Other areas, particularly the highest elevations, were covered with weeds and surface visibility was poor. Since the ridgetop was regarded as a relatively high probability area, it was determined that it should be shovel-tested.

The next area to be surveyed consisted of the woods on the eastern flank of the property (Area "C" in fig. 9). This included a narrow strip of trees along the eastern edges of the two fields as well as the woods on a small ridge in the easternmost sector of the subject property. The trees on the small ridge are mature by comparison to those on the southerly slopes (Area "F," see below) and the understory is thin (excepting only the row of briars that separate the fields from the rigdes). However, surface visibility was so poor due to fallen leaves that walking the ridge was an all but perfunctory excercise. Consequently, it was decided that it too should be shovel-tested.

The survey then moved into the riparian zone ("D" in fig. 9) which consists mainly of a narrow creek which runs along the southern study area boundary and a small tributary drainage which runs down from Area C. The trees in the riparian area are mostly young, apparently due to the mature timber having been strip cut in 1978-1979 (Kelly 1991:pers. comm.). The trees are so dense and interconnected with viney understory that passage anywhere was hampered. However, access to the riparian zone was greatly facilitated by several bulldozer cuts which extended to the southerly creek from the fields in Area B. These cuts, which had apparently been made to provide access for soil sampling equipment, provided access to the southerly creek in the eastern and western areas of the property (fig. 5). Several established hunter's trails wind along both sides of the creek and these were followed.

In most places, the creek channel was quite narrow. However, small terraces were found near its confluence with the above-mentioned tributary on the west where several large granite boulder outcrops were observed. The latter were inspected with considerable care but no indications of prehistoric activity were observed. It was determined that additional shovel-testing should be performed at this location.

The next region examined comprised the wooded area on the south-facing slope (fig. 9, Area "F"). These woods had also been lumbered in 1978-1979 and consist of small trees often accompanied by dense understory growth. Surface visibility in this area was found to be very poor due to fallen leaves. However, the afore-mentioned bulldozer cuts provided a network of cleared area and these were carefully inspected. Area F was regarded as a low-probability area due to the sloping terrain and absence of attractive features.

The final area to be examined is a small panhandle shown as Area E in Figure 9. This area currently provides access to and from the existing landfill. The terrain here is irregular due to the fact that it actually comprises the upper reaches of a drainage. Much of the surface is covered with grass but a dirt road passes down the center of the panhandle. The irregularity of the ground surface and location within a drainage area led me to regard the chances of an archaeological deposit being situated in location as very low.

2. Shovel-Testing Program

The shovel testing was conducted at areas of moderate to high probability as distinguished during the walk-over inspection. Five such areas were distinguished:

(1) The small ridge in the eastern part of the study area. This area was regarded as having a relatively high probability of containing artifacts due to its elevation and the fact that it represents a discrete topographic entity. Four holes were dug on the ridge. Three, A1, A3, and A4 were placed at 50 ft. intervals in a line down the main axis of the ridge (fig. 5). The fourth, A2, was excavated northwest of A1 in a relatively flat area. The soil on the ridge was found to be quite thin. Stratigraphy consisted of about 3" of dark sandy humus overlying 4" of brown topsoil. Yellow subsoil was encountered at a depth of about 7"-8" and each hole was excavated to about 16".

(2) Non-graded area along the road in front of the farmhouse ruins. The farmhouse had been built in a flat cut which had been graded to accomodate the house. Thus there was little or no chance of encountering prehistoric material around the house itself (which we regarded as insignificant based upon our own observations as well as information obtained from interviewing Mr. Butts).

The area along the road in front (east) of the house and service building had apparently not been graded. Surface visibility here was poor due to tall grass. Therefore, a series of three shovel-test pits was dug in a curve parallel and west of the

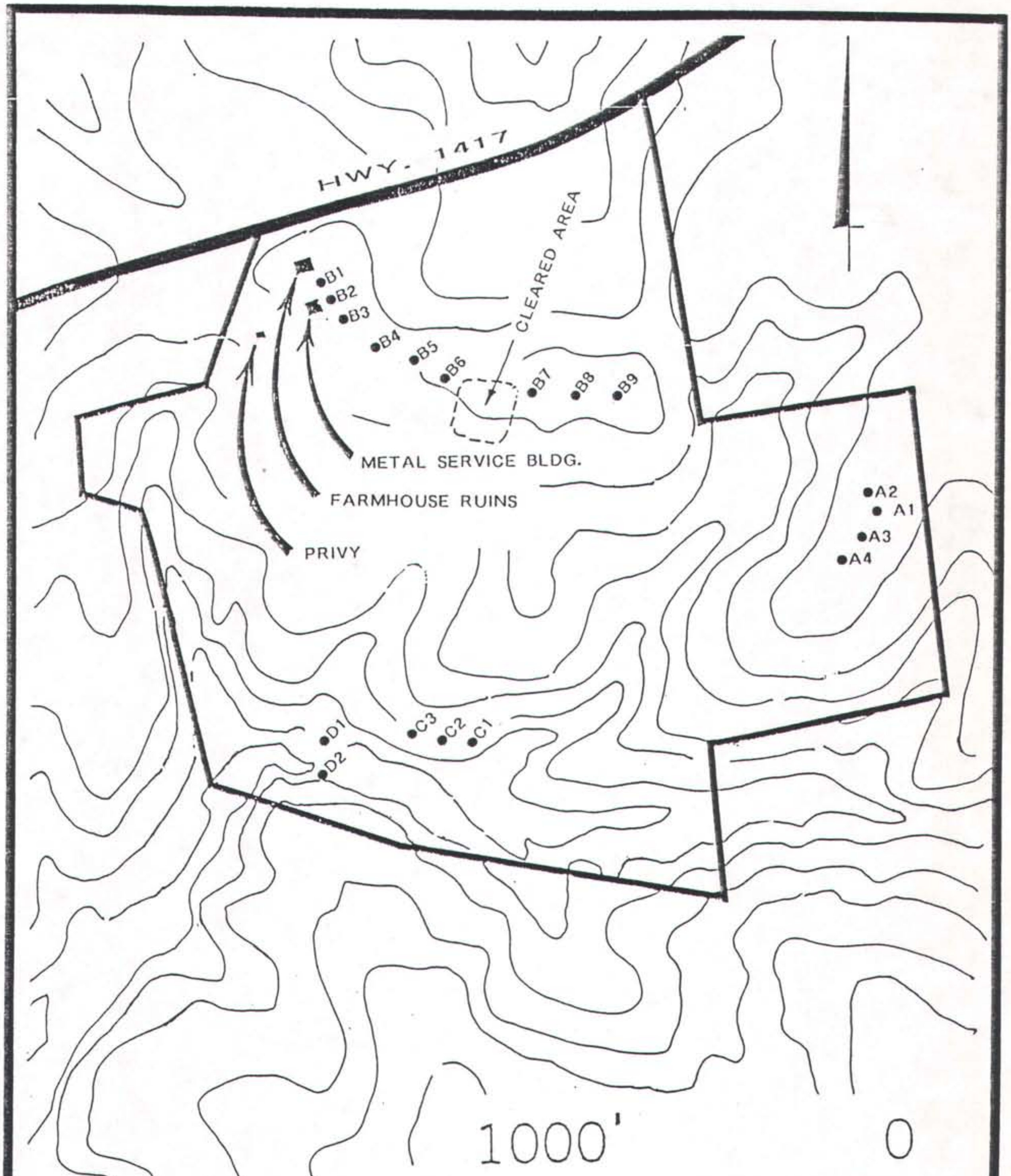


Figure 10. Shovel-Test pit locations and identifications of farm structures.

dirt road alignment. These holes, which were placed 50 ft. apart, were labeled B1 - B3 (fig. 5). The first, B1, proved to have been in a graded location as it consisted exclusively of red clay substratum. Holes B2 and B3, which were also placed at 50' intervals, were in ungraded locations. B2 yielded 10"-12" of brown topsoil overlying a red and yellow mottled substratum which contains plentiful stream pebbles. The historic finds from B2 are listed in the following section. The topsoil in B3 seemed to lack humus altogether as it consisted of about 12" of brownish yellow sand. The substratum in B3 consisted of pale yellow sandy clay mixed with pebbles.

(3) The main ridge across the northern portion of the study area. In my opinion, the main east-west trending ridge in the north-central area of the property had the highest probability of including prehistoric archaeological material of any location within the study area. Therefore, its entire length was checked with shovel-test pits spaced 100 ft. apart (B4 - B9; holes B6 and B7 were space 200' apart due to an area of near perfect surface visibility; see fig. 5). The topsoil in B4 consisted of 10" of orange clay overlying a bright brick red and yellow mottled clay substratum. The stratigraphy along the remainder of the ridge consisted of only 6"-7" of light brownish red loam overlying a substratum of solid brick red clay.

Figure 11. Location of Shovel-test pit C-1 on creek terrace.

(4) The small terrace next to the confluence of two drainages in the south-central area. Three holes placed at 30' intervals were excavated in the terrace (C1 - C3; fig. 5). Not surprisingly, soils in the terrace were found to consist of dark brown moist pure sandy alluvium. Pebbles were completely absent. We estimated, based upon the elevation of the terrace above the water level in the creek, that the terrace comprised some 4' - 5' of such alluvial sediment. However, the shovel test extended to 26".

(5) The boulder outcrop area along the southerly stream in the southwestern part of the property (fig. 4). Several boulders are situated on either side of the stream at this location. One shovel-test pit was excavated on the north side of the creek next to the most prominent boulder. This pit, D1, exposed 3"-4" of humus overlying sterile looking red sand. Once again, the depth of this alluvial deposit was probably considerable. We dug the shovel-test pit to 24". D2 was placed above the two highest boulders on the north side of the creek. Here we encountered bedrock after excavating to a depth of 12".

V. RESULTS

No prehistoric finds of any type were observed during our field investigation. Consequently, we conclude that no prehistoric archaeological material is present within the boundaries of the study area.

Shovel-test pit B2, which was placed on the west site of the road slightly south of the corrugated metal service building was the only unit which yielded finds of any kind. These consisted of series of historic items, all of which are believed to relate to the farmhouse and to be relatively late in time (no earlier than the 1930's). These finds are listed in Table 1.

TABLE 1

Finds from shovel-test pit B2, Halifax County landfill extension study.

Quantity	Description
10	nail fragments; too corroded to identify.
1	fragment of a sheet metal address letter or number.
1	white crockery ware sherd.
7	clear bottle glass fragments.
12	small brick fragments.

(4) The small terrace next to the confluence of two drainages in the south-central area. Three holes placed at 30' intervals were excavated in the terrace (C1 - C3; fig. 5). Not surprisingly, soils in the terrace were found to consist of dark brown moist pure sandy alluvium. Pebbles were completely absent. We estimated, based upon the elevation of the terrace above the water level in the creek, that the terrace comprised some 4' - 5' of such alluvial sediment. However, the shovel test extended to 26".

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A great deal of debris from the burned down farmhouse is also lying about on the surface (fig. 6). This is dominated by burned wood, fallen brick from chimney, composition flooring, cement block pillars (which upon which the structure stood) and corrugated metal roofing. Other objects include the metal from a mattress and a wringer washer. Judging by this debris, we supposed that the house probably dated no earlier than the 1940's.

Fortunately, we were able to glean some confirmation of this surmisal from Mr. Edward Butts, Jr., a life-long resident of Aurelian Springs whose family has lived in the community for generations. Mr. Butts told us that Mr. Ray Stansbury had farmed the property and lived in the house. Although he could not recall precisely when the house was built, Mr. Butts did not think that it dated earlier than the 1930's. The Stansbury family, however, has resided in the Aurelian Springs area since sometime before the Civil War and may have owned the property since well before the farmhouse was built.

The "1914-1915 Map of Halifax, North Carolina" (Hughes 1914-1915) shows two Stansburys residing in Aurelian Springs: J.B Stansbury (no. 8) and (T.W. Stansbury (no. 15). However, aside from the fact that they are an old local family, we were unable to discover any other history relating to the Stansburys. The farmhouse is said to have been burned down by a vandal who was subsequently apprehended.

VI. SIGNIFICANCE EVALUATIONS

The results of our fieldwork indicate that no prehistoric archaeological material is present within the boundaries of our study area. Only the burned rubble of the Stansbury farmhouse remains. The wood and corrugated metal service building is about to fall down and the privy has been turned over. However none of these structures are regarded as significant since they are relatively recent (perhaps too recent to be eligible for the National Register of Historic Places) and, in any event, they lack the historical significance in terms of connections with either prominent historical persons or events. Consequently, the farm buildings are not regarded as significant within the meaning of state or federal historical preservation statutes.

VII. RECOMMENDATIONS

A reasonably thorough study in conjuction with interviews and a literature review has failed to show that the planned landfill extension will affect potentially significant archaeological or historical resources. Therefore, it is recommended that the project be permitted to proceed without additional measures in connection with such resources.

REFERENCES CITED

AKERS, EDWIN A.

1991 Personal communication. Regional historian and life-long resident of Roanoke Rapids.

BUTLER, LINDLEY S.

1976 North Carolina and the Coming of the Revolution, 1763-1776. North Carolina Dept. of Cultural Resources, Division of Archives and History. Raleigh.

BUTTS, EDWARD JR.

1991 Personal communication. Student of local genealogy and life-long resident of Aurelian Springs.

COE, JOFFRE L.

1964. The Formative Cultures of the Carolina Piedmont. Transactions of the American Philosophical Society, Vol. 54, Part 5. Philadelphia.

DEPT. OF CULTURAL RESOURCES

n.d. Historic Halifax. Raleigh.

ENSCI CORP.

1991 Environmental Assessement of Proposed Halifac County Landfill Extensions Site. High Point.

HUGHES, N.C.

1914-1915 Halifax, North Carolina 1914-1915. A Map of Halifax County. Copy on file with the North Carolina Dept. of Cultural Resources. Raleigh.

JONES, MARGARET

1991 Personal Communication. Life-long resident of Halifax area.

KELLY, JOHN

1991 Personal Communication. Director, Halifax County Solid Waste Dept.

PERDUE, THEDA

1964 Native Carolinians: The Indians of North Carolina. University of North Carolina Press. Chapel Hill.

PERKINSON, PHIL H.

1973 North Carolina fluted projectile points--survey report number two. Southern Indian Studies, Vol. 25, pp. 3-60.

SALLS, ROY

1990 The Ancient Mariners: Ten Thousand Years of Marine Exploitation at Eel Point, San Clemente Island, California. Pacific Coast Archaeological Society Quarterly, Vol. 26, Nos. 2 & 3, pp. 61-92.

WARD, TRAWICK, & JOFFRE L. COE

1976 Final Report: An Archaeological Evaluation of the Falls of the Neuse Reservoir. Ms. on file with the Research Laboratories in Anthropology, University of North Carolina. Chapel Hill.

WHEELER, PENNY, & GAIL ELIAS

1976 Haliwa Tribe. IN Halifax Heritage, Historical and Traditional Sketches of Halifax County (prepared by Weldon High School). The Roanoke News Co. Weldon.

E-Local Government

FILE

County of Halifax
P. O. Box 38
Halifax, N.C. 27839
919-583-1131

Neal C. Phillips
County Manager

November 5, 1990

Mr. David A. Stoner
Project Development Manager
Westmoreland-Hadson Partners
c/o Westmoreland Energy, Inc.
2955 Ivy Road, Suite 302
Charlottesville, VA 22901

Subject: Roanoke Valley Project
Ash Management Services
Letter of Commitment

Dear David:

This letter is intended to express Halifax County's commitment to provide ash disposal services for Westmoreland-Hadson Partners' (WHP) Roanoke Valley Project.

As you know, Halifax County and WHP have been mutually working on developing an integrated ash monofill/sanitary landfill facility at the existing Halifax County Landfill. This facility will provide upgraded municipal solid waste disposal capacity to satisfy future regulatory requirements and Halifax County's waste disposal needs. The facility will also include separate ash monofill cells to manage coal ash from the Roanoke Valley Project.

Halifax County concurs with the conceptual design of this facility provided in ENSCI's conceptual engineering report dated October 11, 1990 (Exhibit 1). We will continue discussions with WHP in order to execute a definitive agreement by December 15, 1990.

The definitive agreement shall contain the terms and conditions set forth in the attached term sheet (Exhibit 2). The major components of this arrangement are described below:

- Halifax County will provide ash management services for an initial term of 15 years.
- Ash monofills constructed in accordance with the agreement will be reserved exclusively for disposal of ash from WHP. Halifax County will undertake to provide sufficient capacity at the integrated facility to dispose of up to 120,000 tons/year of ash.

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- Halifax County will secure land adjacent to the existing sanitary landfill for construction of the ash monofill facility.

- Halifax County will design and permit the ash monofill concurrently with the design and permitting of required upgrades to the county's existing sanitary landfill. WHP will reimburse the County for $250,000 of the estimated total $300,000 engineering and permitting fees for the integrated facility.

- Halifax County will own and operate the integrated ash monofill/sanitary landfill facility.

- WHP will reimburse Halifax County for costs associated with construction and operation of the ash monofill, in accordance with the payment terms and conditions of the attached term sheet.

Halifax County looks forward to working with WHP on this mutually beneficial project for managing our respective solid wastes. If you agree with the terms and conditions set forth in this letter, please indicate your agreement by signing and dating the enclosed copy in the space provided below and return the signed copy to the undersigned. If you require any additional information or if I can be of further assistance, please contact me.

Sincerely,

Neal C. Phillips
Halifax County Manager

Accepted:

By: Ray J. Brown III

Title: President, Westmoreland Roanoke Valley a general partner of Westmoreland-Hadson Partners

NCP:ph

xc: L. Lane, Halifax
J. Kelly, Halifax
R. Daley, WHP
M. Sakurada, WHP
G. Richardson, ENSCI
RV File: 6.6.2