# PERMIT APPLICATION REPORT

## CDLF Vertical Expansion for Closed MSWLF Unit

## Halifax County Landfill
## Permit Number 42-04



Prepared for
**Halifax County, North Carolina**
Solid Waste Department



**December 1997**



**G.N. Richardson & Associates**
Engineering and Geological Services
425 N. Boylan Avenue
Raleigh, North Carolina 27603

State of North Carolina
Department of Environment
and Natural Resources
Division of Waste Management

James B. Hunt, Jr., Governor
Wayne McDevitt, Secretary
William L. Meyer, Director

DENR

March 5, 1998

Mr. Charles Archer, County Manager
County of Halifax
P.O. Box 38
Halifax, North Carolina 27839

Subject: Halifax County MSWLF Facility Transition Plan Modification for Permit #42-04

Dear Mr. Archer:

The Solid Waste Section hereby approves the modification of the referenced MSWLF Facility permit to allow the construction and operation of a CONSTRUCTION & DEMOLITION LANDFILL UNIT consisting of approximately 1 acre(see page 5 of the certification letter faxed on 2/26/98) of the Phase 1 area(in accordance with sheet 1/Drawing G1 and sheet 13/Drawing P1 of the approved plans to an elevation of 328 MSL) at the Halifax County landfill. The operation of Phase 1 is effective 5 March 1998 and the operational permit for the facility will be reviewed every five years, on or before 5 March 2003 (see Condition Number 2, Page 1).

Please note operational conditions outlined on pages one thru five for the facility. The Waste Management Specialist for this facility is Mr. Ben Barnes and he can be reached in our Raleigh Regional Office at (919) 571-4700.

If you have any questions about this approval letter, please contact me at (910) 486-1191 or James C. Coffey at (919) 733-0692 Ext. 255.

Sincerely,

Jim Barber
Eastern Area Engineer
Solid Waste Section

cc: Jim Coffey
Terry Dover
Ben Barnes
Raleigh Central Office: Halifax County MSW Facility Transition Plan Permit #42-04

PERMIT NO. 42-04
Modification dated: 3-05-98

STATE OF NORTH CAROLINA

DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES

DIVISION OF SOLID WASTE MANAGEMENT

P.O. BOX 27687 RALEIGH, NC 27611

# SOLID WASTE PERMIT

COUNTY OF HALIFAX

is hereby issued a PERMIT TO OPERATE, a 1 acre area, within

PHASE 1 of the

Construction and Demolition Landfill Unit

located on S.R. 1417, at the Halifax County Landfill, Aurelian Springs, Halifax County in accordance with Article 9, Chapter 130A, of the General Statutes of North Carolina and all rules promulgated thereunder and subject to the conditions set forth in this permit.

James C Coffey

James C. Coffey, Supervisor
Permitting Branch
Solid Waste Section

PERMIT NO. 42-04
MODIFICATION DATED: 3-05-98

# SOLID WASTE PERMIT

Permit to Operate
Halifax County Landfill
Construction and Demolition Debris Landfill Unit

**CONDITIONS OF PERMIT:**

GENERAL

1. When this property is sold, leased, conveyed or transferred, the deed or other instrument of transfer shall contain in the description section in no smaller type than that used in the body of the deed or instrument, a statement that the property has been used as a sanitary landfill.

2. This permit will be subject to review every five years, on or before 5 March 2003, as per 15A NCAC 13B .0201(c) or sooner, according to the issuance date of this permit. Modifications to the facility may be required in accordance with rules in effect at the time of review.

3. The approved plan is described by Attachment 1, "List of Documents for Approved Plan". Where discrepancies may exist, the most recent submittal and the Conditions of Permit shall govern. Some components of the approved plan are reiterated in the Conditions of Permit.

4. This permit is not transferable.

5. The Financial Assurance Instrument(FAI) for this facility shall be amended when Closure Certification has been complete and the Closure/Post-Closure Care portion of the instrument is amended. The FAI shall be reviewed and updated annually for this facility once closure of the MSW unit is complete.

6. If during the operational life of the C&D unit it becomes apparent that the operations at the facility are impacting ground water adversely; the Solid Waste Section will require landfilling activities to cease and closure of the operating unit.

CONSTRUCTION AND OPERATION

1. This permit is for development of the Halifax County Landfill Construction and Demolition Unit, a 1 acre area(see page 5 of certification letter) within Phase 1 in accordance with the approved plan, sheet 1/Drawing G1 and sheet 13/Drawing P1 to an elevation of 328 MSL. Please note that disposal of waste shall not begin along the south boundary of Phase 1 and the existing slope of the MSW unit until such slope has been closed and CQA documentation presented to the Section for approval.

2. This solid waste management facility is permitted to receive the following waste types:
   a. Land-clearing debris as defined in G.S. 130A-290, specifically, solid waste which is generated solely from land-clearing activities, such as stumps, trees, etc.;
   b. Inert debris defined as solid waste which consists solely of material that is virtually inert, such as brick, concrete, rock and clean soil; and
   c. Asphalt in accordance with G.S. 130-294(m).
   d. Construction and demolition debris defined as solid waste resulting solely from construction, remodeling, repair or demolition operations on pavement, buildings, or other structures.
   e. C&D like waste that are similar to wastes typically found in the land clearing-inert debris and C&D waste streams consisting of wastes at this time: roofing shingle waste from the manufacturer, waste building materials from mobile home/modular home manufacturer and wooden pallets. Other wastes **MAY** be approved by the Division upon receipt of a written request with the specific waste type, how its generated, how much is generated; along with any additional information the Division may request to render a final decision on the disposal options for the waste.

   Yard trash as defined in G.S. 130A-290, shall not be disposed in the landfill area. However, yard trash, along with land-clearing debris, may be accepted for processing in the Yard Waste Composting Area.

3. All sedimentation/erosion control activities will be conducted in accordance with the Sedimentation Control Act codified at 15 NCAC 4. Native vegetation shall be established on the completed landfill.

4. The following requirements shall be met prior to operation of Phase 1 at this facility:
   a. Site preparation and or closure of that area of the MSW unit shall be in accordance with the construction closure plans.
   b. Signs shall be posted at the facility in accordance with the Access and Safety Requirements under Operation Condition No. 5 listed below.
   c. The existing groundwater monitoring system will be utilized for ground water monitoring for the C&D unit(s) in accordance with .1630 thru .1633. Assessment monitoring shall continue in accordance with Solid Waste Management Rules and any additional requirements set forth by Solid Waste Section Hydrogeologist.
   d. Closure certification and documentation shall be submitted to the Solid Waste Section and a approved by the Section prior to receiving C&D waste in the proposed unit(s).Partial closure of units will be accepted with certification and documentation of partial unit closure submitted for approval. Seeding and stabilization of cover soils shall be performed prior to receiving C&D waste.

5. Operation of the C&D landfill units shall conform to the operating procedures described in the approved plan, in accordance with Section .1626 of the Solid Waste Management Rules, and in accordance with the following requirements:

   Waste Acceptance and Disposal
   a. The facility shall accept only those solid wastes which it is permitted to receive.
   b. No municipal solid waste, hazardous waste, industrial waste, liquid waste or waste not charaterized as LCID or C&D shall be accepted for disposal.
   c. The permittee shall implement a program at the facility for detecting and preventing the disposal wastes listed in item "b" of this section. The program shall include, at a minimum:
      (i) Random inspections of incoming loads or other comparable procedures:
      (ii) Records of any inspections;
      (iii) Training of personnel to recognize hazardous and liquid wastes;

(iv) Development of a contingency plan to properly manage any identified wastes listed in item "b" of this section; the plan must address identification, removal, storage, and final disposition of waste.

Cover Material Requirements

a. Operational soil cover of at least six inches shall be placed at least once per week or when the active area reaches 1/2 acre in size or more often as necessitated by the nature of the waste so as to prevent the site from becoming a visual nuisance and to prevent fire, windblown materials, vectors or water infiltration.
b. Areas which will not have additional waste placed on them for 12 months or more, but where final termination of operations has not occurred, shall be covered with a minimum of one foot of soil cover.
c. After final termination of disposal operations at the site or major part thereof, or upon revocation of a permit, the fill areas shall be covered with a cap in accordance with .1627(c) or in accordance with the rules at the time of closure.

Access and Safety

a. The facility shall be adequately secured by means of gates, chains, berms, fences, or other security measures approved by the DSWM to prevent unauthorized entry.
b. An attendant shall be on duty at the site at all times while it is open for public use to ensure compliance with operational requirements.
c. The access road to the site shall be of all-weather construction and maintained in good condition.
d. Dust control measures shall be implemented when necessary.
e. Signs providing information on dumping procedures, the hours of operation, the permit number, and other pertinent information shall be posted at the site entrance.
f. Signs shall be posted stating that no MSW, hazardous waste or liquid waste can be received.
g. Traffic signs or markers shall be provided as necessary to promote an orderly traffic pattern to and from the discharge area and to maintain efficient operating conditions.

h. The removal of solid waste from the facility is prohibited unless the owner/operator approves and the removal is not performed on the working face.
i. Barrels and drums shall not be disposed of unless they are empty and perforated sufficiently to ensure that no liquid or hazardous waste is contained therein, except fiber drums containing asbestos.
j. Open burning of solid waste is prohibited.
k. The concentration of explosive gases generated at the facility shall not exceed:
    i. twenty-five percent of the limit for gases in site structures (excluding gas control or recovery system components; and
    ii. the lower explosive limit for gases at the facility boundary.

Erosion and Sedimentation Control

a. Adequate sedimentation and erosion control measures shall be practiced to prevent silt from leaving the site.
b. Adequate sedimentation and erosion control measures shall be practiced to prevent excessive on-site erosion.
c. Provisions for a vegetative ground cover sufficient to restrain erosion must be accomplished within 30 working days or 120 calendar days upon completion of any phase of C&D landfill development.

Drainage Control and Water Protection Requirements

a. Surface water shall be diverted from the operational area.
b. Surface water shall not be impounded over or in waste.
c. A separation distance of at least four feet shall be maintained between waste and the ground-water table.
d. Solid waste shall not be disposed of in water.
e. Leachate shall be contained on site or properly treated prior to discharge. An NPDES permit may be required prior to discharge of leachate to surface waters.

All pertinent landfill operating personnel will receive training and supervision necessary to properly operate this landfill.

6. Ground water quality at this facility is subject to the classification and remedial action provisions referenced in Rule .1634 thru .1637 of 15A NCAC 13B.

7. A closure and post-closure plan must be submitted for approval at least 90 days prior to closure or partial closure of any landfill unit. The plan must include all steps and measures necessary to close and maintain the facility in accordance with all rules in effect at that time. At a minimum, the plan shall address the following:

   a. Design of a final cover system; using the cap requirements outlined in Rule .1627
   b. Construction and maintenance/operation of the final cover system and erosion control structures;
   c. Surface water, ground water, and explosive gas monitoring.

<u>MONITORING AND REPORTING REQUIREMENTS</u>

1. Ground-water monitoring wells and monitoring requirements for the C&D landfill units shall be in accordance with the monitoring system approved in the TRANSITION PLAN for the facility and these additional conditions:

   a. Monitoring well design and construction shall conform to the specifications outlined in <u>Attachment 2</u>, "North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities".
   b. A geologist shall be in the field to supervise well installation, if necessary. The exact locations, screened intervals, and nesting of the wells shall be established after consultation with the SWS Hydrogeologist at the time of well installation for new monitoring wells.
   c. For each new monitoring well constructed, a well completion record shall be submitted to DSWM within 30 days upon completion.
   d. Sampling equipment, procedures, and parameters shall conform to specifications outlined in the above-referenced guidance document, (<u>Attachment 2</u>), or the current guidelines established by DSWM at the time of sampling and in accordance with the approved TRANSITION PLAN OR ASSESSMENT AND REMEDIATION PLAN.

e. In order to determine ground-water flow directions and rates, each monitoring well shall be surveyed, and hydraulic conductivity values and effective porosity values shall be established for the screened intervals for each new monitoring well.

f. The permittee shall sample the monitoring wells semi-annually or as directed by the SWS Hydrogeologist.

g. A readily accessible unobstructed path shall be initially cleared and maintained so that four-wheel drive vehicles may access the monitoring wells at all times.

2. The permittee shall maintain a record of all monitoring events and analytical data. Reports of the analytical data for each water quality monitoring sampling event shall be submitted to DSWM in a timely manner.

3. The permittee shall maintain a record of the amount of solid waste received at the facility, compiled on a monthly basis. Scales shall be used to weigh the amount of waste received.

4. On or before 01 August 98 ( or an earlier date as requested by the Solid Waste Section), and each year thereafter, the permittee shall report the amount of waste received (in tons) at this facility and disposed of in the landfill to the Solid Waste Section and to all counties from which waste was accepted, on forms prescribed by the Section. This report shall include the following information:

   a. The reporting period shall be for the previous year, beginning 01 July and ending on 30 June;
   b. The amount of waste received and landfilled in tons, compiled on a monthly basis, according to Condition 6 described above; and
   c. Documentation that a copy of the report has been forwarded to all counties from which waste was accepted.

5. All records shall be maintained on-site and made available to the SWS upon request.

6. The Post-Closure plan approved in the TRANSITION PLAN shall be implimented and followed upon capping and closing the operating unit(s).

ATTACHMENT LIST

List of Additional Documents for the Approved Transition Plan

1. Site and Construction Transition Plan modification application for the Halifax County Landfill, Permit #42-04. Document titled "Permit Application Report - CDLF Vertical Expansion for closed MSWLF Unit - Halifax County Landfill - Permit Number 42-04" dated 19 December 1997 and received 23 December 1997.

2. Site plans and operations plan dated 19 December 1997 and received 23 December 1997.

3. Certification letter dated 20 February 1998 and faxed to the Solid Waste Section on 26 February 1998 addressing closure of a 1 acre area of Phase 1 C&D Unit.

# PERMIT APPLICATION REPORT

## CDLF Vertical Expansion for Closed MSWLF Unit

## Halifax County Landfill
## Permit Number 42-04

Prepared for
**Halifax County, North Carolina**
Solid Waste Department



STATE OF NORTH CAROLINA
CONSTITUTION
APRIL 12, 1776
HALIFAX COUNTY



**December 1997**

**G.N. Richardson & Associates**
Engineering and Geological Services
425 N. Boylan Avenue
Raleigh, North Carolina 27603

# PERMIT APPLICATION REPORT

## CDLF Vertical Expansion for Closed MSWLF Unit

## Halifax County Landfill
## Permit Number 42-04

Prepared for
**Halifax County**
SOLID WASTE DEPARTMENT
921 Liles Road
Littleton, North Carolina 27850

To the Attention of
**Mr. Richard H. Garner**
DIRECTOR

GNRA Project No. HALIFAX-13

NORTH CAROLINA LICENSED SEAL 983 GEOLOGIST G. DAVID GARRETT
12/19/97

G. David Garrett, P.G.
Principal, Senior Geologist

NORTH CAROLINA PROFESSIONAL SEAL 021668 ENGINEER PIETER K. SCHEER
12/19/97

Pieter K. Scheer, P.E.
Project Engineer

**December 1997**

**G.N. Richardson & Associates**
Engineering and Geological Services
425 N. Boylan Avenue
Raleigh, North Carolina 27603

**Permit Application Report**
**CDLF Vertical Expansion for Closed MSW Landfill**
**Halifax County, North Carolina**

Table of Contents

Tables



Figures *Refer to Drawings listed below, located in the accompanying plan set.*



*The other drawings in the plan set present construction details*

<u>Appendices</u>

# 1.0 EXECUTIVE SUMMARY

The planned facility is a Construction and Demolition debris landfill (CDLF), to be developed above a closed MSWLF unit at the Halifax County Landfill (Permit #42-04). The CDLF will be constructed within a 4.6 acre footprint, in a portion of the closed MSW landfill that had not achieved final closure grades per the Amended Transition Plan of December 1996 (Transition Plan). This report modifies the Transition Plan for the MSW landfill, in that new closure contours for the MSW unit are presented.

The CDLF vertical expansion will allow the landfill to achieve more appropriate final grades over the entire footprint, which will promote better runoff characteristics and reduce future potential for surface water infiltration to the MSW. The expansion will take place entirely within the permitted waste boundary. This activity is allowed per NC DWM correspondence dated March 1, 1997. The CDLF will be designed and operated pursuant to 15 NCAC 13B .0503 through .0505, while the ground water monitoring and final cover for the closed MSW facility is subject to the appropriate .1600 rules.

The landfill will cease operation as a MSW disposal facility by December 31, 1997. Final cover construction for the MSW unit has commenced and is scheduled for completion within 180 days of the closure date. Those areas that are now 'on grade' will receive a final cover that meets or exceeds the current regulatory minimum cover (RMC) requirements. The area of the planned CDLF expansion will be closed initially with the RMC. The side slopes and cap will be closed incrementally in accordance with the Amended Transition Plan as those areas are brought to final grade with C&D wastes.

This permit application report has been prepared with geologic data from a recent evaluation of hydrogeological conditions at the old MSW landfill (as part of the ongoing ground water monitoring program), the original site investigation for the MSW landfill (performed ca. 1981), and numerous investigations for other disposal sites within the permitted facility boundary. The latter consists of the active Ash Monofill, a lined future MSWLF unit (which received a "site suitability" review letter from NC DWM) and a new CDLF (currently under review).

Data and conclusions for the site characterization have been drawn from these earlier studies to demonstrate continuity of geologic conditions within the permitted facility boundary. This report is a stand-alone permit application document for the planned CDLF, which, through summary of the prior site investigations, provides an overall characterization of subsurface conditions near the old MSW landfill. All relevant data from the earlier work are reproduced herein. This report includes a discussion of applicable siting criteria and a site-wide hydrogeological evaluation that includes ground water level observations covering a period of more than one year.

The MSW landfill is current with ground water monitoring requirements and has a good overall history of compliance. After December 31, 1997, Halifax County will transfer its MSW wastes via a private hauler. The County wishes to reserve the right to pursue a permit to construct the lined MSWLF unit and the new CDLF unit at some future time.

# 2.0 SITE REPORT

## 2.1 Regional and Local Characterization Study - *.0504 (1) (a) and (b)*

This section presents a brief description of the regional and local studies, presented in the Amended Transition Plan of December 1996. That document presented maps and aerial photos, not reproduced in this report. The facility is located twelve miles south of Roanoke Rapids, one mile north of the intersection of NC 48 and SR 1001, near the town of Littleton. The site has been owned and operated by Halifax County as a solid waste landfill since 1981.

The property is zoned agricultural. Area land use is primarily undeveloped or agricultural. Scattered houses and businesses exist along NC 48 and the other paved roads in the area. The permitted facility is bound on the north by SR 1417 and to all other directions by private property. Access to the site is from SR 1417, which connects to SR 1418 to the north and SR 1001 to the south. Both of these roads connect to NC 48 and serve as the primary waste transportation routes. All off-site access roads are paved. Current waste transportation routes over public roads will not be modified. Utility easements adjacent to the facility boundary include an overhead electric power line and a buried telephone cable, located along SR 1417 at the north end of the site. No other utilities or easements are known within the site boundary.

No surface water intakes or residential subdivisions are known to exist within two miles of the site. Municipal water is not available in the vicinity. The nearest known public water service area is Roanoke Rapids. Significant ground water users within two miles of the site include two schools: a high school located northeast at a distance of 1.5 miles, and an elementary school located southeast at a distance of 0.8 miles from the facility boundary. Neither ground water user facility is down gradient of the site, nor are these facilities expected to be influenced by the planned site development. A potable well survey, conducted in conjunction with the Transition Plan for the old MSW landfill, identified 24 potable water wells within 2000 feet of the site boundary, excluding two wells at the nearer school that are outside the 2000-foot radius. None of the area water wells are down gradient of the landfill.

The unlined MSW landfill is a potential contaminant source within the permitted facility boundary. This facility has been investigated and is monitored per the approved Sampling and Analysis Plan (SAP) prepared for the Transition Plan. A former C&D disposal facility exists on the opposite side of a creek, several hundred feet downstream from the planned CDLF expansion area. This unit is not expected to affect ground water at the planned CDLF site.

Other nearby potential contaminant sources (outside the 2000 foot radius) include a junkyard (automobiles, construction/farm machinery, and other debris) located 0.75 miles northeast at the intersection of SR 1417 and SR 1418, a chicken farm located south on SR 1001, and two gas stations located at the NC 48 - SR1001 intersection. These facilities are neither up gradient nor down gradient of the site. None of these facilities have been investigated with regard to potential ground water contamination, nor are any allegations of suspected contamination made herein.

## 2.2 Facility Development Plan - *.0504 (1) (a) and (b)*

The proposed CDLF will occupy the northern half of a permitted vertical expansion area that did not achieve final grades per the December 1996 Transition Plan. Drawings FC1 and FC2 show the projected final closure contours as of December 31, 1997 and proposed final closure contours per the Transition Plan, respectively. Operation of the CDLF will be conducted in accordance with the .0500 rules, while ground water and landfill gas monitoring will continue in accordance with the applicable .1600 rules.

Other active waste disposal facilities within the facility boundary will include the Ash Monofill, operated by Halifax County exclusively for disposal of coal-fired power plant ash from a nearby cogeneration facility. The County's white goods, tires and composting operations now occupy an undeveloped portion of the site, designated as the future lined MSWLF unit.

### 2.2.1 Previous Site Studies

The following are previous reports that have been completed for the Halifax County Landfill by GNRA and submitted to NC DWM:

1. Site Suitability Study and Design Report - Halifax County Ash Monofill, March 1991
2. Halifax County Landfill Vertical Expansion - Design & Operations Plans, June 1991
3. Transition Plan Amendment Report - Unlined MSW Landfill, December 1996
4. Part 1 Site Application Report - Lined MSW Landfill, May and October 1996
5. Permit Application Report - Halifax County C&D Landfill, August 1997 (new facility)
6. Review and Discussion of Appendix II Sampling Requirements, July 1995 (follow up to the baseline Appendix I ground water monitoring report, prepared by others, April 1995)
7. Appendix II Baseline Sampling Reports:
   August 9, 1995 (date of sampling event)
   October 19, 1995
   December 4, 1995
   February 12, 1996 (4th Quarter Summary)
8. Semi-Annual Monitoring Reports:
   August 8, 1996
   February 25, 1997
   August 18, 1997

### 2.2.2 Ground Water Monitoring Program

Presently there are seven wells in the compliance monitoring network. The compliance wells are now sampled semi-annually, scheduled for February and August each year. The background well is MW-1, located behind the office/maintenance building. The compliance wells are located in proximity to the landfill perimeter. Three regularly monitored wells, MW-2a, MW-3ad and MW-16a, were installed in August 1995 to replaced improperly located wells that were too close to the waste boundary. MW-6s and MW-7s were installed circa 1993, to supplement two older wells, MW-6d and MW-7d.

Current sampling and analysis protocol alternates between the Appendix II list (in February) and the Appendix I list, plus a subset of detected Appendix II constituents (in August). Baseline assessment monitoring of Appendix I parameters, required by NC DWM at all unlined MSW landfills, included four independent sampling events completed between September 1994 and March 1995. The Appendix I monitoring results triggered the requirement for Appendix II monitoring, which commenced with four closely spaced samples completed between August 1995 and February 1996. Following completion of baseline Appendix II sampling, the facility reverted to semi-annual monitoring.

Sampling and laboratory analytical work are performed by an independent contractor. Results for each sampling event are entered into a data base and statistically analyzed by GNRA prior to reporting to NC DWM. Although the data show that a minor ground water impact exists, as would be expected at any unlined landfill, the landfill is not an environmental or public health hazard, and the regulatory issues are relatively minor by comparison with other landfills in the State. There is no danger to the public due to the ground water impact and certainly no cause for alarm. Several mitigating factors exist that lessen or negate the risk to the public:

- The ground water flow patterns beneath the landfill are relatively well understood.
- The landfill is isolated, and there are no down gradient ground water users, no one's well is susceptible to influence by the landfill.
- The landfill is located at the confluence of two creeks, which serve as ground water discharge features.
- Wetlands exist immediately down gradient of the landfill, which serve as natural buffers to surface water.
- Monitoring of the creeks do not show any water quality impact from the landfill.
- Post-closure ground water quality is expected to improve after installation of the final cover, due to the reduction in surface water infiltration to the MSW.
- There is no evidence that the ground water impact is migrating off-site.

Site characterization data used to support these conclusions regarding the water quality monitoring program are presented in Appendices D through F. The current Sampling and Analysis Plan (SAP) is presented in Appendix G. The ground and surface water monitoring locations appear to be appropriate to provide representative data for this site. No changes to the water quality monitoring program are proposed.

### 2.2.3 Projected Waste Contours as of December 31, 1997

Projected final contours on the south side of the landfill above the El. 300 contour, now undergoing final closure, are based on a recent topographic survey. The contours on Drawing FC1 represent top of intermediate cover. Final cover contours above the El. 300 contour will be at least 2 feet higher, due to the final cover thickness. The south portion of the landfill will be closed with a 5% cap, covering about 2.3 acres, which transitions to 4H:1V side slopes. The planned crest elevation will be El. 346. The northern portion of the landfill above the El. 300 contour, the planned location of the CDLF expansion, currently exhibits slopes that vary from 5% to 10%, with maximum elevations near the center of the landfill at El. 322.

### 2.2.4 Proposed CDLF - Overview of Design and Operation

Please refer to the accompanying site drawings. Placement of C&D wastes will commence in the southwest portion of the CDLF area, along the previously closed 4H:1V slope that leads to the final cap. Fill sequencing will progress along the west side of the CDLF area toward the north corner, then along the east side of the CDLF area to complete the first of two lifts. Waste will be placed along exterior side slopes to achieve a 4H:1V slope ratio, per the Amended Transition Plan. Final cover will be placed incrementally as the side slopes achieve final grades. The second lift of C&D waste will bring the north side of the 5% final cap to grade, covering about 1.4 acres. A final cover will be installed on the north side of the cap, in accordance with the Amended Transition Plan. An Operations Plan for the CDLF facility is presented in Appendix J.

### 2.2.5 Final Cover Considerations

The Amended Transition Plan calls for above for the 4H:1V side slopes. The projected schedule for completion of final cover at the closed MSW landfill is June 30, 1998, or roughly 180 days beyond the date the facility stops receiving MSW. The CDLF area will be prepared with a final closure of the MSW wastes prior to placing C&D wastes. Side slopes and the final cap within the CDLF area will be closed incrementally as those areas achieve final grades.

### 2.2.6 Special Considerations for C&D Disposal over Closed MSW Landfills

The NC DWM memorandum of March 1, 1997 requires demonstration that the proposed disposal of C&D wastes will neither adversely impact the cap nor allow increased infiltration to the closed MSWLF unit. This demonstration is made based on the following considerations:

- The final cover for the closed MSW landfill, actually the base of the proposed CDLF, will be constructed at grades that promote surface runoff ($\geq 5\%$) and will consist of soils exhibiting a permeability of $10^{-5}$ cm/sec, or less.

- The construction quality assurance (CQA) program for the final cover of the closed MSW landfill will provide a measure of assurance that the final cover meets design objectives in limiting surface infiltration to the MSW.

- Preliminary test results from the CQA program for the final cover construction, now in progress, indicate that soil permeability values of $10^{-5}$ cm/sec, or less, can be achieved with the current construction equipment and techniques.

- The C&D waste thickness will be ± 25 feet. The relatively low additional loading due to the C&D waste is not expected to cause excessive settlement or stability problems relative to the final cover of the closed MSW landfill.

- Appropriate operational and maintenance practices, described in the Operations Plan (Appendix J), will limit the potential for stability problems and lessen the likelihood for standing surface water to occur.

- The CDLF will ultimately receive final cover that meets or exceeds the RMC requirements.

## 2.3 Applicable Location Restrictions - *.0503 (1) (a) - (d), and .0504 (1) (f)*

The following location restrictions are addressed for completeness with applicable NC DWM rules and to demonstrate compliance with regulatory location requirements. The planned CDLF will exist above an existing MSW landfill, which operated between ca. 1981 and 1997.

### 2.3.1 Flood Plain - *.0503 (1) (a)*

An inspection of FIRM mapping [1], reprinted in Appendix B, indicates that no areas of the site exist within the 100 year flood limits. Design grades will be set such that no restriction to the flow of the unnamed tributary will occur, and the risk of exposure of the waste due to flooding or scouring will be minimal.

### 2.3.2 Endangered and Threatened Species - *.0503 (1) (b) (i and ii)*

Detailed studies of the ash monofill site identified no endangered species habitats in the vicinity of the Halifax County Landfill. The planned CDLF is located entirely within the currently permitted facility boundary, above the closed MSW landfill. There are no likely plant or animal species of interest within the planned footprint.

### 2.3.3 Archaeological and Historical Site - *.0503 (1) (b) (iii)*

A Phase 1 Cultural Resource Study was performed in 1991 for the adjacent ash monofill, permitted and constructed in 1992. That study identified no significant historical or cultural artifacts within the site boundary. Based on the location of the planned CDLF above the closed MSWLF unit, there are no likely sites of interest within the planned CDLF footprint.

---

1 Flood Insurance Rate Map, Panel 370327 0060 B, National Flood Insurance Program, 1991

### 2.3.4 State Nature and Historic Preserve - *.0503 (1) (b) (iv)*

Refer to Section 2.3.2 above. A letter from the NC Natural Heritage Program (NC DEHNR Division of Parks and Recreation) pertaining to the ash monofill site, presented in Appendix B, indicates no state park/recreation areas or endangered species habitats known in the vicinity of Halifax County landfill.

### 2.3.5 Airport Safety - *.0503 (1) (c)*

There will be no putrescible wastes placed in the planned C&D landfill. Birds are not expected to be attracted to this facility. There are no known airports within 5000 feet of the site.

### 2.3.6 Cover Soils - *.0503 (1) (d)*

On-site soils consist of clayey silt and sandy silt that will serve as suitable cover materials. Preliminary soil testing completed for the final closure of the MSW landfill, is presented in Appendix E. These soils are found on an adjacent borrow site, located just east of the landfill. Earlier studies indicate that there are sufficient soil quantities in the borrow site to meet the anticipated cover soil requirements.

## 2.4 Site Design Requirements - *.0503 (2) (a) through (g)*

### 2.4.1 Explosive Gases - *.0503 (2) (a)*

The site will be managed such that explosive gas concentrations will not exceed regulatory thresholds. This will be accomplished through proper waste screening and periodic monitoring of an existing landfill gas monitoring network. Currently, landfill gas concentrations in excess of regulatory thresholds have not been detected. The inert waste stream of the planned CDLF is not anticipated to produce methane. The final cover design includes explosive gas control devices.

### 2.4.2 Public Access - *.0503 (2) (b)*

The site will be accessible to the public only during daylight business hours. An operator will be on duty during operations. The site will be secured by a fence and locking entrance gate.

### 2.4.3 Surface Water Protection - *.0503 (2) (c)*

The site will not discharge pollutants into the waters of the State, in accordance with the NPDES requirements and applicable state and federal law. No dredged material or fill material will be placed into waters of the State, including designated wetlands. The site shall not cause non-point source pollution to the waters of the State that exceeds assigned water quality standards. These requirements will be met through best management practice for storm water runoff control.

### 2.4.4 Ground Water Protection - *.0503 (2) (d)*

Ground water elevations outside the footprint of the closed MSW landfill are such that there will be in excess of 4 feet of vertical separation between the bottom of C&D wastes and the maximum seasonal high water table. The site will be managed to prevent the likelihood of ground water impact. Due to the inert nature of the C&D wastes, a liner and leachate collection system will not be required. The final cover system above the closed MSW landfill will prevent surface water runoff at the CDLF from co-mingling with the underlying MSW.

### 2.4.5 Open Burning - *.0503 (2) (e)*

Open burning of waste will not be allowed, per NC DWM rules.

### 2.4.6 Horizontal Buffers - *.0503 (2) (f)*

The planned CDLF meets the horizontal buffer requirements of 200 feet along the each property line. There are no private dwellings or water wells within 500 feet of the planned facility. No C&D wastes will be placed within 50 feet of the perennial stream (unnamed tributary).

### 2.4.7 Sedimentation and Erosion Control - *.0503 (2) (g)*

A sedimentation and erosion control plan will be implemented and proper maintenance of control structures will be observed to meet this requirement. Calculations for the sedimentation and erosion control plan are presented in Appendix K.

## 3.0 GEOLOGY AND HYDROGEOLOGY

### 3.1 Geological and Hydrogeological Evaluation - *.0504 (1) (c) (i and ii)*

Site geology and ground water characteristics beneath the closed MSW landfill and planned CDLF have been determined through examination of test boring records for the original landfill permit, field supervision of the three monitoring wells installed in 1995, and correlation to test borings performed outside the MSW landfill footprint for other disposal sites. Based on this correlation of information (Appendix D), the geology and hydrogeology of the planned CDLF site is believed to be similar to that determined elsewhere in the permitted facility boundary.

### 3.1.1 Local and Regional Geology

A review of historical literature [2] and available geologic mapping [3] indicates that the proposed

---

[2] Mundorff, M.J., Ground Water in the Halifax Area, North Carolina, NC Department of Conservation and Development, Division of Mineral Resources, Bulletin No. 51, 1946.

[3] North Carolina Geologic Map, NC Geological Survey, 1985.

landfill site is situated on the eastern edge of the Eastern Piedmont Physiographic Province, just west of the Coastal Plain overlap. 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 of the eastern Piedmont exhibit a northeast strike and locally dip gently eastward, as a result of regional metamorphism and folding that produced a broad plunging anticline.

The area was simultaneously intruded by a number of felsic (granite) plutons. The rock formation underlying the subject site is a granitic pluton identified as the Butterwood Creek intrusive. A few miles east of the site, the crystalline rocks of the Piedmont plunge beneath non-indurated fluvial and deep-marine sedimentary deposits of the Coastal Plain. During late Tertiary times, portions of the eastern Piedmont were over washed by deltaic streams and shallow seas. This resulted in the deposition of a thin veneer of clayey sands and rounded quartz gravel, which is still visible along the uplands near the site.

The Area Topographic Lineament Study (Appendix C) shows that primary lineaments observed in the area topographic mapping are reflected by the northeast-southwest orientation of Bear Swamp and the main ridge occupied by SR 1417. The leg of the unnamed tributary to the northeast of the closed MSW landfill parallels this orientation, which coincides with the regional strike of mapped geologic formations.

Secondary topographic lineaments noted throughout the region include subparallel ridges and drainage features oriented north-south. These secondary features align with the prominent topographic features within the permitted facility boundary. The north-south orientation is believed to reflect a regional joint alignment. The unnamed tributary and Brewer's Creek follow an east-west orientation on either side of the closed MSW landfill. Brewer's Creek approaches the confluence with the unnamed tributary from the southeast. These short-segmented linear features suggest additional bedrock fracture orientations.

Topography in the vicinity consists of gently sloping, subparallel ridges, flanked by relatively shallow drainage swales. These generally dry swales drain to either Brewer's Creek to the south or north to the unnamed tributary. The planned CDLF unit will drain entirely toward the unnamed tributary. A relatively thin deposit of sandy alluvium exists immediately near the unnamed tributary. The unnamed tributary exhibits year-round base flow and serves as a ground water discharge feature for the uppermost aquifer on the site.

The on-site soils are chiefly in-situ weathering products of granitic origin. Weathering and erosion along the widely spaced bedrock jointing produced large rounded boulders and irregular outcrops exposed along the creek bottom east of the study area (south of the ash Monofill site). Granite outcrops observed during area reconnaissance (and core run recoveries examined during the test drilling) exhibit a coarse porphyritic texture, with 1 to 2 inch diameter potassic feldspar crystals embedded in a fine matrix of feldspar, quartz, mica and minor accessory minerals.

The granite outcrops are located east of the existing MSW landfill, along the unnamed tributary. These outcrops exhibit a highly differential weathering pattern along two widely spaced, steeply dipping joint sets, which appears to align with the principal orientation of vicinity lineaments, and surficial exfoliation (near horizontal convex fracturing) that results in rounded surface exposures. Two smaller outcrops are located to the far eastern edge of the lined MSWLF study area and 30-acre tract, respectively (see Drawing G1). The outcrops are generally too weathered to obtain reliable strike and dip measurements on the joint surfaces.

Based on earlier test boring investigations and observation of conditions within the MSW landfill (and elsewhere in the vicinity), the bedrock at the site exhibits a highly differential weathering pattern that is typical of the late Paleozoic granites in eastern North Carolina. This pattern is characterized by isolated "ridge caps" and scattered rounded boulders. Test borings within areas of the site have been extended as much as 30 feet deep within a few feet of an outcrop. The differential weathering within the subsurface results in isolated "pinnacles" of bedrock occurring within the weathered residual soil profile. This is common within the Piedmont, especially in granitic terranes. No unusual geologic features or conditions, including seismic hazards or unstable areas, have been identified on the site.

### 3.1.2 Site Investigation and Stratigraphy - *.0504 (1) (c) (i) (G)*

Based on compilation of test boring data from previous site suitability studies for three disposal units within the permitted waste boundary and overview of the ongoing ground water monitoring program for the old MSW landfill, subsurface and hydrogeological conditions are similar in all respects throughout the permitted facility boundary, including the immediate vicinity of the closed MSW landfill footprint. The locations of relevant test borings used in this site characterization are shown on Drawing G3. Hydrogeologic profiles prepared from test boring data for monitoring wells constructed in 1995 and other borings performed on adjacent portions of the property are presented on Drawing G4. Test boring data are summarized in Table 1A, with reprints of the various boring logs, including data for the original MSW permit application, presented in Appendix D.

**Test Borings** - The "MW" series borings, listed in Table 1A and Appendix D, are part of the existing ground water monitoring network. Three of the wells were replaced in 1995 under GNRA's supervision. Other site data includes soil borings for the Ash Monofill site, performed ca. 1991 by GNRA, and the original site investigation for the closed MSW landfill, performed ca. 1981 by Law Engineering. That investigation included four borings within the footprint of the old MSW landfill.

The 45 acre study area for the planned Subtitle D MSWLF unit is located directly north of the closed MSW landfill, across the unnamed tributary. This area was characterized with 58 test borings, 35 of which (the "B" and "G" series, and H-1d) were advanced to depths which encountered rock and/or ground water, and 21 of which were completed as grouted standpipe piezometers. Those borings are supplemented by 23 earlier borings located in and around the study area, 20 of which were finished as ground water piezometers, including the "H" and "MW"series, and L-1 (a remnant 1981 piezometer). All the "B", "G" and "H" series borings were installed for and supervised by GNRA personnel. That portion of the site received a letter from NC DWM, dated January 29, 1997, stating that "all geologic and hydrogeologic issues have been sufficiently addressed to proceed with site suitability for the proposed facility."

The tract to the east of the closed MSW landfill, including a portion of the "30-acre" tract shown on Drawing G3, were investigated for a new CDLF unit by GNRA with the "BP" series borings in early 1997. All but three of these borings encountered ground water and were converted to piezometers. The older "GY" borings, evidently used for an earlier, uncompleted CDLF permit application, were installed by others. No data logs could be located for the "GY" series. These piezometers were used only for ground water level observation.

**Hydrogeologic Profile** - Site stratigraphy is based more on the in-situ weathering pattern than actual depositional units. This characterization is necessary because of localized, subtle variation in grain size and mineral composition in the parent bedrock, and post-depositional jointing that results in a highly differential weathering profile. The variability in weathering is not conducive to a consistent stratigraphy that can be assigned unique hydrologic properties. This does not mean, however, that the geology is overly complex, or that the site cannot be effectively monitored. Quite the contrary, in fact, because the hydrogeological properties identified in the various test boring investigations are very typical of porous media aquifers within the Piedmont.

The upper residual soils are stiff, reddish-orange clayey silt and silty clay. These soils generally extend to depths of 10 to 15 feet below the surface, deeper at some locations. These soils are dry to slightly moist and exhibit some mottling and/or dark brown iron-manganese oxide staining along joint surfaces. The coloration gives evidence of past water movement, but these near surface soils are not considered to be water-bearing based on the test boring data.

The near-surface soils are underlain by pink-white and gray, sandy and clayey silt and silty sand that exhibits a relict texture derived from the parent bedrock (saprolite). These soils texturally resemble the nearby granite outcrops. At nearly every test boring, ground water was not encountered until the surficial soils had been completely penetrated, e.g. the deeper saprolite appears to be the uppermost aquifer on the site. These soils grade with depth to residual silty coarse sand, weathered rock and fractured bedrock.

Test borings adjacent to the perennial streams encountered a relatively thin veneer (less than 10 feet in thickness) of coarse grained alluvium, often overlain by man-made fill. This soil is limited to the immediate vicinity of the stream banks, within the ground water discharge zones, and does not appear to significantly affect the general pattern of ground water movement at the site. These soils are included with the unconsolidated overburden soils for hydrogeological considerations. The principal hydrogeologic units determined for this site are as follows:

> Unit 1 - granular saprolite (coarse grain, weathered overburden soils and unconsolidated alluvial deposits (limited to the perennial stream banks)

> Unit 2 - weathered bedrock with variable fracture density, defined as consolidated bedrock that cannot be penetrated by conventional soil-auger boring techniques.

Unit 1, has two subunits, defined on the basis of standard penetration test (SPT) values, used here as an indication of the degree of weathering:

> Unit 1a - defined by SPT values less than 100 blows per foot (bpf), and
>
> Unit 1b - soils that exhibit SPT values above 100 bpf but could be penetrated with a hollow stem auger.

Unit 2 was penetrated by rotary coring techniques in several borings around the site. Based on the test boring data, the various units and subunits exhibit transitional boundaries that vary both laterally and vertically within the subsurface profile, due to differential weathering. Table 1b presents a summary of the representative borings that define these hydrogeologic units.

### 3.1.3 Water Table Information

Short-term water level observations, taken at time of boring completion and following 24 hours, are tabulated on Table 1A for the existing monitoring well network and the relevant nearby piezometers, where available. Seven-day water level readings were not acquired at several test boring locations, but water levels have been observed monthly at most of the piezometers and monitoring wells since at least March 1996. Long-term ground water level observation data is presented on Table 1C and Table 3.

**Estimated Seasonal High Water** - The data from Table 3 were used to construct a hydrograph for selected piezometers and monitoring wells within the permitted facility boundary. This can be found following Table 3. The hydrograph indicates that seasonal high ground water levels typically occur in the late winter and spring months of the year. The highest water levels yet recorded at most of the monitoring wells were observed between December 1996 and May 1997, except at MW-3, which exhibited its highest levels shortly after installation in August 1995.

### 3.1.4 Laboratory Testing

Laboratory test results for nearby test boring samples are summarized in Table 2. Relevant laboratory data are presented in Appendix E. All laboratory testing was performed in accordance with appropriate ASTM test procedures. The data include bulk soil samples that represent future cover soils for the CDLF and undisturbed samples that represent in-situ conditions. Selected split spoon samples were also tested. Sample analysis includes grain size and Atterberg limits to verify soil classifications. Other testing performed to determine the engineering and hydrological properties of the on-site soils includes standard Proctor compaction, triaxial shear strength, consolidation, and flexible wall permeability (hydraulic conductivity) testing.

A majority of the soils within the permitted facility boundary are silty and sandy clays and clayey silts, i.e., Unified Soil Classification System (USCS) classifications of CL, ML and SC. A minority of the soils are classified as CH. A few soil samples that exhibited grain size distributions very close to the 50% passing the #200 sieve criteria were classified as a silty sand

(SM), as opposed to a sandy silt (ML) or sandy clay (CL). Due to the well-graded grain size distribution of the near surface soils, some of the samples were assigned dual classifications. The overall engineering behavior of the near surface soils tends to be more clay-like, while the hydraulic properties of the deeper soils is more like a sand. This is consistent with the observed weathering-induced "stratigraphy." Typical laboratory permeability values for the undisturbed samples of the near surface soils vary on the order $10^{-5}$ to $10^{-6}$ cm/sec.

The proposed borrow soils for periodic and final cover are the more fine grained CL and ML existing near the surface. The proposed borrow site for these soils consists of those portions of the 30-acre tract that are outside the planned future CDLF footprint. Flexible wall permeability tests performed on remolded bulk samples indicate that permeability values of $1.0 \times 10^{-5}$ cm/sec, or lower, can be achieved with the near-surface soils existing within the proposed borrow site. These soils are generally limited to the uppermost 10 to 15 feet within the 30-acre tract.

### 3.2 Potentiometric Surfaces Map - *.0504 (1) (c) (iii)*

Ground water potentiometric surfaces, based on observed seasonal high ground water elevations, are shown on Drawing G3. The potentiometric contours reflect estimates of hydraulic head, the likely highest elevations below which saturated soils are expected to be found, but these contours may not reflect actual ground water depths at a given location. The potentiometric surface reflects a subdued expression of the surface topography, typical of Piedmont sites, and indicates a ground water flow pattern directed generally west to northwest, toward the perennial streams.

### 3.3 Ground Water Flow Characteristics

The upper-most aquifer, Unit 1, is characterized as a closed-loop, partially confined, porous flow medium, with a relatively short separation between the recharge and discharge zones. A conceptual ground water flow model, shown on Drawing G4, consists of the following:

- recharge occurs over most of the site from the non-saturated surface soils located to the east (uphill) of the closed MSWLF footprint
- partially confined flow occurs within a saturated layer of porous saprolite, existing between the lower permeability near surface soil and underlying bedrock
- some downward recharge occurs into the deeper, weathered bedrock fractures
- discharge occurs along the perennial stream existing at the north side of the site.

These conditions are considered typical of piedmont terranes. Based on test boring data, Unit 1 varies from 25 to 40 feet in thickness, measured between the upper point of saturation (water table) and the estimated depth of competent bedrock. There are no obvious confining layers, except for partial confinement caused by the non-saturated near surface soils.

Ground water movement within the deeper bedrock aquifer, Unit 2, typically occurs as discreet fracture flow in the less weathered bedrock. The discreet fractures offer more restricted flow paths and provide partial to complete confinement, based on the earlier site work. However, the fracture density observed within the upper portions of the bedrock in recovered core runs lead to a conclusion that the upper portion of Unit 2 exhibits porous media characteristics. Unit 2 has been penetrated by a number of test borings within the permitted facility boundary.

### 3.3.1 Horizontal Ground Water Flow

A summary of measured hydraulic conductivities (based on slug tests) and apparent horizontal hydraulic gradients and velocities is presented on Table 4. Horizontal hydraulic gradients were estimated based on the potentiometric contours. Ground water velocities were calculated using apparent horizontal hydraulic gradients, hydraulic conductivity values and empirical effective porosity values, according to the equation:

$$V = KI/n:$$

| | | | |
|---|---|---|---|
| Where: | V | = | Ground Water Velocity |
| | K | = | Hydraulic Conductivity (from rising head tests) |
| | I | = | Hydraulic Gradient (from water table elevations) |
| | n | = | Porosity (based on referenced values). |

Saturated hydraulic conductivity values for the upper-most aquifer (Unit 1a) vary from 0.12 to 2.5 feet/day ($4.3 \times 10^{-5}$ to $9.0 \times 10^{-4}$ cm/sec, respectively), based on slug tests of the adjacent monitoring wells. Elsewhere in the permitted facility boundary, the hydraulic conductivity varies from 0.03 to 28 ft/day ($1.0 \times 10^{-5}$ to $1.0 \times 10^{-2}$ cm/sec, respectively). The variation is due, in part, to the differential weathering characteristics of the subsurface and the relative position of the well/piezometer within the aquifer (discharge zone vs. recharge zone). Horizontal ground water gradients vary from 0.023 at BP-3 to 0.112 at BP-7 (units are ft/ft). Corresponding ground water velocities vary from 0.033 ft/day at BP-3 to 12.8 ft/day at BP-7.

It should be noted that slug tests are short-term, non-steady state tests that measure permeability within a limited zone of influence about each piezometer. The velocity calculations are somewhat sensitive to variable hydraulic gradients and the conductivity. However, the hydraulic conductivity calculations are not sensitive to aquifer thickness and empirical porosity values. Laboratory porosity values are based on the *total* percentage of pore space (voids) within a soil, where *effective* porosity reflects the degree of interconnectivity of the pore space. Laboratory porosity values can be adversely affected by sample disturbance, where the published empirical values used in this analysis [4] are based on field tests and reflect more probable in-situ conditions. A summary discussion of the slug test data and hydraulic conductivity calculations is presented with the calculations in Appendix F.

---

[4] Driscoll, F.G., Groundwater and Wells, 2nd ed., Johnson Division, St. Paul, MN, 1986, p. 67.

providing that it is packaged according to 40 CFR 61 and applicable state regulations. The operations plan (Appendix J) describes a waste screening procedure.

### 4.5 Operating Equipment - *.0504 (1) (g) (iii)*

The list of equipment currently used and required for operation of the planned C&D landfill follows (excluding private contractor equipment occasionally used):

| Equipment Type | Model, Purchase Date | Anticipated Function |
|---|---|---|
| Landfill Compactor | Rex 355B, 7/8/92 | Waste placement and compaction |
| Track Loader | Fiat FL-10E, 8/29/94 | Stripping soil and grading |
| Track Loader | Fiat FL-175, 8/29/94 | Wet weather excavation, general maintenance |
| Scraper Excavator | Dresser 412, 11/1/91 | Daily cover excavation, cover placement |
| Lawn Tractor | Long 2510, 5/10/94 | Grounds maintenance |

### 4.6 Ground Water Monitoring Plan - *.0504 (1) (g) (iv)*

No changes are proposed to the Ground Water Sampling and Analysis Plan (SAP). The currently approved SAP is reprinted in Appendix G.

## 5.0 SPECIFIC FACILITY DATA - *.0504 (2) (h)*

### 5.1 Legal Description of Site - *.0504 (2) (h) (i)*

A boundary survey prepared by a North Carolina registered land surveyor is presented in Appendix A. The site is wholly owned by Halifax County. The proposed CDLF is located entirely within the current waste footprint for the closed MSW landfill, and entirely within the permitted facility boundary.

### 5.2 Responsible Parties - *.0504 (2) (h) (ii)*

Halifax County Department of Solid Waste will own and operate the C&D landfill. County employees or contract labor working under the Director's supervision shall be responsible for operating and maintaining the facility in compliance with the permit and applicable regulations.

### 5.3 Projected Future Land Use - *.0504 (2) (h) (iii)*

The CDLF will be closed in accordance with the permit and applicable regulations. No future development of the closed MSW/CDLF site is anticipated at this time.

## 5.4 Anticipated Operational Life - *.0504 (2) (h) (iv)*

The planned C&D landfill is expected to provide about 97,000 cubic yards of C&D waste disposal space. The anticipated annual loading of 8,500 tons (30 tons/day, 200 days/year) will require about 9,900 cubic yards per year, based on an estimated 0.86 tons per cubic yard for C&D wastes. The planned CDLF will to provide approximately 10 years of capacity. No further expansion of the CDLF within the closed MSW landfill footprint is anticipated.

## 5.5 Footprint Development - *.0504 (2) (h) (v)*

The planned waste cell development sequence is shown in the plan drawings (Drawing P1) and described by the Operations Plan (Appendix J).

## 5.6 Earthwork - *.0504 (2) (h) (vi)*

Earthwork calculations are presented in Appendix K. The planned CDLF will occupy roughly 4.6 acres above the closed MSW landfill. Closure of the area prior to receiving C&D wastes will require approximately 24,200 cubic yards of soil, including a 20 percent compaction factor, and assuming a 24 inch thick final cover above the MSW. These quantities are programed into the final cover plan for the MSW landfill.

## 5.7 Seeding and Mulching - *.0504 (2) (h) (vii)*

A seeding and mulching schedule is provided in the project technical specifications presented in Appendix H. All berms and exterior slopes shall be seeded after construction and placement of final cover. The final cover of the closed MSW landfill, including the base area of the planned CDLF, will be vegetated.

## 5.8 Erosion Control Measures - *.0504 (2) (h) (viii) and (ix)*

An erosion and sedimentation control plan is presented in Appendix K. This plan was submitted to and approved by NC DENR- Division of Land Quality, as part of the permit documents for the Amended Transition Plan. The plan will be implemented to prevent excess soil loss and lessen the possibility for impacting surface water quality.

## 5.9 Compliance with Design Requirements - *.0504 (2) (h) (x)*

Discussion of how this facility design will comply with the requirements of rule .0503 (2) is made through the text of Section 2.4 of this report.

## 5.10 Miscellaneous - Animal Carcass Disposal - *.0504 (2) (h) (xi)*

Animal carcass disposal is regulated by General Statute 103-403 and Veterinary Division Rule 2 NCAC 52 .0102. The disposal area will be located at least 300 feet from a flowing stream or any public body of water (Drawing G1). The carcasses will be buried at least 3 feet deep in trench excavations. No carcass disposal will occur in an area of shallow ground water, nor within 50 feet of a ground water monitoring well. The disposal trench area will be laid out in a grid that will be excavated and utilized as needed. Several carcasses may be placed in single excavation, provided they are covered immediately.

# Tables

**Table 1 A**
**Test Boring/Piezometer Data and**
**Short-Term Ground Water Observations**

| Elevation Data | | | | Test Boring Data | | | | | Piezometer Construction Data | | | | | Ground Water Observations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Boring Number | Boring Date | Ground Elev. | PVC Pipe Elev. | Boring Depth, ft. | PWR Depth, ft. | PWR Elev. | Refusal Depth, ft. | Refusal Elev. | Top of Piez. Screen Depth, ft. | Top of Piez. Screen Elev. | Bot. of Piez. Screen Depth, ft. | Bot. of Piez. Screen Elev. | Stickup ft. | Time of Boring Depth, ft. | Time of Boring Elev. | 24-hour readings Depth, ft. | 24-hour readings Elev. |
| MW-2A | 07/25/95 | 243.2 | 246.43 | 16 | 12.5 | 230.71 | -- | -- | 4 | 239.2 | 14 | 229.2 | 3.22 | 7.3 | 235.9 | (3) | (3) |
| MW-3As | 07/25/95 | 249.4 | 252.85 | 9 | -- | -- | -- | -- | 4 | 245.4 | 9 | 240.4 | 3.44 | 6 | 243.4 | (3) | (3) |
| MW-3Ad | 07/25/95 | 249.5 | 252.68 | 21 | -- | -- | -- | -- | 9 | 240.5 | 19 | 230.5 | 3.20 | 5.5 | 244.0 | (3) | (3) |
| MW-6s | 01/06/92 | 251.3 | 253.26 | 23 | -- | -- | -- | -- | 8 | 243.3 | 23 | 228.3 | 2.0 | 11.33 | 240.0 | 23 | 228.3 |
| MW-6d | 10/30/91 | 250.8 | 253.22 | 40 | -- | -- | -- | -- | 25 | 225.8 | 40 | 210.8 | 2.4 | 11.58 | 239.3 | 40 | 210.8 |
| MW-7s | 01/07/92 | 248.4 | 250.44 | 17.5 | -- | -- | -- | -- | 2.5 | 245.9 | 17.5 | 230.9 | 2.1 | 3.17 | 245.2 | 17 | 231.4 |
| MW-7d | 10/31/91 | 247.9 | 249.09 | 40 | -- | -- | -- | -- | 25 | 222.9 | 40 | 207.9 | 1.2 | 3.92 | 243.9 | 40 | 207.9 |
| MW-15 | 09/21/94 | 307.1 | 309.09 | 20 | -- | -- | -- | -- | 35 | 272.6 | 49 | 258.1 | 2.03 | 41.5 | 265.6 | 42.15 | 264.9 |
| MW-16A | 07/26/95 | 268.6 | 271.46 | 19.5 | 15 | 253.59 | -- | -- | 5 | 264.1 | 19.5 | 249.1 | 2.87 | 7.2 | 261.4 | (3) | (3) |
| BP-3 | 12/06/95 | 313.7 | 315.39 | 50 | -- | -- | -- | -- | 38 | 275.7 | 48 | 265.7 | 1.69 | 45.51 | 268.2 | 45.22 | 268.5 |
| BP-4 | 12/06/95 | 310.8 | 313.16 | 48 | -- | -- | -- | -- | 38 | 272.8 | 48 | 262.8 | 2.36 | 38.3 | 272.5 | 36.25 | 274.6 |
| BP-6 | 12/05/95 | 315.0 | 317.28 | 25 | -- | -- | -- | -- | 15 | 300.0 | 25 | 290.0 | 2.28 | | | | |
| GY-1 | (2) | 291.2 | 292.51 | 30 | -- | -- | -- | -- | (2) | (2) | (2) | (2) | 1.31 | (2) | (2) | (2) | (2) |
| GY-2 | (2) | 297.9 | 299.99 | 20 | -- | -- | -- | -- | (2) | (2) | (2) | (2) | 2.09 | (2) | (2) | (2) | (2) |
| GY-3 | (2) | 304.2 | 304.20 | 50 | -- | -- | -- | -- | (2) | (2) | (2) | (2) | 0.00 | (2) | (2) | (2) | (2) |
| G-13S | 11/30/95 | 249.9 | 252.34 | 20.0 | -- | -- | -- | -- | 10.0 | 239.9 | 20.0 | 229.9 | 2.4 | 8.91 | 240.99 | 8.8 | 241.1 |
| G-13D (Core) | 12/27/95 | 250.1 | 252.12 | 54.5 | 30.5 | 219.6 | 30.5 | 219.6 | 44.5 | 205.6 | 54.5 | 195.6 | 2.0 | 24.21 | 225.89 | 23.72 | 226.4 |

1. Ground water and piezometer elevations are based on topographic surveys performed 2/25/96 and 5/15/97

2. No data exists for GY series brings, performed by others ca. 1994 (used for ground water level observation only)

3. No 7-day ground water levels were obtained - see Table 1 C

**Table 1B**
**Summary of Hydrogeological Properties**
**Halifax County Landfill**

| Hydrological Unit | Well No. | Hydrogeological Description*** | Aquifer Thickness | Effective Porosity | Total Porosity | Conductivity k (ft/day) | Grain Size Distribution | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | % Gravel | % Sand | % Silt | % Clay |
| 1a | MW-3Ad | Silty Sand | 35 | 0.20 | | 0.31 | | | | |
| | MW-6s | Silty Sand | 35 | 0.20 | | 0.12 | | | | |
| | MW-6d | Sandy Silt | 35 | 0.17 | | 2.47 | | | | |
| | MW-7s | Sand | 35 | 0.20 | | 0.08 | | | | |
| | MW-7d | Sandy Silt | 35 | 0.17 | | 0.17 | | | | |
| | MW-15 | Sandy Clay | 15**** | 0.15 | | 0.90 | | | | |
| | BP-3 | Sandy Silt | 22 | 0.17 | 0.403 | 0.29 | 0 | 59 | 40* | |
| | BP-4 | Silt | 40 | 0.17 | | 2.21 | | | | |
| | BP-6 | Sandy Silt | 40 | 0.17 | 0.432 | 10.80 | 0 | 20 | 35 | 45 |
| | BP-7 | Sandy Silt | 40 | 0.17 | | 22.84 | | | | |
| | BP-8 | Sandy Silt | 40 | 0.17 | 0.459 | 3.2 | 0 | 37 | 10 | 53 |
| | BP-9 | Silty Clayey Sand | 40 | 0.17 | | 3.45 | 0 | 48 | 34 | 18 |
| | BP-10 | Sandy Silt | 40 | 0.17 | | 27.92 | | | | |
| | G-13s** | Silty Sand | 27 | 0.20 | | 0.03 | | | | |
| | B-4s** | Clayey Sand | 10 | 0.15 | | 3.64 | | | | |
| 1b | MW-2A | Residual Soil (>100 bpf) | 35 | 0.12 | | 1.84 | | | | |
| | MW-16A | | 35 | 0.12 | | 0.06 | | | | |
| 2 | G-13d** | Weathered Bedrock | | | | | | | | |
| | B-4d** | | 25 | 0.10 | 0.36 | 1.80 | 0 | 81 | 9 | 5 |

**Notes:** Effective porosities based upon published values (see Hydrogeologic Report)

Hydraulic Conductivities calculated from slug tests (see Appendix B)

NM = Not Measured

Total porosity and grain size distribution determined in laboratory tests.

Aquifer thickness calculated from high water table measurements

Hydraulic Conductivity in ft/day

* Represents combined silt and clay fractions (#200 sieve wash)

** Earlier borings for approved MSWLF Phase I site investigation

*** Based on field classifications given in test boring logs

**** Based on slug test analysis performed by others

**Table 1C**
**Long-Term Ground Water Level Observations**
**August 1995 to November 1997**

| Boring Number | Boring Date | Ground Elev. | PVC Pipe Elev. | 08/08/95 GW Depth | 08/08/95 Elev. | 09/12/95 GW Depth | 09/12/95 Elev. | 12/27/95 GW Depth | 12/27/95 Elev. | 01/24/96 GW Depth | 01/24/96 Elev. | 02/26/96 GW Depth | 02/26/96 Elev. | 03/20/96 GW Depth | 03/20/96 Elev. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-2A | 07/25/95 | 243.2 | 246.43 | 5.81 | 240.62 | 6.21 | 240.22 | -- | -- | -- | -- | -- | -- | -- | -- |
| MW-3As | 07/25/95 | 249.4 | 252.85 | 8.48 | 244.37 | 9.24 | 243.61 | -- | -- | -- | -- | -- | -- | -- | -- |
| MW-3Ad | 07/25/95 | 249.5 | 252.68 | 8.75 | 243.93 | 10.53 | 242.15 | -- | -- | -- | -- | -- | -- | -- | -- |
| MW-6s | 01/06/92 | 251.3 | 253.26 | 13.33 | 239.93 | 13.35 | 239.91 | 12.63 | 240.63 | -- | -- | -- | -- | 12.21 | 241.05 |
| MW-6d | 10/30/91 | 250.8 | 253.22 | 13.27 | 239.95 | -- | -- | 12.54 | 240.68 | -- | -- | -- | -- | 11.99 | 241.23 |
| MW-7s | 01/07/92 | 248.4 | 250.44 | 6.38 | 244.06 | 6.31 | 244.13 | -- | -- | -- | -- | -- | -- | 5.57 | 244.87 |
| MW-7d | 10/31/91 | 247.9 | 249.09 | 4.84 | 244.25 | -- | -- | -- | -- | -- | -- | -- | -- | 3.82 | 245.27 |
| MW-15 | 09/21/94 | 307.1 | 309.09 | 45.43 | 263.66 | -- | -- | -- | -- | -- | -- | -- | -- | 42.56 | 266.53 |
| MW-16A | 07/26/95 | 268.6 | 271.46 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| BP-3 | 12/06/95 | 313.7 | 315.39 | -- | -- | -- | -- | -- | -- | 46.95 | 268.44 | 46.11 | 269.28 | 45.45 | 269.94 |
| BP-4 | 12/06/95 | 310.8 | 313.16 | -- | -- | -- | -- | -- | -- | 39.44 | 273.72 | 38.23 | 274.93 | 37.9 | 275.26 |
| BP-6 | 12/05/95 | 315.0 | 317.28 | -- | -- | -- | -- | -- | -- | 16.3 | 300.98 | 13.31 | 303.97 | 13.8 | 303.48 |
| GY-1 | (2) | 291.2 | 292.51 | -- | -- | -- | -- | -- | -- | dry | | dry | | dry | |
| GY-2 | (2) | 297.9 | 299.99 | -- | -- | -- | -- | -- | -- | 21.63 | 278.36 | 21.64 | 278.35 | 21.64 | 278.35 |
| GY-3 | (2) | 304.2 | 304.20 | -- | -- | -- | -- | -- | -- | 39.13 | 265.07 | 39.1 | 265.10 | 38.68 | 265.52 |
| G-13S | 11/30/95 | 249.9 | 252.34 | -- | -- | -- | -- | -- | -- | 10.92 | 241.42 | 10.98 | 241.36 | 11 | 241.34 |
| G-13D (Core) | 12/27/95 | 250.1 | 252.12 | -- | -- | -- | -- | -- | -- | 10.42 | 241.7 | 10.56 | 241.56 | 10.55 | 241.57 |

1. Piezometer elevations are based on topographic surveys performed 2/25/96 and 5/15/97
2. No data exists for GY series borings, performed by others ca. 1994
3. G-13 and G-13d are located across the unnamed tributary from the closed MSW landfill
4. MW series borings are the regular monitoring network
5. BP and GY borings are located east (upgradient) of closed MSW landfill

Table 1C
Long-Term Ground Water Level Observations

| Well | 04/23/96 | | 05/22/96 | | 06/25/96 | | 07/31/96 | | 08/27/96 | | 10/02/96 | | 10/29/96 | | 11/27/96 | | 12/31/96 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. | GW Depth | Elev. |
| MW-2a | 5.5 | 240.93 | 5.67 | 240.76 | 6 | 240.43 | 5.77 | 240.66 | -- | -- | 5.47 | 240.96 | 5.5 | 240.93 | 5.53 | 240.90 | 5.43 | 241.00 |
| MW-3as | 8.66 | 244.19 | 9.31 | 243.54 | 9.6 | 243.25 | 9 | 243.85 | 9.05 | 243.80 | 8.64 | 244.21 | 9.1 | 243.75 | 8.96 | 243.89 | 8.95 | 243.90 |
| MW-3ad | 9.27 | 243.41 | 9.62 | 243.06 | 10.28 | 242.40 | 9.59 | 243.09 | 9.43 | 243.25 | 8.96 | 243.72 | 9.2 | 243.48 | 9.36 | 243.32 | 9.31 | 243.37 |
| MW-6s | 12.17 | 241.09 | 12.46 | 240.80 | 13.04 | 240.22 | 17.71 | 235.55 | 12.93 | 240.33 | 12.31 | 240.95 | 12.48 | 240.78 | 12.29 | 240.97 | 12 | 241.26 |
| MW-6d | 12.01 | 241.21 | 12.22 | 241.00 | 12.89 | 240.33 | 12.61 | 240.61 | 12.81 | 240.41 | 12.24 | 240.98 | 12.33 | 240.89 | 12.22 | 241.00 | 11.79 | 241.43 |
| MW-7s | 5.67 | 244.77 | 5.82 | 244.62 | 6.22 | 244.22 | 6.07 | 244.37 | 6.18 | 244.26 | 5.71 | 244.73 | 5.7 | 244.74 | 5.67 | 244.77 | 5.43 | 245.01 |
| MW-7d | 3.95 | 245.14 | 4.14 | 244.95 | 4.61 | 244.48 | 4.48 | 244.61 | 4.56 | 244.53 | 4.05 | 245.04 | 4.07 | 245.02 | 3.95 | 245.14 | 3.7 | 245.39 |
| MW-15 | 42.63 | 266.46 | 42.14 | 266.95 | 42.03 | 267.06 | 41.77 | 267.32 | 41.62 | 267.47 | 41.96 | 267.13 | 41.56 | 267.53 | 41.7 | 267.39 | 40.9 | 268.19 |
| MW-16a | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 4.8 | 266.66 | 4.74 | 266.72 | 4.34 | 267.12 |
| BP-3 | 45.25 | 270.14 | 44.91 | 270.48 | 44.98 | 270.41 | 44.88 | 270.51 | 44.84 | 270.55 | 44.89 | 270.50 | 44.5 | 270.89 | 44.6 | 270.79 | 44.29 | 271.10 |
| BP-4 | 37.49 | 275.67 | 37.28 | 275.88 | 37.95 | 275.21 | 38.61 | 274.55 | 38.48 | 274.68 | 37.98 | 275.18 | 37.29 | 275.87 | 37.52 | 275.64 | 36.5 | 276.66 |
| BP-6 | 13.61 | 303.67 | 14.39 | 302.89 | 18.35 | 298.93 | 18.48 | 298.80 | 18.36 | 298.92 | 18.42 | 298.86 | 15.25 | 302.03 | 15.94 | 301.34 | 15.78 | 301.50 |
| GY-1 | dry | | dry | | dry | | dry | | dry | | dry | | dry | | dry | | dry | |
| GY-2 | 21.65 | 278.34 | 21.67 | 278.32 | dry | | 21.67 | 278.32 | 21.66 | 278.33 | 21.67 | 278.32 | 21.72 | 278.27 | 21.74 | 278.25 | 21.75 | 278.24 |
| GY-3 | 38.39 | 265.81 | 38.1 | 266.10 | 38.02 | 266.18 | 37.87 | 266.33 | 37.8 | 266.40 | 37.8 | 266.40 | 37.59 | 266.61 | 37.72 | 266.48 | 37.2 | 267.00 |
| G-13S | 10.98 | 241.36 | 11.24 | 241.1 | 12.03 | 240.31 | 11.8 | 240.54 | 11.97 | 240.37 | 11.37 | 240.97 | 11.4 | 240.94 | 11.33 | 241.01 | 10.92 | 241.42 |
| G-13D (Core) | 10.53 | 241.59 | 10.78 | 241.34 | 11.56 | 240.56 | 11.27 | 240.85 | 11.51 | 240.61 | 10.88 | 241.24 | 10.92 | 241.2 | 10.82 | 241.3 | 10.34 | 241.78 |

**Table 1C**
**Long-Term Ground Water Level Observations**



| Well | 01/31/97 GW Depth | Elev. | 02/25/97 GW Depth | Elev. | 03/28/97 GW Depth | Elev. | 05/01/97 GW Depth | Elev. | 06/30/97 GW Depth | Elev. | 07/17/97 GW Depth | Elev. | 08/28/97 GW Depth | Elev. | 09/30/97 GW Depth | Elev. | 11/04/97 GW Depth | Elev. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-2a | 5.47 | 240.96 | 5.54 | 240.89 | 5.54 | 240.89 | 5.5 | 240.93 | 6.05 | 240.38 | 6.16 | 240.27 | 6.07 | 240.36 | 5.8 | 240.63 | -- | |
| MW-3as | 8.95 | 243.90 | — | — | 9.04 | 243.81 | 8.75 | 244.10 | 10.19 | 242.66 | 10.38 | 242.47 | 10.08 | 242.77 | 9.65 | 243.20 | -- | |
| MW-3ad | 9.35 | 243.33 | 9.41 | 243.27 | 9.3 | 243.38 | 9.15 | 243.53 | 10.12 | 242.56 | 10.32 | 242.36 | 9.85 | 242.83 | 9.24 | 243.44 | -- | |
| MW-6s | 11.97 | 241.29 | 12.19 | 241.07 | 12.22 | 241.04 | 11.85 | 241.41 | 13.27 | 239.99 | 13.47 | 239.79 | 13.37 | 239.89 | 13.04 | 240.22 | 12.97 | 240.29 |
| MW-6d | 11.78 | 241.44 | — | — | 11.91 | 241.31 | 11.64 | 241.58 | 13.08 | 240.14 | 13.32 | 239.90 | 13.22 | 240.00 | 12.91 | 240.31 | 12.91 | 240.31 |
| MW-7s | 5.49 | 244.95 | 5.46 | 244.98 | 5.61 | 244.83 | 5.37 | 245.07 | 6.37 | 244.07 | 6.49 | 243.95 | 6.5 | 243.94 | nm | nm | -- | |
| MW-7d | 3.72 | 245.37 | — | — | 3.91 | 245.18 | 3.67 | 245.42 | 4.74 | 244.35 | 4.97 | 244.12 | 4.92 | 244.17 | 4.7 | 244.39 | 4.54 | 244.55 |
| MW-15 | 40.57 | 268.52 | 40.61 | 268.48 | 40.3 | 268.79 | 40.23 | 268.86 | 40.93 | 268.16 | 41.17 | 267.92 | 41.75 | 267.34 | 42.22 | 266.87 | -- | |
| MW-16a | 4.3 | 267.16 | 4.43 | 267.03 | 4.54 | 266.92 | 4.23 | 267.23 | 5.72 | 265.74 | 5.96 | 265.50 | 6.54 | 264.92 | nm | nm | -- | |
| BP-3 | 43.37 | 272.02 | 43.46 | 271.93 | 43.13 | 272.26 | 43.39 | 272.00 | 43.91 | 271.48 | 44.27 | 271.12 | 45.04 | 270.35 | 45.67 | 269.72 | 46.54 | 268.85 |
| BP-4 | 36.11 | 277.05 | 35.93 | 277.23 | 35.97 | 277.19 | 36.12 | 277.04 | 37.77 | 275.39 | 38.45 | 274.71 | 39.53 | 273.63 | 40.45 | 272.71 | 41.38 | 271.78 |
| BP-6 | 17.49 | 299.79 | 12.48 | 304.80 | 13.1 | 304.21 | 14.6 | 302.72 | 19.0 | 298.26 | 20.88 | 296.40 | 22.51 | 294.77 | 23.58 | 293.7 | 24.26 | 293.02 |
| GY-1 | dry | | dry | | dry | | dry | | dry | | dry | | | | dry | | -- | |
| GY-2 | 21.71 | 278.28 | dry | | dry | | dry | | dry | | dry | | | | dry | | -- | |
| GY-3 | 36.91 | 267.29 | 36.85 | 267.35 | 36.52 | 267.68 | 36.44 | 267.76 | 37.03 | 267.17 | lost | | | | | | | |
| G-13S | 10.74 | 241.6 | 10.81 | 241.53 | 10.92 | 241.42 | 10.66 | 241.68 | 11.75 | 240.59 | 12.12 | 240.22 | 12.02 | 240.32 | 11.67 | 240.67 | 12.13 | 240.21 |
| G-13D (Core) | 10.3 | 241.82 | 10.4 | 241.72 | 10.43 | 241.69 | 10.28 | 241.84 | 12.22 | 239.9 | 12.53 | 239.59 | 12.46 | 239.66 | 12.12 | 240 | 11.64 | 240.48 |

Table 2
Geotechnical Laboratory Data

| Sample Number | Sample Depth, ft. | Sample Type | Grain Size Distributuion and Soil Classification: % >3" >75 mm | % Gravel 75 mm> | % Sand 4.5 mm> | % Silt 0.075 mm> | % Clay 0.005 mm> | Liquid Limit | Plasticity Index | USCS Class. | Hydrogeologic Description*** | Natural Moisture % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BP-1 | 0-1.5 | Jar | 0 | 0 | 29 | 18 | 53 | 59 | 27 | MH | Silty Sandy Clay | -- |
| BP-2 | 0-1.5 | Jar | 0 | 0 | 30 | 20 | 50 | 57 | 29 | CH | Silty Sandy Clay | -- |
| BP-3 | 3.0 - 5.0 | Bulk | 0 | 0 | 59 | 40* | -- | 37 | 10 | SM | Silty Sandy Clay | 13.8 |
| BP-6 (1) | 0-1.5 | Jar | 0 | 0 | 20 | 35 | 45 | 58 | 12 | MH | Sandy Silty Clay | -- |
| BP-6 (2) | 3.5-5.0 | Jar | 0 | 0 | 47 | 32 | 21 | 59 | 7 | MH | Clayey Silty Sand | -- |
| BP-6 | 15-20 | Bulk | 0 | 0 | 48 | 52* | -- | 49 | 15 | ML | Clayey Silty Sand | 34.2 |
| BP-7 | 1.0-10.0 | Bulk | 0 | 0 | 39 | 39 | 22 | 43 | 15 | ML | Clayey Silty Sand | 36.7 |
| BP-8 | 1.0-10.0 | Bulk | 0 | 0 | 37 | 10 | 53 | 49 | 15 | ML | Silty Sandy Clay | 25.1 |
| BP-9 | 15 - 20 | Bulk | 0 | 0 | 48 | 34 | 18 | 45 | 6 | ML | Clayey Silty Sand | 31.8 |
| BP-12 | 0-1.5 | Jar | 0 | 0 | 18 | 65 | 17 | 72 | 13 | MH | Clayey Sandy Silt | 72.0 |
| BP-13 | 0-1.5 | Jar | 0 | 0 | 20 | 62 | 18 | 70 | 16 | MH | Clayey Sandy Silt | 57.8 |
| B-4 | 1.0 - 3.0 | Tube | 0 | 0 | 81 | 9 | 5 | 31 | 14 | SM/ML | Clayey Silty Sand | 17.3 |
| B-8 | 5.0 - 7.0 | Tube | 0 | 0 | 51 | 31 | 18 | 50 | 28 | SM/CL | Clayey Silty Sand | 23.8 |

The following bulk samples are considered to be representative of future cover soils for the facility, pursuant to Rule .0504 (1) (c) (i) (F)

| Sample Number | Sample Depth, ft. | Sample Type | Remolded Moisture-Density Data: Max. Dry Density, pcf | Optimum Moisture, % | Natural Moisture, % | Total** Porosity, % | Hydraulic Conductivity Data: Rem. Dry Density, pcf | Remolded Moisture, % | Ksat @ 5 psi cm/sec |
|---|---|---|---|---|---|---|---|---|---|
| BP-3 | 3.0 - 5.0 | Bulk | 107.5 | 19.0 | 13.8 | 0.403 | 102.5 | 22.0 | 3.97E-08 |
| BP-6 | 15.0 - 20.0 | Bulk | 102.6 | 21.5 | 34.2 | 0.432 | 97.6 | 24.5 | 1.45E-07 |
| BP-8 | 1.0-10.0 | Bulk | 98.1 | 24.0 | 25.1 | 0.459 | 92.9 | 24.4 | 2.96E-07 |

The following Undisturbed Samples were collected during Nov-Dec 1995 for the MSW site permitting report and are considered representative:

| Sample Number | Sample Depth, ft. | Sample Type | In-Situ Moisture-Density and Hydraulic Conductivity Data: Dry Density, pcf | Wet Density, pcf | Natural Moisture, % | Total Porosity,% | Ksat @ 5 psi cm/sec** |
|---|---|---|---|---|---|---|---|
| B-4 | 1.0 - 3.0 | Tube | 110.6 | 129.8 | 17.3 | 0.356 | 3.19E-06 |
| B-8 | 5.0 - 7.0 | Tube | 99.5 | 123.2 | 23.8 | 0.420 | 1.62E-05 |

**Note to Above:**

Moisture Contents are Dry Unit Weight Based

* Represents silt and clay fractions combined (<200 sieve wash)

** Total Porosity values are backcalculated from Void Ratios

*** Based on laboratory grain size analysis

Falling head triaxial permeability tests were run with 1 to 2 psi
with differential pressure across sample, hydraulic gradient of 12

Samples tested by Geotechnologies, Inc., Raleigh, NC

Moisture data for bulk samples acquired from individual jar samples collected with the bulk sample. Samples were oven-dried to determine moisture content. These data are considered representative of in-situ moisture conditions for earth work considerations.

**Table 3**
**Ground Water Hydrograph**

**Sheet 1**

Data for Nearest Permanent Monitoring Wells and Piezometers

| Boring Number | Boring Date | Ground Elev. | PVC Pipe Elev. | 03/20/96 Elev. | 04/23/96 Elev. | 05/22/96 Elev. | 06/25/96 Elev. | 07/31/96 Elev. | 08/27/96 Elev. | 10/02/96 Elev. | 10/29/96 Elev. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-2A | 07/25/95 | 243.21 | 246.43 | | 240.93 | 240.76 | 240.43 | 240.66 | | 240.96 | 240.93 |
| MW-3As | 07/25/95 | 249.41 | 252.85 | | 244.19 | 243.54 | 243.25 | 243.85 | 243.80 | 244.21 | 243.75 |
| MW-3Ad | 07/25/95 | 249.48 | 252.68 | | 243.41 | 243.06 | 242.40 | 243.09 | 243.25 | 243.72 | 243.48 |
| MW-6s | 01/06/92 | 251.30 | 253.26 | 241.05 | 241.09 | 240.80 | 240.22 | 235.55 | 240.33 | 240.95 | 240.78 |
| MW-6d | 10/30/91 | 250.84 | 253.22 | 241.23 | 241.21 | 241.00 | 240.33 | 240.61 | 240.41 | 240.98 | 240.89 |
| MW-7s | 01/07/92 | 248.37 | 250.44 | 244.87 | 244.77 | 244.62 | 244.22 | 244.37 | 244.26 | 244.73 | 244.74 |
| MW-7d | 10/31/91 | 247.86 | 249.09 | 245.27 | 245.14 | 244.95 | 244.48 | 244.61 | 244.53 | 245.04 | 245.02 |
| MW-15 | 09/21/94 | 307.06 | 309.09 | 266.53 | 266.46 | 266.95 | 267.06 | 267.32 | 267.47 | 267.13 | 267.53 |
| MW-16A | 07/26/95 | 268.59 | 271.46 | | | | | | | | 266.66 |
| BP-3 | 12/06/95 | 313.70 | 315.39 | 269.94 | 270.14 | 270.48 | 270.41 | 270.51 | 270.55 | 270.50 | 270.89 |
| BP-4 | 12/06/95 | 310.80 | 313.16 | 275.26 | 275.67 | 275.88 | 275.21 | 274.55 | 274.68 | 275.18 | 275.87 |
| BP-6 | 12/05/95 | 315.00 | 317.28 | 303.48 | 303.67 | 302.89 | 298.93 | 298.80 | 298.92 | 298.86 | 302.03 |
| GY-1 | (2) | 291.20 | 292.51 | | | | | | | | |
| GY-2 | (2) | 297.90 | 299.99 | 278.35 | 278.34 | 278.32 | | 278.32 | 278.33 | 278.32 | 278.27 |
| GY-3 | (2) | 304.20 | 304.20 | 265.52 | 265.81 | 266.10 | 266.18 | 266.33 | 266.40 | 266.40 | 266.61 |
| G-13S | 11/30/95 | 249.90 | 252.34 | 241.34 | 241.36 | 241.10 | 240.31 | 240.54 | 240.37 | 240.97 | 240.94 |
| G-13D (Core) | 12/27/95 | 250.10 | 252.12 | 241.57 | 241.59 | 241.34 | 240.56 | 240.85 | 240.61 | 241.24 | 241.20 |

**Table 3**
**Ground Water Hydrograph**

**Sheet 2**

Data for Nearest Permanent Monitoring Wells and Piezometers

| 11/27/96 Elev. | 12/31/96 Elev. | 01/31/97 Elev. | 02/25/97 Elev. | 03/28/97 Elev. | 05/01/97 Elev. | 06/30/97 Elev. | 07/17/97 Elev. | 08/28/97 Elev. | 09/30/97 Elev. | 11/04/97 Elev. |
|---|---|---|---|---|---|---|---|---|---|---|
| 240.90 | 241.00 | 240.66 | 240.89 | 240.89 | 240.93 | 240.38 | 240.27 | 240.36 | 240.63 | |
| 243.89 | 243.90 | 243.90 | | 243.81 | 244.10 | 242.66 | 242.47 | 242.77 | 243.20 | |
| 243.32 | 243.37 | 243.33 | 243.27 | 243.38 | 243.53 | 242.56 | 242.36 | 242.83 | 243.44 | |
| 240.97 | 241.26 | 241.29 | 241.07 | 241.04 | 241.41 | 239.99 | 239.79 | 239.89 | 240.22 | 240.29 |
| 241.00 | 241.43 | 241.44 | | 241.31 | 241.58 | 240.14 | 239.90 | 240.00 | 240.31 | 240.31 |
| 244.77 | 245.01 | 244.95 | 244.98 | 244.83 | 245.07 | 244.07 | 243.95 | 243.94 | | |
| 245.14 | 245.39 | 245.37 | | 245.18 | 245.42 | 244.35 | 244.12 | 244.17 | 244.39 | 244.55 |
| 267.39 | 268.19 | 268.52 | 268.48 | 268.79 | 268.86 | 268.16 | 267.92 | 267.34 | 266.87 | |
| 266.72 | 267.12 | 267.16 | 267.03 | 266.92 | 267.23 | 265.74 | 265.50 | 264.92 | | |
| 270.79 | 271.10 | 272.02 | 271.93 | 272.26 | 272.00 | 271.48 | 271.12 | 270.35 | 269.72 | 268.85 |
| 275.64 | 276.66 | 277.05 | 277.23 | 277.19 | 277.04 | 275.39 | 274.71 | 273.63 | 272.71 | 271.78 |
| 301.34 | 301.50 | 299.79 | 304.80 | 304.21 | 302.72 | 298.26 | 296.40 | 294.77 | 293.70 | 293.02 |
| | | | | | | | | | | |
| 278.25 | 278.24 | 278.28 | | | | | | | | |
| 266.48 | 267.00 | 267.29 | 267.35 | 267.68 | 267.76 | 267.17 | | | | |
| 241.01 | 241.42 | 241.60 | 241.53 | 241.42 | 241.68 | 240.59 | 240.22 | 240.32 | 240.67 | 240.21 |
| 241.30 | 241.78 | 241.82 | 241.72 | 241.69 | 241.84 | 239.90 | 239.59 | 239.66 | 240.00 | 240.48 |

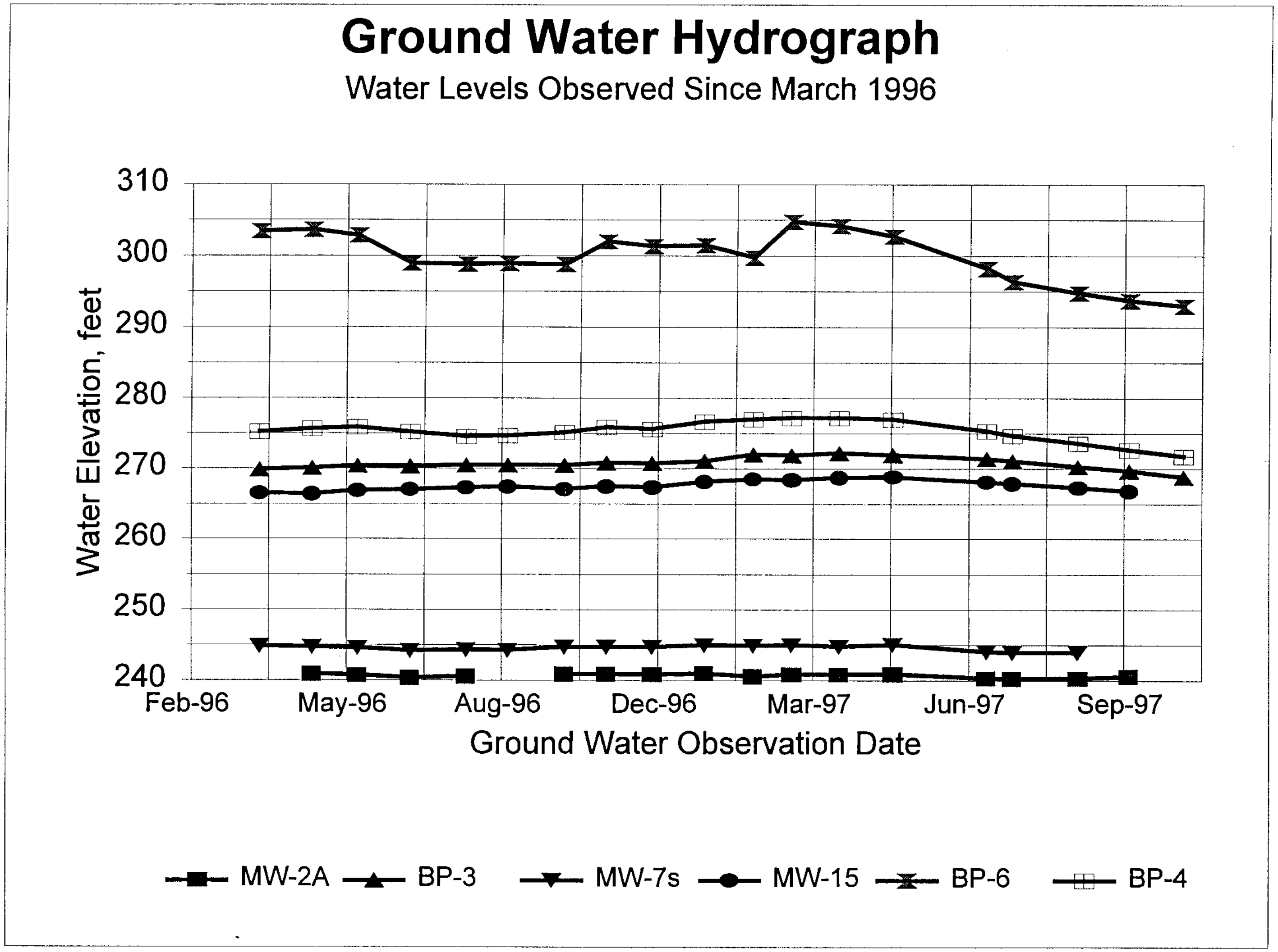

Ground Water Hydrograph
Water Levels Observed Since March 1996
310
300
290
280
270
260
250
240
Water Elevation, feet
Feb-96
May-96
Aug-96
Dec-96
Mar-97
Jun-97
Sep-97
Ground Water Observation Date
MW-2A
BP-3
MW-7s
MW-15
BP-6
BP-4

**Table 4**
**Horizontal Ground Water Gradient and Velocity Calculations**

| Hydr. Unit | Well / Piez. No. | Hydraulic Conductivity (k) ft/day | Hydraulic Conductivity (k) cm/sec | Hydraulic Gradient (I) | Effective Porosity (n) | Ground Water Velocity (V) |
|---|---|---|---|---|---|---|
| 1a | MW-3ad | 0.31 | 1.11E-04 | 0.041 | 0.2 | 0.064 |
| | MW-6s | 0.12 | 4.31E-05 | 0.021 | 0.2 | 0.013 |
| | MW-6d | 2.47 | 8.87E-04 | | 0.17 | |
| | MW-7s | 0.08 | 2.87E-05 | 0.04 | 0.2 | 0.016 |
| | MW-7d | 0.17 | 6.10E-05 | | 0.17 | |
| | MW-15 | 0.9 | 3.23E-04 | 0.03 | | |
| | BP-3 | 0.27 | 9.69E-05 | 0.023 | 0.17 | 0.04 |
| | BP-4 | 2.21 | 7.93E-04 | 0.040 | 0.17 | 0.52 |
| | BP-6 | 10.80 | 3.88E-03 | 0.070 | 0.17 | 4.45 |
| | BP-7 | 22.84 | 8.20E-03 | 0.112 | 0.17 | 15.05 |
| | BP-8 | 3.20 | 1.15E-03 | 0.050 | 0.17 | 0.94 |
| | BP-9 | 3.45 | 1.24E-03 | 0.030 | 0.17 | 0.61 |
| | BP-10 | 27.92 | 1.00E-02 | 0.060 | 0.17 | 9.85 |
| | G-13s | 0.03 | 1.08E-05 | | 0.2 | |
| | B-4s | 3.65 | 1.31E-03 | | 0.15 | |
| 1b | MW-2a | 1.21 | 4.34E-04 | 0.033 | 0.12 | 0.33 |
| | MW-16a | 0.04 | 1.44E-05 | 0.029 | 0.12 | 0.01 |
| 2 | B-4d | 1.82 | 6.53E-04 | 0.093 | 0.1 | 1.69 |

Notes: Ground Water Velocity Calculated from Equation:
$V=KI/n$
Hydraulic Gradient in ft/ft
Effective Porosity in ft/ft
Ground Water Velocity in ft/day

Effective Porosity values from published literature (see footnote in text).
Hydraulic Conductivity values from aquifer slug testing using the Bouwer method.
Hydraulic Gradient values calculated from the potentiometric surface map.

Slug tests for MW-6d, MW-7d and MW-15 were performed and analyzed by others.
Hydraulic Conductivity values from aquifer slug testing
Hydraulic Gradient values calculated from hydraulic gradient map

Hydraulic Conductivity Conversion Factor:
1 ft/day = 3.59E-04 cm/sec

Table 5
Vertical Gradient Calculations
Halifax County Landfill

**Vertical Gradient Calculations**

**Nested Pair:** **G-13s - Shallow Well**
**G-13d - Deep Well**

Vertical Gradient (VG) = $\frac{\text{Deep WTE - Shallow WTE}}{\text{Deep MOS - Shallow MOS}}$

| Well | Water Table Elev. (WTE) 4/23/96 | Water Table Elev. (WTE) 6/25/96 | Water Table Elev. (WTE) 8/27/96 | Middle of Screened Interval (MOS) |
|---|---|---|---|---|
| G-13s | 241.36 | 240.31 | 240.37 | 234.9 |
| G-13d | 241.59 | 240.56 | 240.61 | 200.6 |
| | **VG for 4/23/96 = -0.01 Upward** | **VG for 6/25/96 = -0.01 Upward** | **VG for 8/27/96 = -0.01 Upward** | |

**Nested Pair:** **B-4s - Shallow Well**
**B-4d - Deep Well**

| Well | Water Table Elev. (WTE) 4/23/96 | Water Table Elev. (WTE) 6/25/96 | Water Table Elev. (WTE) 8/27/96 | Middle of Screened Interval (MOS) |
|---|---|---|---|---|
| B-4s | 269.58 | 265.17 | 264.42 | 264.3 |
| B-4d | 263.65 | 260.93 | 259.61 | 249.6 |
| | **VG for 4/23/96 = 0.40 Downward** | **VG for 6/25/96 = 0.29 Downward** | **VG for 8/27/96 = 0.33 Downward** | |

**MW-6s - Shallow Well**
**MW-6d - Deep Well**

| Well | Water Table Elev. (WTE) 4/23/96 | Water Table Elev. (WTE) 6/25/96 | Water Table Elev. (WTE) 8/27/96 | Middle of Screened Interval (MOS) |
|---|---|---|---|---|
| MW-6s | 241.09 | 240.22 | 240.33 | 235.8 |
| MW-6d | 241.21 | 240.33 | 240.41 | 218.3 |
| | **VG for 4/23/96 = -0.01 Upward** | **VG for 6/25/96 = -0.01 Upward** | **VG for 8/27/96 = -0.00 Upward** | |

**MW-7s - Shallow Well**
**MW-7d - Deep Well**

| Well | Water Table Elev. (WTE) 4/23/96 | Water Table Elev. (WTE) 6/25/96 | Water Table Elev. (WTE) 8/27/96 | Middle of Screened Interval (MOS) |
|---|---|---|---|---|
| MW-7s | 244.77 | 244.22 | 244.26 | 238.9 |
| MW-7d | 245.14 | 244.48 | 244.53 | 215.4 |
| | **VG for 4/23/96 = -0.02 Upward** | **VG for 6/25/96 = -0.01 Upward** | **VG for 8/27/96 = -0.01 Upward** | |

**H-1 - Shallow Well**
**H-1d - Deep Well**

| Well | Water Table Elev. (WTE) 4/23/96 | Water Table Elev. (WTE) 6/25/96 | Water Table Elev. (WTE) 8/27/96 | Middle of Screened Interval (MOS) |
|---|---|---|---|---|
| H-1 | 285.26 | 281.84 | 281.45 | 278.9 |
| H-1d | 284.08 | 281.13 | 280.61 | 256.4 |
| | **VG for 4/23/96 = 0.05 Upward** | **VG for 6/25/96 = 0.03 Upward** | **VG for 8/27/96 = 0.04 Upward** | |

Monitoring Wells G-3s and G-5s have been dry, and therefore a vertical gradient cannot be calculated

# Figures

Figures *Refer to Drawings listed below, located in the accompanying plan set.*

| | |
|---|---|
| G1 | Overall Facility Plan - *.0504 (1) (a) and (b)* |
| G2 | Existing Site Conditions - *.0504 (2) (a) (i) through (vii), and .0504 (1) (c) (ii)* |
| G3 | Test Borings/Piezometers and Ground Water Potentiometric Surfaces - *.0504 (1) (c) (iii)* |
| G4 | Hydrogeological Cross Sections *.0504 (1) (c) (i) (G), and .0504 (2) (f)* |
| FC1 | Projected MSWLF Final Cover Contours - *.0504 (2) (b) (i) through (vi)* |
| FC2 | Proposed CDLF Final Cover Contours *.0504 (2) (c) (ii) and (iii)* |
| P1 | CDLF Phasing Plan |

*The other drawings in the plan set present construction details*

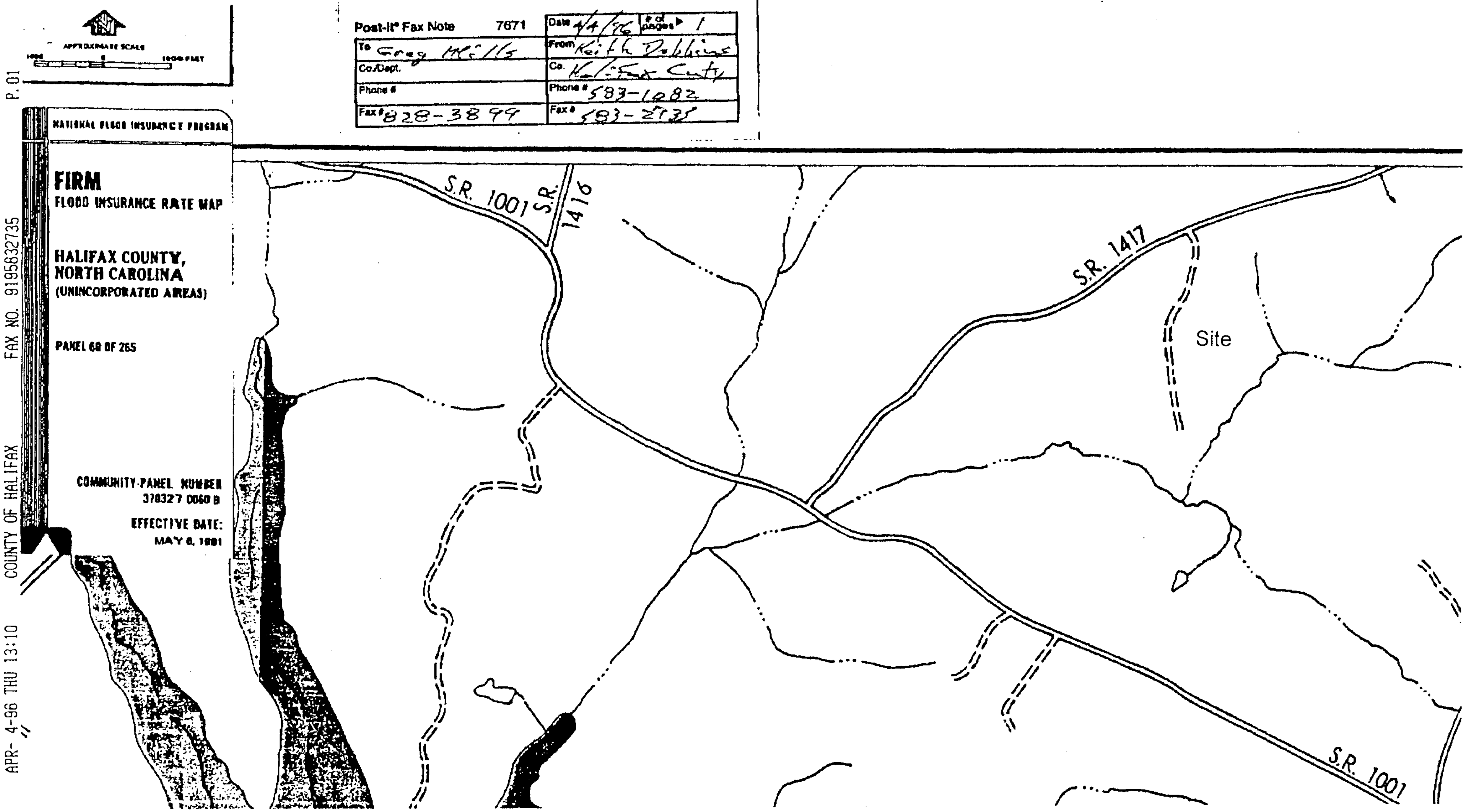
# Appendix A

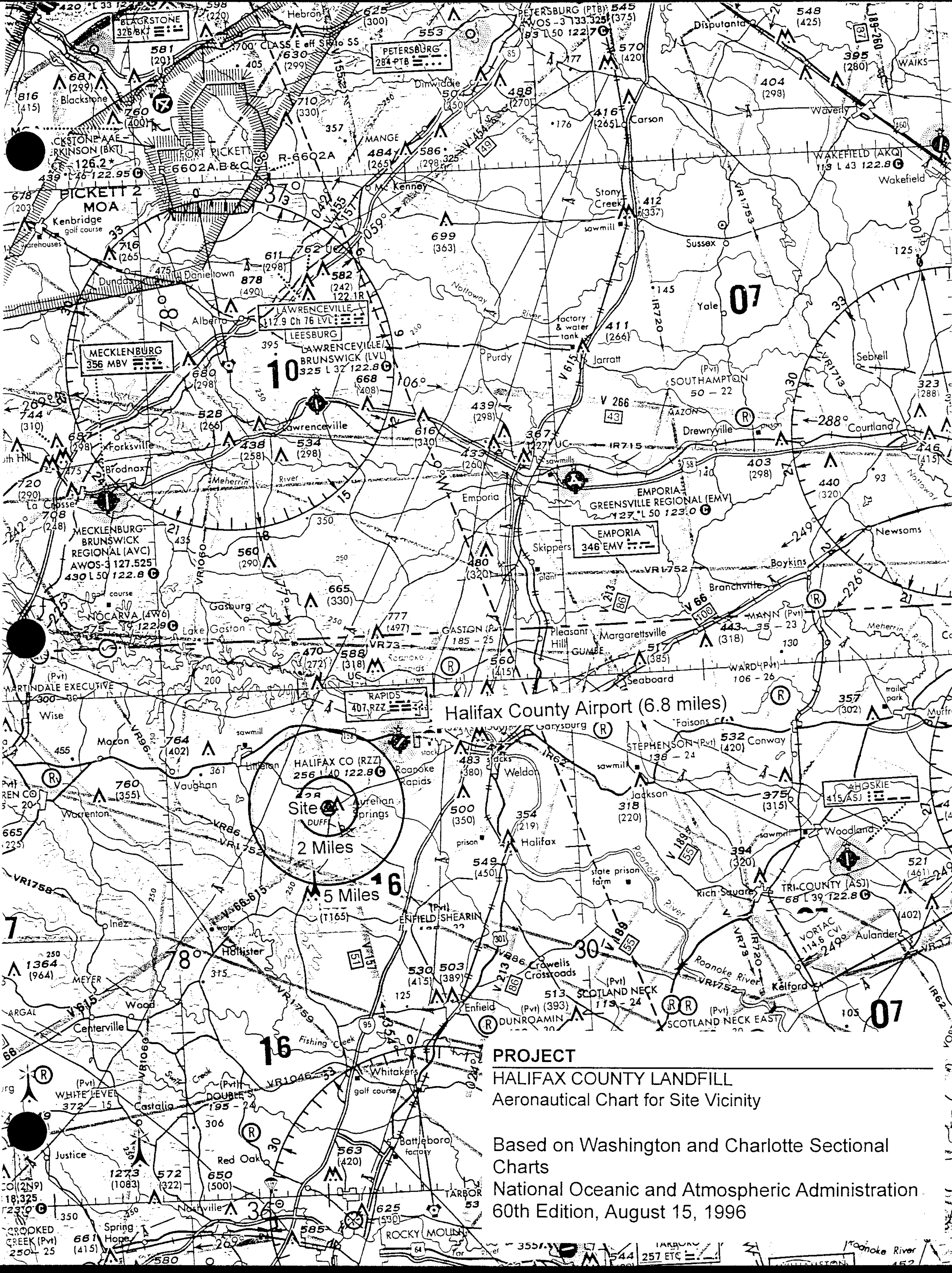
# Appendix B

# Appendix C

APR- 4-96 THU 13:10 COUNTY OF HALIFAX FAX NO. 9195832735 P. 01

| Post-it® Fax Note 7671 | Date 4/4/96 | # of pages ▶ 1 |
|---|---|---|
| To Greg Mills | From Keith Dobbins | |
| Co./Dept. | Co. Halifax County | |
| Phone # | Phone # 583-1082 | |
| Fax # 828-3899 | Fax # 583-2735 | |






## PROJECT

HALIFAX COUNTY LANDFILL
Aeronautical Chart for Site Vicinity

Based on Washington and Charlotte Sectional Charts
National Oceanic and Atmospheric Administration
60th Edition, August 15, 1996

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.

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

P.O. Box 27687, Raleigh, North Carolina 27611-7687 Telephone 919-733-4181

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.

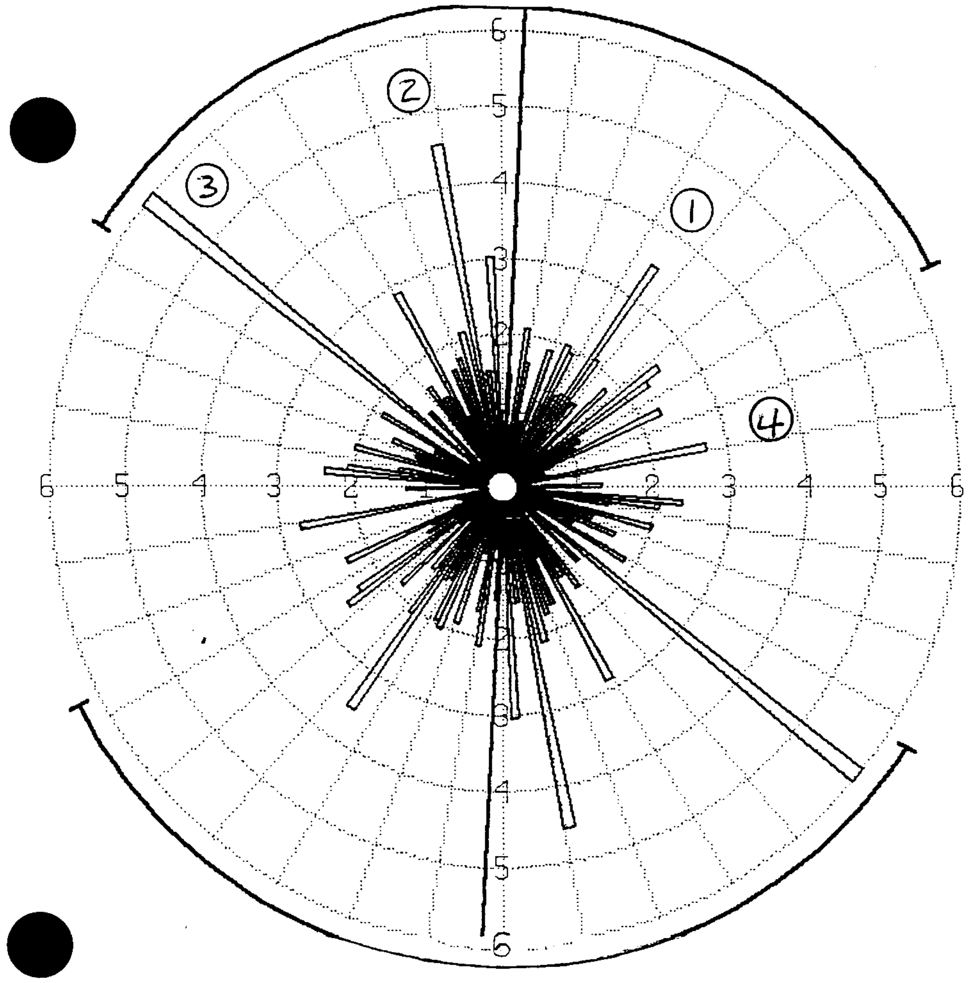
Sincerely,

David Brook

David Brook
Deputy State Historic Preservation Officer

DB:slw

Enclosures




| | |
|---|---|
| Calculation Method | Frequency |
| Class Interval | 2 Degrees |
| Filtering | Activated |
| Minimum Azimuth | 0 Degrees |
| Maximum Azimuth | 180 Degrees |
| Data Type | Bidirectional |
| Rotation Amount | 0 Degrees |
| Population | 139 |
| Maximum Percentage | 6 Percent |
| Mean Percentage | 1.4 Percent |
| Standard Deviation | 1.01 Percent |
| Vector Mean | 2.82 Degrees |
| Confidence Interval | 60.03 Degrees |
| R-mag | 0.11 |

| Preferential Lineaments | Orientation (From Map) | Example from Topographic Map |
|---|---|---|
| 1 | N35°E | Unnamed tributary southeast of study area<br>Dry run southeast of old MSW site<br>Unnamed tributary southeast of ash Monofill<br>Bear Swamp (See Figure 1A, not included in numerical analysis) |
| 2 | N10-12°W | Numerous drainage swales (no well defined creeks) including 45 acre study area |
| 3 | N50°W | Brewer's Creek south of permitted facility boundary<br>Drainage swales located northeast of ash Monofill |
| 4 | N70°E | Unnamed tributary due south of ash Monofill<br>Brewer's Creek west of permitted facility boundary |

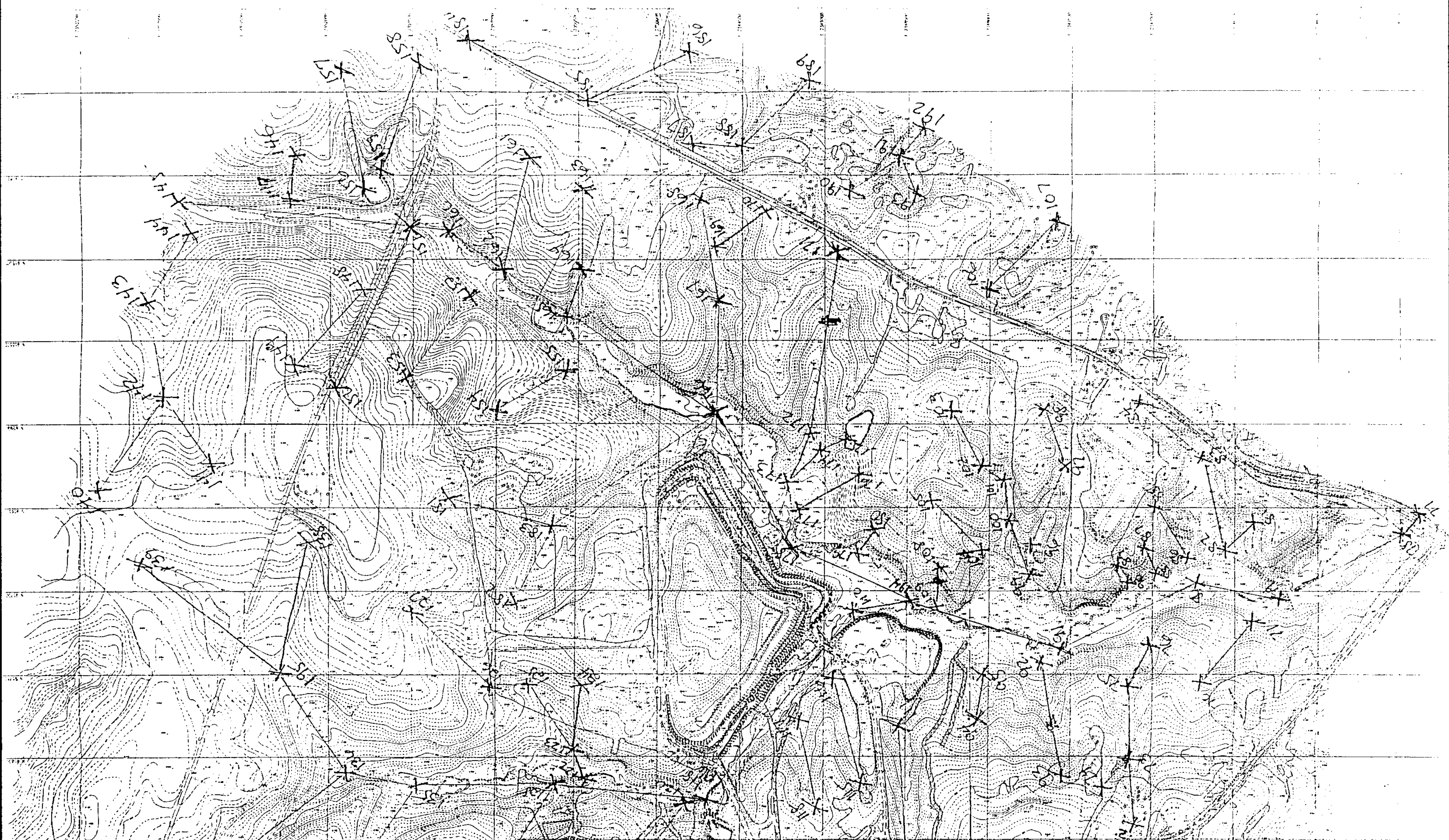
Miscellaneous orientations on short segmented intervals, resulting in high degree of data dispersivity reflected in low R-mag value, is possibly due to random erosion patterns or subparallel structural lineaments.

**PROJECT** **Figure 9**

HALIFAX COUNTY LANDFILL
Rose Diagram of Sructurally Controlled Topographic Features

Numerical analysis of topographic features performed using Rockworks™Version 7 Software
Rockworks is copyrighted by Rockware, Inc.

**G.N. Richardson & Associates**
Engineering and Geological Services



# Appendix D

# FIELD BOREHOLE LOG

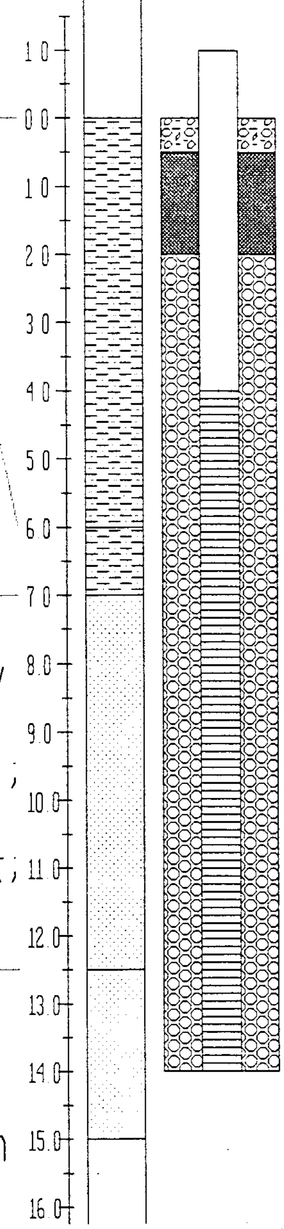
BOREHOLE NUMBER: MW-2A

PROJECT NUMBER HALIFAX-2
PROJECT NAME HALIFAX COUNTY LANDFILL
LOCATION HALIFAX, NC
DRILLING COMPANY BORE & CORE
RIG TYPE & NUMBER MOBILE B-57 ATV
DRILLING METHOD HOLLOW STEM AUGER
WEATHER HOT, HUMID
FIELD PARTY BILL BROW
GEOLOGIST DAVID GARRETT
DATE BEGUN 7/25/95 DATE COMPLETED 7/26/95

TOP OF CASING ELEVATION -
TOTAL DEPTH 16.0
GROUND SURFACE ELEVATION -
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 7.3 FT | |
| Time | 2:00 PM | |
| Date | 7/25/95 | |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0–2.0 | | | | | | | | SILTY SAND: Loose red-brown very silty clayey coarse-fine SAND; SM-ML; fill pad. |
| 2.0–4.0 | | Ss | S1 | D | | | | |
| 4.0–7.0 | 2, 3, 3, 8, 10, 11 | Ss | S2 | | | | | SILT: M. stiff black-gray fine sandy clayey SILT; wet; alluvium; ML. |
| 7.0–12.5 | 10, 7, 7 | Ss | S3 | W | | | | SAND: Loose light-gray and red-gray slightly silty-clayey fine-coarse SAND; alluvium; very clayey from 9.5' to 10.5'; fine rounded gravel from 10.5' to 12.5'; Water level at 7.3 ft; SW-SM; SC, CL, SW. |
| 12.5–16.0 | 25, 50/0.4' | Ss | | | | | | SAND: V. dense brown clayey fine SAND w/ scattered coarse sand; SM-ML; residual soil; well developed upon completion by surging and overpumping. |



# FIELD BOREHOLE LOG

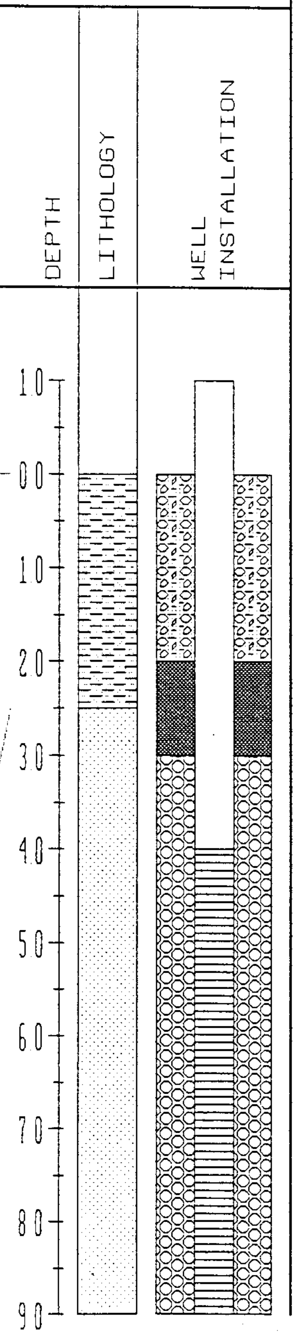
BOREHOLE NUMBER: MW-3A-S

PROJECT NUMBER HALIFAX-2
PROJECT NAME HALIFAX COUNTY LANDFILL
LOCATION HALIFAX, NC
DRILLING COMPANY BORE & CORE
RIG TYPE & NUMBER MOBILE B-57 ATV
DRILLING METHOD HOLLOW STEM AUGER
WEATHER HOT, HUMID
FIELD PARTY BILL BROW
GEOLOGIST DAVID GARRETT
DATE BEGUN 7/25/95 DATE COMPLETED 7/25/95

TOP OF CASING ELEVATION -
TOTAL DEPTH 21
GROUND SURFACE ELEVATION -
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 5.5 FT | |
| Time | 3:50PM | |
| Date | 7/25/95 | |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 1.0 | | | | | | | | |
| 0.0 | | | | | | | | SILTY SAND: Loose brwon-gray dry silty fine SAND w/ scattered roots, sticks, and inert debris on surface; possible fill; SM. |
| 1.0 | | | | | | | | |
| 2.0 | | | | | | | | |
| 3.0 | | | | | | | | |
| 4.0 | | | | | | | | SAND: Soft, dark brown wet clayey silty fine SAND w/ small sticks, rounded pebbles; alluvium; CL/ML. |
| 5.0 | | | | | | | | |
| 6.0 | | | | | | | | |
| 7.0 | | | | | | | | |
| 8.0 | | | | | | | | |
| 9.0 | | | | | | | | |



# FIELD BOREHOLE LOG

| BOREHOLE NUMBER |
|---|
| MW-3A-D |

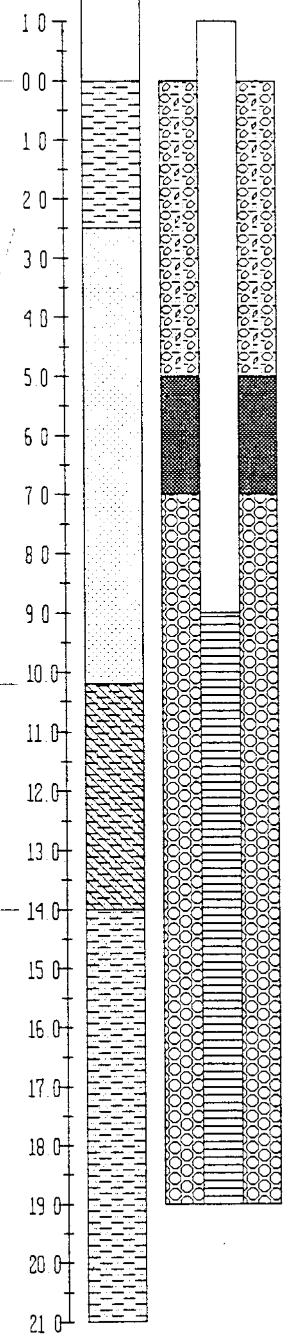
PROJECT NUMBER HALIFAX-2
PROJECT NAME HALIFAX COUNTY LANDFILL
LOCATION HALIFAX, NC
DRILLING COMPANY BORE & CORE
RIG TYPE & NUMBER MOBILE B-57 ATV
DRILLING METHOD HOLLOW STEM AUGER
WEATHER HOT, HUMID
FIELD PARTY BILL BROW
GEOLOGIST DAVID GARRETT
DATE BEGUN 7/25/95 DATE COMPLETED 7/25/95

TOP OF CASING ELEVATION -
TOTAL DEPTH 21
GROUND SURFACE ELEVATION -
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 6.0 FT | |
| Time | 3:45PM | |
| Date | 7/25/95 | |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 1.0 | | | | | | | | |
| 0.0 – 2.5 | | | | D | | | | SILTY SAND: Loose brwon-gray dry silty fine SAND w/ scattered roots, sticks, and inert debris on surface; SM |
| 3.0 – 4.5 | 2, 1, 1 | Ss | S1 | | | | | |
| 4.0 – 10.0 | | | | | | | | SAND: Soft, dark brown wet clayey silty fine SAND w/ small sticks, rounded pebbles; alluvium; CL/ML |
| 9.0 – 10.5 | 4, 4, 6 | Ss | S2 | W | | | | |
| 10.0 – 14.0 | | | | | | | | CLAYEY SILT: Stiff orange-yellow clayey SILT w/ coarse sand, scattered mica; relict rock texture; residual soil; ML; saturated below 11'. |
| 14.0 – 15.5 | 6, 6, 7 | Ss | S3 | | | | | SILTY SAND: Orange-white mottled silty fine-coarse SAND, trace clay, mica; residual soil, weathered granite; SM. |
| 19.0 – 20.5 | 8, 9, 13 | Ss | S4 | | | | | |
| 21.0 | | | | | | | | |

DEPTH | LITHOLOGY | WELL INSTALLATION



MW 6S

N. C. Department of Human Resources
Division of Health Services

# WELL COMPLETION RECORD

COMPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. DEPARTMENT OF HUMAN RESOURCES, SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH P. O. BOX 2091, RALEIGH, N.C. 27602

SOLID WASTE SECTION JAN 27 ...

| | |
|---|---|
| NAME OF SITE: Halifax County Landfill | PERMIT NO.: 41-0176-WM-0033 |
| ADDRESS: S.R. 1417 Aurelian Springs, N.C. | OWNER (print): Halifax County |
| DRILLING CONTRACTOR: Bore and Core, Inc. | REGISTRATION NO.: 763 |

Casing Type: PVC dia. 2 in. — Grout Depth: from 0 to -6' ft. - dia. 7 in.

Casing Depth: from 3'2 to -9'8 ft. - dia. 2 in. — Bentonite Seal: from -6 to -7' ft. - dia. 7 in.

Screen Type: 010 slotted PVC dia. 2 in. — Sand/Gravel PK: from -7 to -23 ft. - dia. 7 in.

Screen Depth: from -9'8 to -23' ft. - dia. 2 in. — Total Well Depth: from 3 to -23' ft. - dia. 7 in.

Static Water Level: 11'4" below ground surface ~~feet from top of casing~~ — Date Measured 1 / 6 / 92

Yield (gpm): ______ Method of Testing: ______ Casing is ______ feet above land surface

## DRILLING LOG

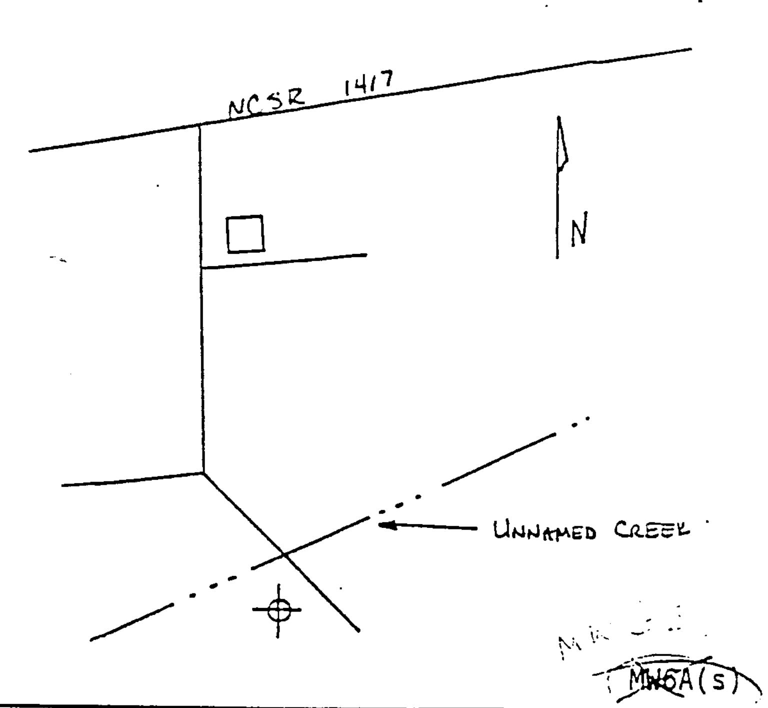
| DEPTH FROM | TO | FORMATION DESCRIPTION |
|---|---|---|
| 0.0 | 8.4 | Brown fine sandy silt |
| 8.4 | 23.0 | Wet, brown, silty fine |
| | | to medium sand |

Well numbering scheme changed on 12-13-93 to match scheme used during past sampling episodes.

LK

## LOCATION SKETCH

(show distance to numbered roads, or other map reference points)




~~MW-7~~

REMARKS:

DATE: 1/6/92 SIGNATURE: [signature]

MW 63

MW-63

MW-7

TEST BORING FIELD REPORT

Name Halifax County Landfill Aurelian Springs, N.C. Job No. 3720

ield Supervisor Tony Crew Ken Hrs. Drilling Hrs. Moving ~~MW6A(s)~~ Boring #

ate 1/6/92 Weather Cool Ground Surface Elevation

| Soil Strata | | | Sampling/Blows per F | | | | |
|---|---|---|---|---|---|---|---|
| om | To | Soil Description and Remarks | No. | Depth | 1st6" | 2nd6" | 3r |
| ).0 | 8.4 | Brown fine sandy silt | | | | | |
| 3.4 | 23.0 | Wet brown silty fine to medium sand/gravel B.T. 23.0' | | | | | |
| | | | | | | | |
| | | Set 2"x 15' screen at 23.0 with 10' riser 4 bags sand | | | | | |
| | | ½ bucket bentonite, grout to top, 1 2" locking cap 1 4"x 5' | | | | | |
| | | protective casing | | | | | |

Level 11'4" at TOB

t Level at

ter Level at 24 Hours

ter Losses

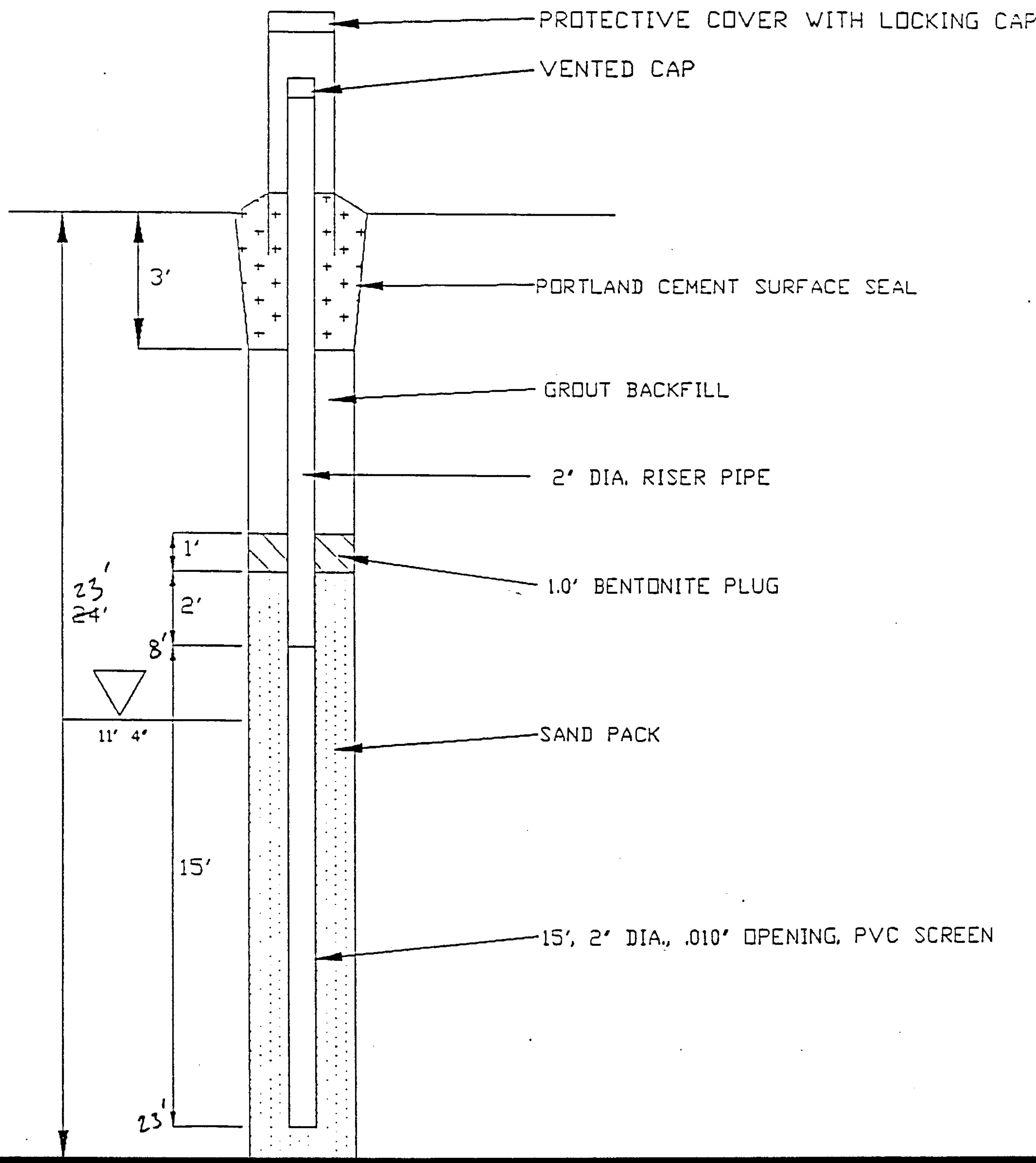
sing. Size Length

Note: (Record Methods of Drilling & Depths)

CME 450 ATV
4¼" I.D. H.S.A.
0.0' - 23.0'

# TYPICAL MONITORING WELL SCHEMATIC

PROJECT HALIFAX COUNTY LANDFILL VERTICAL EXPANSION
WELL NUMBER MW-6a(s)



Division of Health Services

# WELL COMPLETION RECORD

MW-6A MW-6d

LETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. RTMENT OF HUMAN RESOURCES, SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH, 091, RALEIGH, N.C. 27602

| | |
|---|---|
| . OF SITE: lifax County Sanitary Landfill | PERMIT NO.: 41-0176-WM-0033 |
| ESS: R. 1417 Aurelian Springs, N.C. | OWNER (print): Halifax County |
| ING CONTRACTOR: re & Core, Inc. | REGISTRATION NO.: 763 |

Type: PVC dia. 2 in.
Depth: from 2' to -25 ft. - dia. 2 in.
Type: slotted .010 dia. 2 in.
Depth: from -25 to -40 ft. - dia. 2 in.

Grout Depth: from 0' to -21' ft. - dia. 4 in.
Bentonite Seal: from -21' to -23 ft. - dia. 4 in.
Sand/Gravel PK: from -23 to -40 ft. - dia. 4 in.
Total Well Depth: from 2' to -41 ft. - dia. 4 in.

Water Level: 11' 7" Below ground surface ~~feet from top of casing~~ Date Measured 11 / 26 / 91

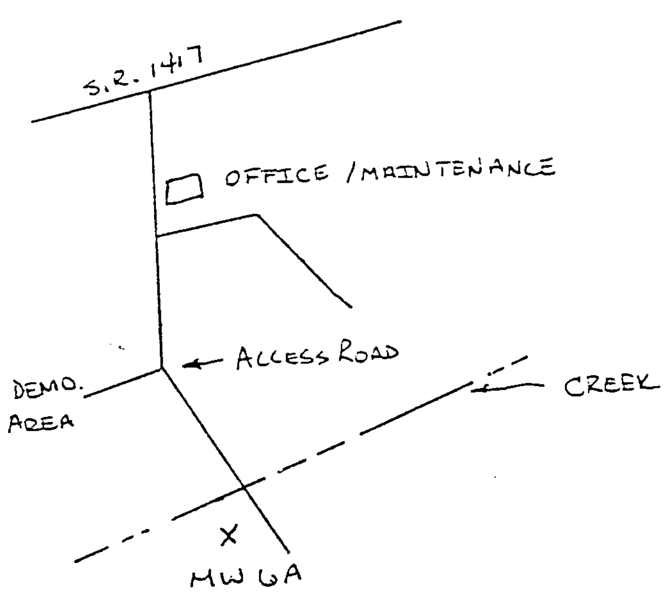
gpm): ______ Method of Testing: ______ Casing is ______ feet above land surface

## DRILLING LOG

| DEPTH | | FORMATION DESCRIPTION |
|---|---|---|
| OM | TO | |
| | 2.8 | Brown fine sandy silt |
| . | 10.6 | Brown medium to fine silt |
| 0.6 | 22.4 | Damp DrkBr.Med. sandy silt |
| 2.4 | 40.0 | Wet Br. fine sandy silt |

## LOCATION SKETCH

(show distance to numbered roads, or other map reference points)




ARKS: Well screened too deep.
Static water level is above the screen.

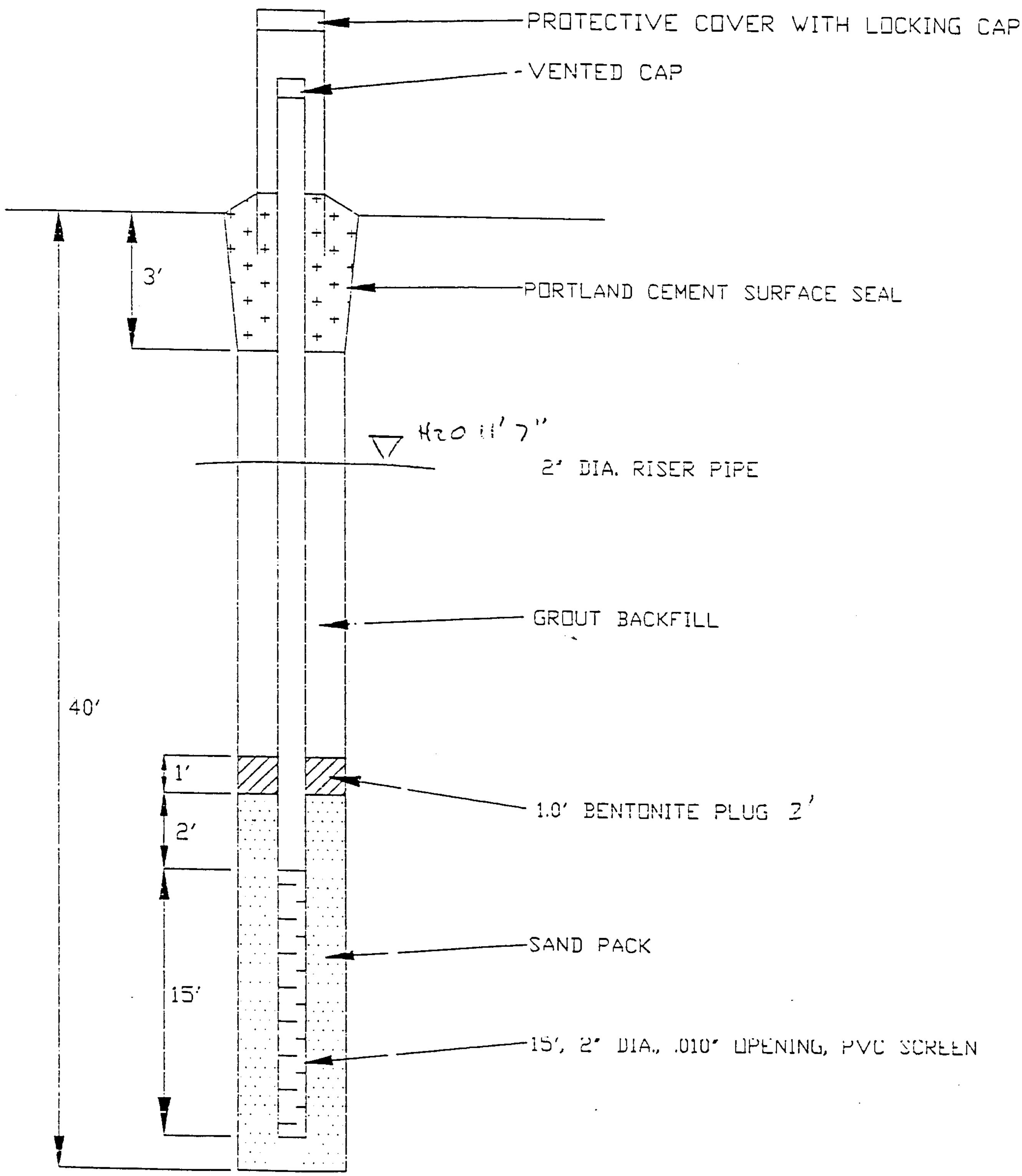
T ______ SIGNATURE: ______

3342 (6/85)
& Hazardous Waste Management Branch

# TYPICAL MONITORING WELL SCHEMATIC

PROJECT HALIFAX COUNTY LANDFILL VERTICAL EXPANSION
WELL NUMBER MW-6A

6d



TEST BORING FIELD REPORT

MW 6d

Name Halifax County Landfill Vertical Expansion Job No. ____

Supervisor Tony Crew Ben Hrs. Drilling ____ Hrs. Moving ____ Boring # MW6

ate 10/30/91 Weather ____ Ground Surface Elevation ____

| Soil Strata | | | Sampling/Blows per Ft. | | | | |
|---|---|---|---|---|---|---|---|
| om | To | Soil Description and Remarks | No. | Depth | 1st6" | 2nd6" | 3rd6" |
| .0 | 2.8 | Brown fine sandy silt w/rocks | | | | | |
| .8 | 10.6 | Brown medium to fine sandy silt | | | | | |
| .6 | 22.4 | Damp dark brown medium sandy silt | | | | | |
| .4 | 40.0 | Wet brown fine sandy silt | | | | | |
| | | | | | | | |
| | | B.T. 40.0 | | | | | |
| | | Set 2"x15' PVC screen at 40.0 with 30' PVC riser 4 bags | | | | | |
| | | sand, ½ bucket bentonite 1 2" locking cap, 1 4"x5' | | | | | |
| | | protective casing | | | | | |

ter Level ____ at TOB

ter Level ____ at ____

Level ____ at 24 Hours

t Losses ____

sing, Size ____ Length ____

Note: (Record Methods of Drilling & Depths)

CME 450 ATV
4¼" ID hollow stem auger
0.0 - 40.0

N. C. Department of Human Resources
Division of Health Services

MW 7S

# WELL COMPLETION RECORD

)MPLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C
DEPARTMENT OF HUMAN RESOURCES, SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH
P. O. BOX 2091, RALEIGH, N.C. 27602

| NAME OF SITE: | PERMIT NO.: |
|---|---|
| Halifax County Landfill | 41-0176-WW-0033 |

| ADDRESS: | OWNER (print): |
|---|---|
| S.R. 141/ Aurelian Springs, NC | Halifax County |

| DRILLING CONTRACTOR: | REGISTRATION NO.: |
|---|---|
| Bore and Core, Inc. | 763 |

Casing Type: PVC dia. 2 in. Grout Depth: from 0 to -1 ft. - dia. 7 in
Casing Depth: from 2.5 to -2.5 ft. - dia. 2 in. Bentonite Seal: from -1 to -2 ft. - dia. 7 in
Screen Type: .010 slotted PVC dia. 2 in. Sand/Gravel PK: from -2 to -17 ft. - dia. 7 in
Screen Depth: from -2.5 to -17.5' ft. - dia. 2 in. Total Well Depth: from 2.5 to -17.5 ft. - dia. 7 in
below ground surface
Static Water Level: 3'2" ~~feet from top of casing~~ Date Measured 1 / 7 / 92

Thin sand pack between bentonite & screen.

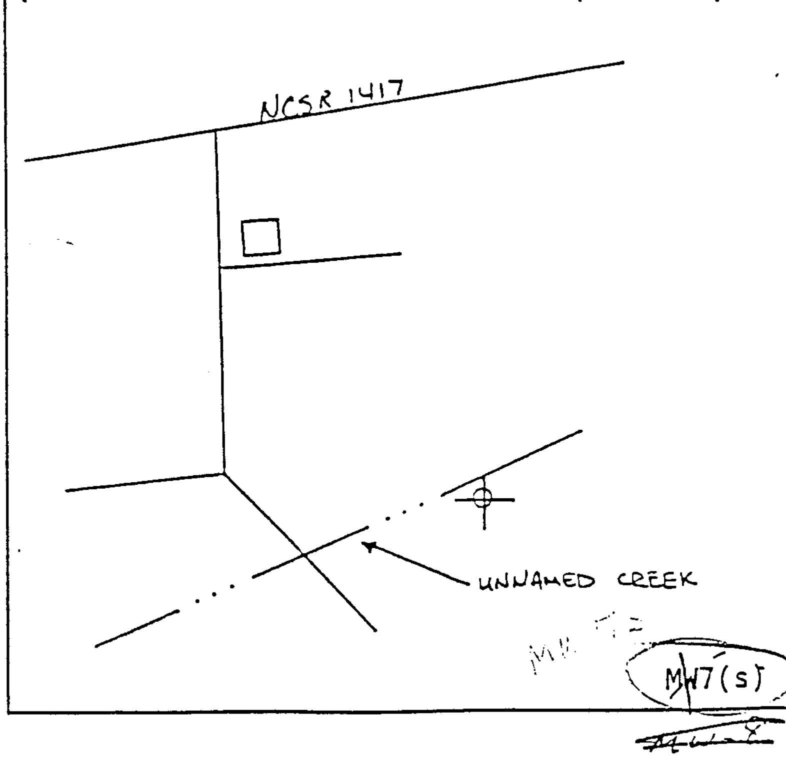
Yield (gpm): ____ Method of Testing: ____ Casing is ____ feet above land surface

## DRILLING LOG

| DEPTH FROM | TO | FORMATION DESCRIPTION |
|---|---|---|
| 0.0 | 3.4 | Brown fine to medium sandy silt |
| 3.4 | 17.0 | Damp brown fine to medium sand/gravel |

## LOCATION SKETCH

(show distance to numbered roads, or other map reference points)




REMARKS:

DATE: 1-7-92 SIGNATURE: John D Barnard

MW 7S

# TEST BORING FIELD REPORT

Name Halifax County Landfill - Aurelian Springs, N.C. Job No. ~~[illegible]~~ 3720

Field Supervisor Tony Crew Ken Hrs. Drilling ____ Hrs. Moving ____ Boring # MW7-S

Date 1-7-92 Weather Cool Ground Surface Elevation ____

| | | Soil Strata | Sampling/Blows per | | | | |
|---|---|---|---|---|---|---|---|
| rom | To | Soil Description and Remarks | No. | Depth | 1st 6" | 2nd 6" | 3 |
| 0.0 | 3.4 | Brown fine to medium sandy silt | | | | | |
| 3.4 | 17.0 | Damp brown fine to medium sand/gravel B.T. 17.0 | | | | | |
| | | | | | | | |
| | | Set 2"x 15' screen at 17.~~0~~5' with 5.0' riser 4 bags | | | | | |
| | | sand, ½ bucket bentonite, grout to top. 1, 2" locking cap | | | | | |
| | | 1, 4"x 5' protective casing. | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

Level 3'2" at TOB

Level ____ at ____

t Level ____ at 24 Hours

ter Losses ____

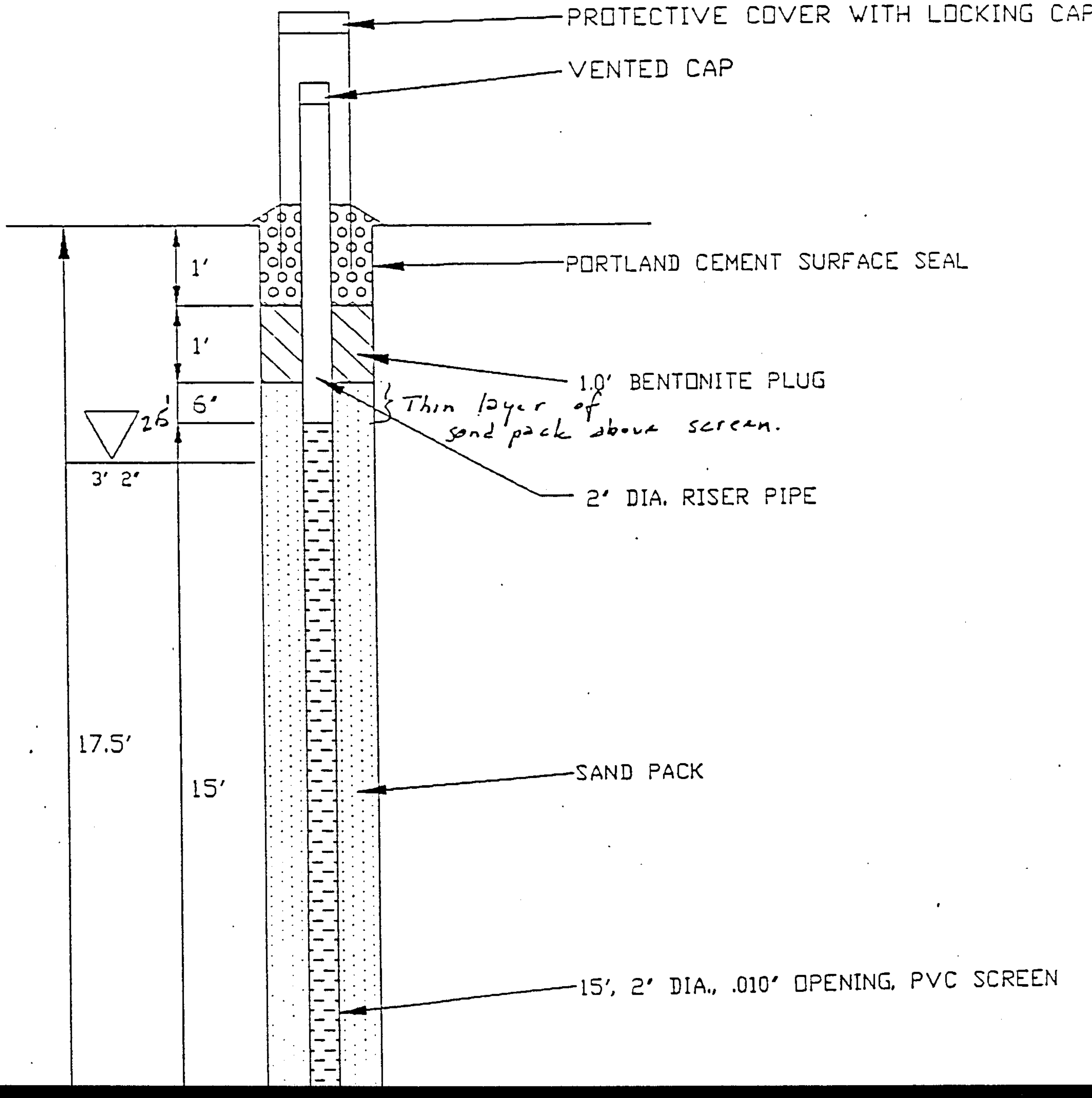
sing, Size ____ Length ____

Note: (Record Methods of Drilling & Depths)

CME 450 ATV
4¼" I.D. H.S.A.
0.0' - 17.0'

# TYPICAL MONITORING WELL SCHEMATIC

PROJECT HALIFAX COUNTY LANDFILL VERTICAL EXPANSION
WELL NUMBER MW-7(S)



Division of Health Services

# WELL COMPLETION RECORD

MW-7 MW-7d

PLETE ALL INFORMATION REQUESTED BELOW FOR EACH WELL INSTALLED, AND RETURN FORM TO THE N.C. RTMENT OF HUMAN RESOURCES, SOLID AND HAZARDOUS WASTE MANAGEMENT BRANCH, 091, RALEIGH, N.C. 27602

| | |
|---|---|
| OF SITE: ifax County Sanitary Landfill | PERMIT NO.: 41-0176-WM-0033 |
| ESS: . 1417 Aurelian Springs, N.C. | OWNER (print): Halifax County |
| ING CONTRACTOR: e & Core, Inc. | REGISTRATION NO.: 763 |

Type: PVC dia. 2 in.
Depth: from 2 to -25 ft. - dia. 2 in.
Type: slotted PVC .010 dia. 2 in.
Depth: from -25 to -40 ft. - dia. 2 in.

Grout Depth: from 0 to -21' ft. - dia. 4" in.
Bentonite Seal: from -21' to -23' ft. - dia. 4" in.
Sand/Gravel PK: from -23' to 40' ft. - dia. 4" in.
Total Well Depth: from 2' to -40' ft. - dia. 4" in.

Water Level: 3' 11" Below ground surface feet from top of casing

Date Measured 11 / 26 / 91

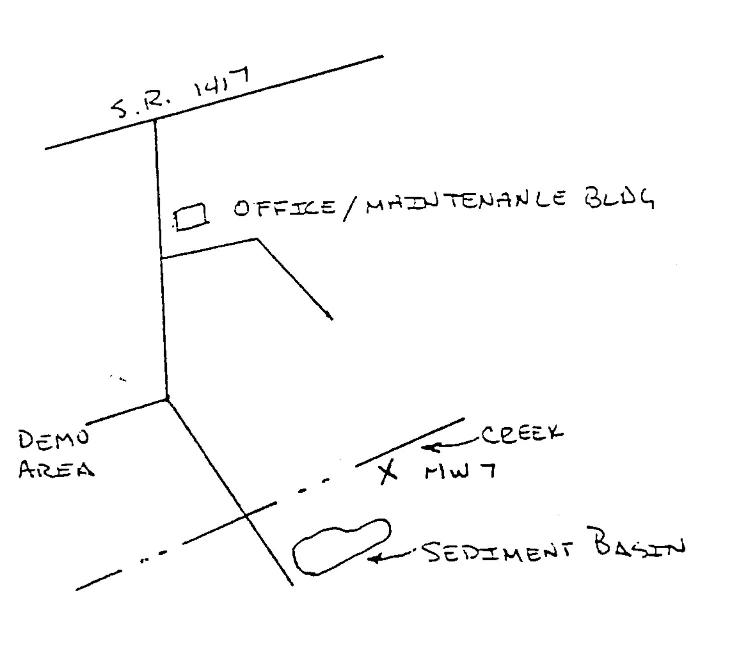
(gpm): ______ Method of Testing: ______ Casing is ______ feet above land surface

DRILLING LOG

| DEPTH FROM | TO | FORMATION DESCRIPTION |
|---|---|---|
| | 1.4 | Brown fine sandy silt |
| 4 | 6.7 | Brown fine sandy silt |
| 7 | 14.3 | Damp DrkBr. fine very sandy silt. |
| .3 | 40.0 | Wet Brown medium sandy silt/gravel |

LOCATION SKETCH

(show distance to numbered roads, or other map reference points)



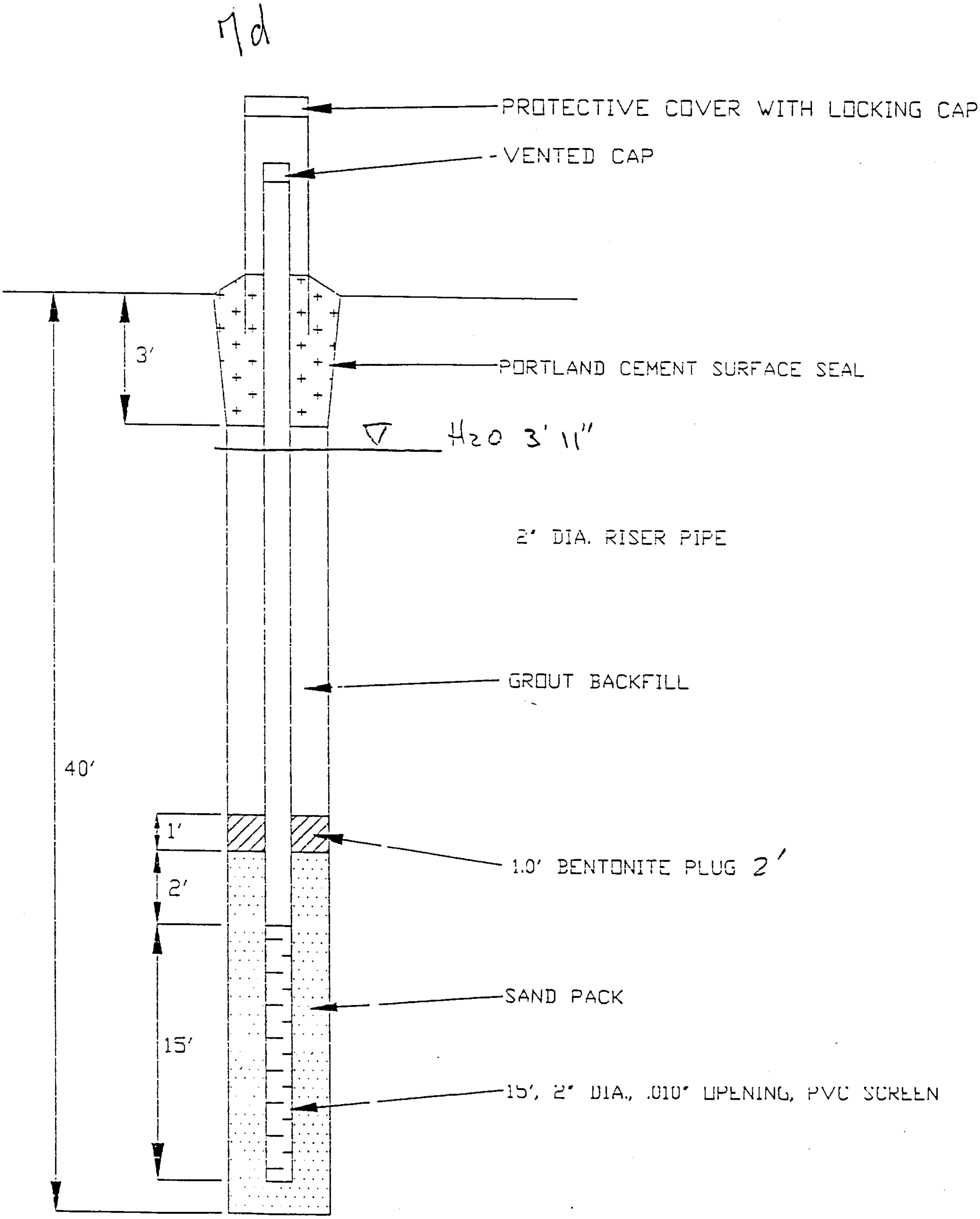

MARKS: Well screened too deep.
Static water table is above the screen.

T ______ SIGNATURE: ______

3342 (6/85)
& Hazardous Waste Management Branch

# TYPICAL MONITORING WELL SCHEMATIC

PROJECT HALIFAX COUNTY LANDFILL VERTICAL EXPANSION
WELL NUMBER MW-7



# TEST BORING FIELD REPORT

MW7d

Name Halifax County Landfill Vertical Expansion Job No. ______

d Supervisor Tony Crew Ben Hrs. Drilling ____ Hrs. Moving ____ Boring # MW7

Date 10/31/91 Weather ______ Ground Surface Elevation ______

| Soil Strata | | | Sampling/Blows per Ft | | | | |
|---|---|---|---|---|---|---|---|
| rom | To | Soil Description and Remarks | No. | Depth | 1st6" | 2nd6" | 3rd6" |
| .0 | 1.4 | Brown fine sandy silt with roots | | | | | |
| .4 | 6.7 | Brown fine sandy silt | | | | | |
| .7 | 14.3 | Damp dark brown fine very sandy silt | | | | | |
| .3 | 40.0 | Wet brown medium sandy silt with gravel B.T. 40.0 | | | | | |
| | | | | | | | |
| | | Set 2" PVC screen (15') at 40.0 with 30' PVC riser 4 bags | | | | | |
| | | sand, ½ bucket Bentonite 1 2" locking cap, 1 4"x5' | | | | | |
| | | protective casing | | | | | |

ater Level ______ at TOB

ater Level ______ at ______

Level ______ at 24 Hours

a Losses ______

asing, Size ______ Length ______

Note: (Record Methods of Drilling & Depths)

CME 450 ATV

4¼" ID hollow stem auger

0.0 - 40.0

Civil & Environmental Consultants, Inc.

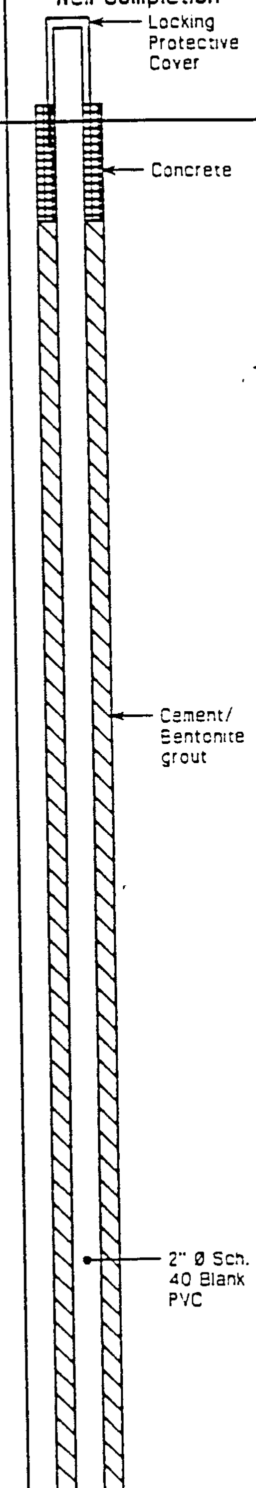
Cincinnati, OH (513) 489-0200 • (800) 759-5614

Pittsburgh, PA (412) 921-4302 • (800) 365-2324

| | | |
|---|---|---|
| Hazen & Sawyer | | JOB NO.: 94521 |
| Halifax County Landfill | | LOG OF MW-15 |
| Halifax, NC | | Sheet 1 of 2 |
| LOGGED BY: J. Barnard | GROUND SURFACE ELEVATION: 307.1 FT. MSL | |
| DRILLER: Parratt-Wolff | TOP OF CASING ELEVATION: 309.10 FT. MSL | |
| DATE DRILLED: 9/21/94 | INITIAL WATER LEVEL: 41.5 ' BGS | DATE: 9/21/94 |
| DRILL METHOD: 4 1/4" ID Hollow Stem Auger | STATIC WATER LEVEL: 42.15 ' BGS | DATE: 9/28/94 |

| HNu (ppm) | Recovery (in.) | Blow Counts | Elevation MSL | Depth (ft.) | Materials Description |
|---|---|---|---|---|---|
| | NA | NA | 305 | 0–5 | Orangish-brown, SILT, trace fine to coarse sand, trace clay, sl. moist. |
| | 22 | 6, 8, 12, 14 | 300 | 5–10 | Reddish-brown silty CLAY, trace fine sand, dry to sl. moist. |
| | 17 | 4, 6, 7, 8 | 295 | 10–11.3 | Reddish-brown clayey SILT. |
| | | | | 11.3–15 | Orangish-brown, trace pink, clayey fine SAND to fine GRAVEL, sl. moist. |
| | 23 | 4, 5, 6, 7 | 290 | 15–20 | Orangish-brown, trace gray, clayey SILT, some fine sand to fine gravel, sl. moist. |
| | 22 | 7, 8, 11, 19 | 285 | 20–25 | Pink, orangish-tan, and white, silty fine to coarse SAND, trace fine gravel, micaceous (Granite Saprolite), sl. moist. Hard drilling beginning at approx. 22'. |
| | 23 | 24, 25, 28, 25 | 280 | 25– | Same as above, dry to sl. moist. |

Well Completion



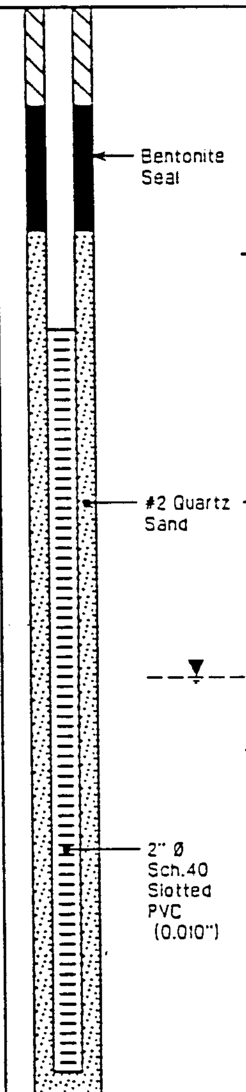
CEC
Civil & Environmental Consultants, Inc.
Cincinnati, OH (513) 489-0200 • (800) 759-5614
Pittsburgh, PA (412) 921-4302 • (800) 365-2324

Hazen & Sawyer
Halifax County Landfill
Halifax, NC

JOB NO.: 94521
LOG OF MW-15


| HNu (ppm) | Recovery (in.) | Blow Counts | Elevation MSL | Depth (ft.) | Graphic Log | Materials Description |
|---|---|---|---|---|---|---|
| | 22 | 14 18 19 24 | | | | Same, dry. |
| | | | 275 | 33 | | |
| | 13 | 14 16 18 19 | | | | Pink, orangish-tan, and white, silty fine to coarse SAND, high % of pink feldspar crystals, sl. moist. |
| | | | 270 | 38 | | |
| | 21 | 9 10 7 8 | | | | Same, with increasing clay content, moist. |
| | | | 265 | 43 | | |
| | | | 260 | 48 | | |
| | | | | | | Bottom of boring at 50.0' BGS. |
| | | | 255 | 53 | | |
| | | | 250 | 58 | | |

Well Completion



# FIELD BOREHOLE LOG

| BOREHOLE NUMBER |
| --- |
| MW-16A |

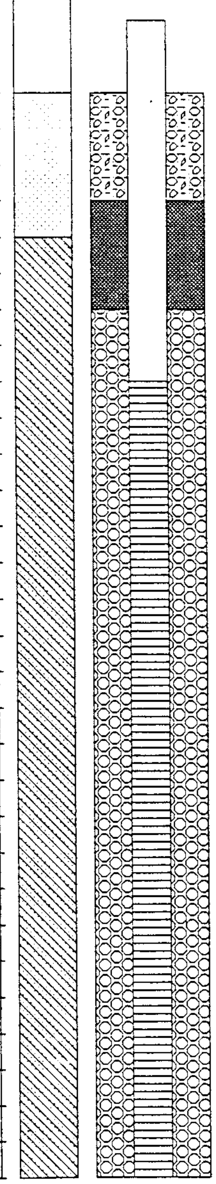
PROJECT NUMBER HALIFAX-2
PROJECT NAME HALIFAX COUNTY LANDFILL
LOCATION HALIFAX, NC
DRILLING COMPANY BORE & CORE
RIG TYPE & NUMBER MOBILE B-57 ATV
DRILLING METHOD HOLLOW STEM AUGER
WEATHER HOT, HUMID
FIELD PARTY BILL BROW
GEOLOGIST GREG MILLS
DATE BEGUN 7/26/95 DATE COMPLETED 7/26/95

TOP OF CASING ELEVATION -
TOTAL DEPTH 16.0
GROUND SURFACE ELEVATION -
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
| --- | --- | --- |
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 7.2 FT | |
| Time | 3:00 PM | |
| Date | 7/26/95 | |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION | DEPTH |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 0 | | | | | | | | | 1 0 |
| 0 0 | | | | | | | | SAND: Tan coarse grained SAND w/ some organics. | 0 0 |
| 1 0 | | | | | | | | | 1 0 |
| 2 0 | | | | D | | | | CLAYEY SAND: White, pink and orange coarse grained clayey SAND with mica, feldspar, K-feldspar, and some quartz; weathered granite; residual soil; SC. | 2 0 |
| 3 0 | | | | | | | | | 3 0 |
| 4 0 | 6<br>7<br>9 | Ss | S1 | | | | | | 4 0 |
| 5 0 | | | | | | | | | 5 0 |
| 6 0 | | | | | | | | | 6 0 |
| 7 0 | | | | | | | | | 7 0 |
| 8 0 | | | | | | | | | 8 0 |
| 9 0 | 5<br>8<br>8 | Ss | S2 | W | | | | | 9 0 |
| 10 0 | | | | | | | | | 10 0 |
| 11 0 | | | | | | | | | 11 0 |
| 12 0 | | | | | | | | | 12 0 |
| 13 0 | | | | | | | | | 13 0 |
| 14 0 | 36<br>50/0 4' | Ss | S3 | | | | | | 14 0 |
| 15 0 | | | | | | | | | 15 0 |

LITHOLOGY | WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-1

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, 45 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/6/95 DATE COMPLETED: 12/6/95

TOP OF CASING ELEVATION: -
TOTAL DEPTH: 36.0 FT
GROUND SURFACE ELEVATION: -
SHEET: 1 OF: 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | Dry | - |
| Time | - | - |
| Date: | - | - |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0 | 3 5 7 | Ss | S1 | | | 18" | | SANDY CLAY: Orange brown sandy clay and topsoil; took a jar sample from 0 to 1.5 feet. |
| 3.5 | 8 16 15 | Ss | S2 | | | 18" | | CLAYEY SANDY SILT: Yellow-orange clayey sandy silt; abundant feldspar; trace mica. |
| 8.5 | 5 6 9 | Ss | S3 | | | 18" | | |
| 13.5 | 5 6 7 | Ss | S4 | | | 18" | | SILTY SAND: Yellow tan fine silty sand; powdery; felsic; trace mica. |
| 18.5 | 4 5 6 | Ss | S5 | | | 18" | | |
| 23.5 | 5 10 9 | Ss | S6 | | | 12" | | SILTY SAND: Slightly clayey silty sand; micaceous; coarse sand; gravel at 25'. |
| 28.5 | 10 50/.4 | Ss | S7 | | | 8" | | |
| 29.0 | | | | | | | | SILTY SAND: Relict granite; very felsic; iron stained; quartz sand and mica; auger refusal at 36'. |
| 33.5 | 50/.3 | Ss | S8 | | | 3" | | |
| 36.0 | | | | | | | | |

# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-2

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: MOBILE DRILL CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, 45 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/5/95 DATE COMPLETED: 12/5/95

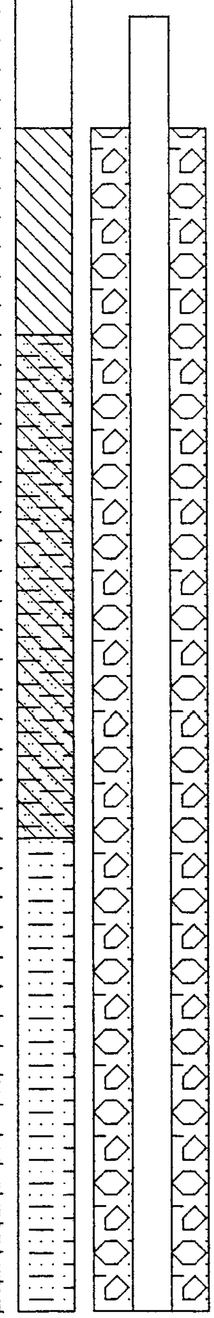
TOP OF CASING ELEVATION: -
TOTAL DEPTH: 40.0 FT
GROUND SURFACE ELEVATION: -
SHEET: 1 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 27 | - |
| Time | 13:30 | - |
| Date: | 12/5/95 | - |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0 | 2, 4, 6 | Ss | S1 | | | 12" | | CLAY: Orange brown clay with a 3" layer of topsoil above it; took a jar sample from 0 to 1.5 feet. |
| 3.0 | 7, 8, 9 | Ss | S2 | D | | 16" | | SANDY CLAYEY SILT: Orange brown sandy clayey silt; slightly plastic. |
| 8.0 | 5, 8, 11 | Ss | S3 | D | | 14" | | |
| 12.0 | | | | | | | | SANDY SILT: Pink to white to tan sandy silt; relict granite structure visible; sample contains feldspar, mica and quartz; wet at 28.5'. |
| 13.0 | 4, 5, 8 | Ss | S4 | M | | 16" | | |
| 18.0 | 5, 11, 11 | Ss | S5 | M | | 18" | | |

DEPTH scale: 2.0, 1.0, 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0

LITHOLOGY / WELL INSTALLATION



# FIELD BOREHOLE LOG

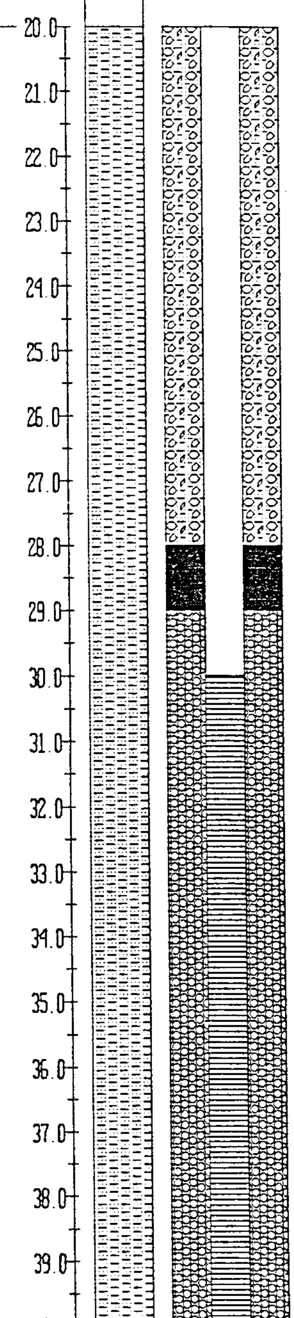
| BOREHOLE NUMBER |
|---|
| BP-2 |

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: MOBILE DRILL CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, 45 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/5/95 DATE COMPLETED: 12/5/95

TOP OF CASING ELEVATION: -
TOTAL DEPTH: 40.0 FT
GROUND SURFACE ELEVATION: -
SHEET: 2 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | - | - |
| Time | - | - |
| Date | - | - |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 20.0 | | | | | | | | SANDY SILT: Pink to white to tan sandy silt; relict granite structure visible; samples contain feldspar, mica and quartz; wet at 28.5'. |
| 23.0 | 7, 10, 14 | Ss | S6 | M | | 16" | | |
| 28.0 | 8, 12, 16 | Ss | S7 | W | | 16" | | |
| 33.0 | 5, 8, 12 | Ss | S8 | W | | 14" | | |
| 38.0 | 5, 9, 14 | Ss | S9 | W | | | | |
| 40.0 | | | | | | | | |



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-3

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, 45 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/5/95
DATE COMPLETED: 12/6/95

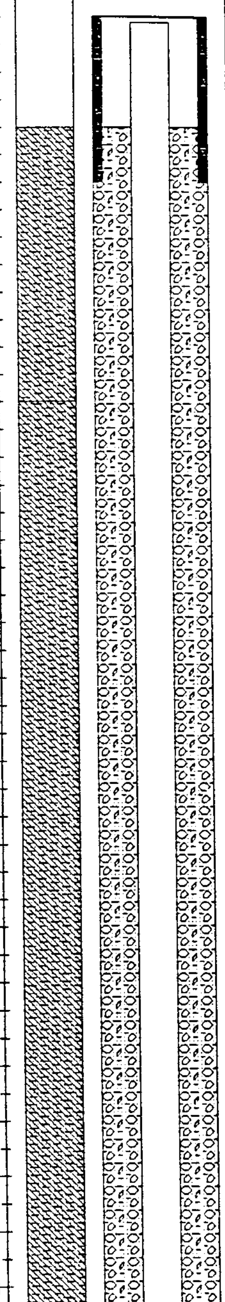
TOP OF CASING ELEVATION: 315.39
TOTAL DEPTH: 50.0 FT
GROUND SURFACE ELEVATION: 313.70
SHEET: 1 OF 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 45.51 | 45.22 |
| Time | 8:45 AM | 4 PM |
| Date | 12/6/95 | 12/7//95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0 | 4<br>8<br>12 | Ss | S1 | | | 18" | | SANDY SILTY CLAY: Red-orange-brown with some yellow; took a bulk sample from 3 to 5 feet. |
| 3.0 | 10<br>11<br>9 | Ss | S2 | | | 18" | | |
| 5.0 | | | | | | | | CLAYEY SANDY SILT: Orange yellow brown; abundant feldspar and mica; four pieces of quartz gravel at 19 ft. |
| 8.0 | 4<br>7<br>8 | Ss | S3 | | | 16" | | |
| 13.0 | 4<br>5<br>6 | Ss | S4 | | | 18" | | |
| 18.0 | 6<br>9<br>13 | Ss | S5 | | | 16" | | |
| 23.0 | 6 | Ss | S6 | | | | | |

Depth scale: 2.0, 1.0, 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0

LITHOLOGY / WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-3

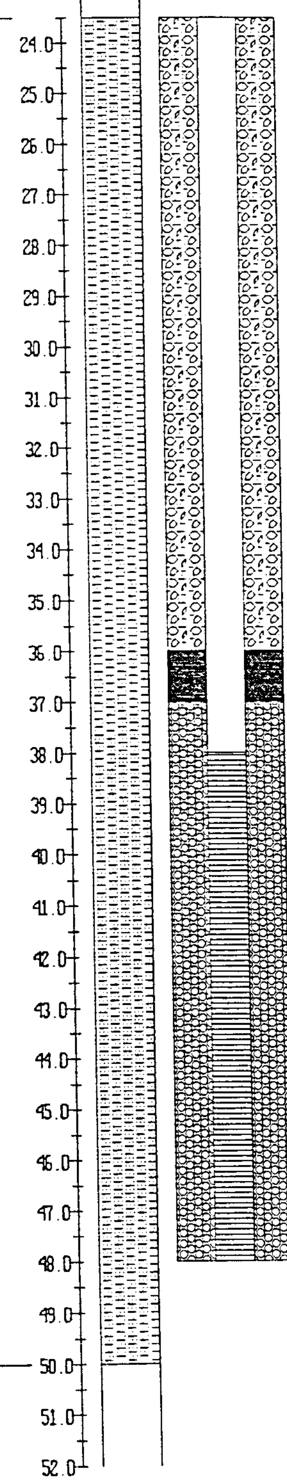
PROJECT NUMBER HALIFAX-5
PROJECT NAME HALIFAX COUNTY
LOCATION HALIFAX, NORTH CAROLINA
DRILLING COMPANY BORE AND CORE
RIG TYPE & NUMBER CME 450
DRILLING METHOD HOLLOW STEM AUGER
WEATHER CLOUDY, 45 DEGREES
FIELD PARTY L. FOSKEY
GEOLOGIST G. MILLS
DATE BEGUN 12/5/95 DATE COMPLETED 12/6/95

TOP OF CASING ELEVATION 315.39
TOTAL DEPTH 50.0 FT
GROUND SURFACE ELEVATION 313.70
SHEET 2 OF 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 45.51 | 45.22 |
| Time | 8:45 AM | 4 PM |
| Date | 12/6/95 | 12/7//95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 23.5–25.0 | 6 / 12 / 13 | Ss | S6 | | | | | SANDY SILT: White-orange relict granite with abundant feldspar; more k-spar and coarse quartz sand at 33.5 ft. |
| 28.0–29.5 | 10 / 16 / 18 | Ss | S7 | | | | | |
| 33.0–34.5 | 7 / 12 / 16 | Ss | S8 | | | 12" | | |
| 38.0–39.5 | 9 / 13 / 17 | Ss | S9 | | | 8" | | |
| 43.0–44.5 | 7 / 12 / 17 | Ss | S10 | | | 10" | | |
| 48.0–49.5 | 10 / 17 / 21 | Ss | S11 | | | | | |
| 50.0 | | | | | | | | Boring Terminated at 50 feet. |

DEPTH | LITHOLOGY | WELL INSTALLATION



# FIELD BOREHOLE LOG

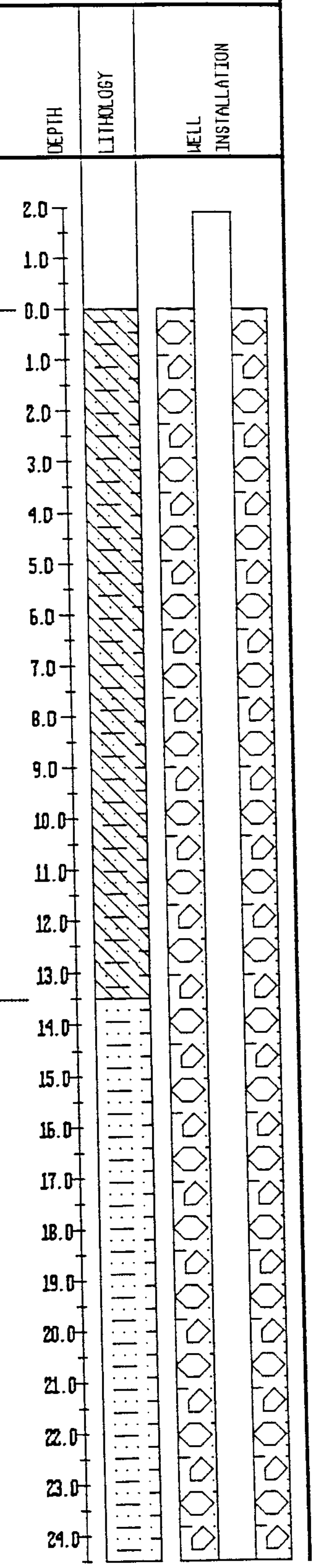
BOREHOLE NUMBER: BP-4

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: SOME CLOUDS, 34 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/6/95 DATE COMPLETED: 12/6/95

TOP OF CASING ELEVATION: 313.16
TOTAL DEPTH: 48.0 FT
GROUND SURFACE ELEVATION: 310.8
SHEET: 1 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 38.30 | 36.25 |
| Time | 4:00 pm | 4:00 pm |
| Date: | 12-6-95 | 12-7-95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0 | 2, 3, 6 | Ss | S1 | | | 18" | | SANDY SILTY CLAY: Orange brown; slightly plastic. |
| 3.0 | 6, 7, 8 | Ss | S2 | D | | 18" | | |
| 8.0 | 4, 5, 8 | Ss | S3 | M | | 18" | | |
| 13.0 | 4, 8, 10 | Ss | S4 | D | | 17" | | SANDY SILT: Relict Granite; moist, pink to gray micaceous sandy silt with quartz and abundant feldspar. |
| 18.0 | 8, 11, 14 | Ss | S5 | D | | 18" | | |
| 23.0 | 7, 10, 13 | Ss | S6 | M | | 18" | | |



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-4

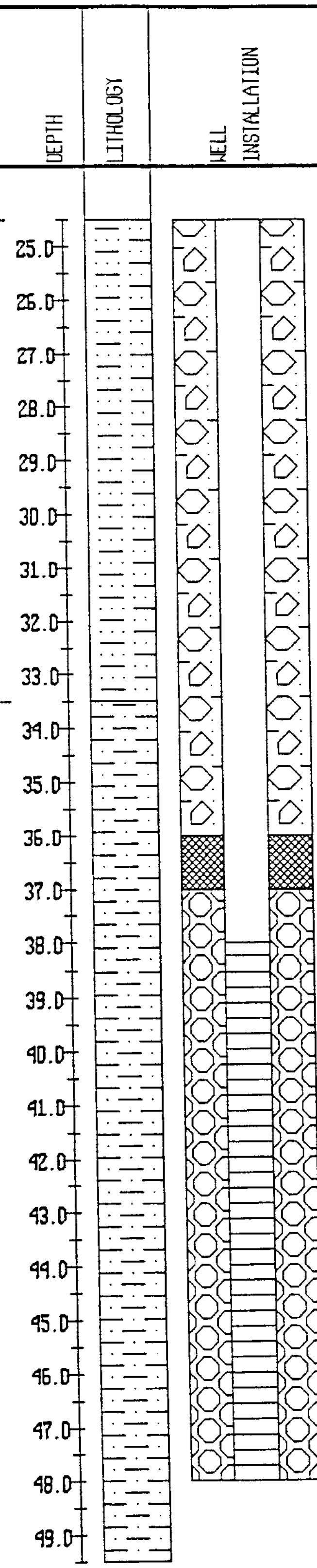
PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: SOME CLOUDS, 34 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/6/95 DATE COMPLETED: 12/6/95

TOP OF CASING ELEVATION: 313.16
TOTAL DEPTH: 48.0 FT
GROUND SURFACE ELEVATION: 310.8
SHEET: 2 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 38.30 | 36.25 |
| Time | 4:00 pm | 4:00 pm |
| Date: | 12-6-95 | 12-7-95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 24.5 | 13 | | | | | | | SANDY SILT: Relict Granite; moist, pink to gray micaceous sandy silt with quartz and abundant feldspar. |
| 28.5–29.5 | 11 10 14 | Ss | S7 | M | | 14" | | |
| 33.5–34.5 | 3 4 6 | Ss | S8 | M | | | | SILT: Thin 1/8" layers of gray and tan with an interface of orange - iron staining and black Mn staining in a vertical direction; relict granite texture more pronounced at bottom of boring. |
| 38.5–39.5 | 6 11 14 | Ss | S9 | W | | | | |
| 43.5–44.5 | 13 16 25 | Ss | S10 | W | | | | |
| 48.5–49.5 | 10 16 16 | Ss | S11 | W | | | | |

DEPTH scale: 25.0, 26.0, 27.0, 28.0, 29.0, 30.0, 31.0, 32.0, 33.0, 34.0, 35.0, 36.0, 37.0, 38.0, 39.0, 40.0, 41.0, 42.0, 43.0, 44.0, 45.0, 46.0, 47.0, 48.0, 49.0



# FIELD BOREHOLE LOG

| BOREHOLE NUMBER: |
|---|
| BP-5 |

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, 45 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/5/95 DATE COMPLETED: 12/5/95

TOP OF CASING ELEVATION: -
TOTAL DEPTH: 40.0 FT
GROUND SURFACE ELEVATION: -
SHEET: 1 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 27 | - |
| Time | - | - |
| Date: | 12/5/95 | - |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION | DEPTH | LITHOLOGY | WELL INSTALLATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.0 | | | | | | | | | 2.0 | | |
| 1.0 | | | | | | | | | 1.0 | | |
| 0.0 | 4<br>3<br>8 | Ss | S1 | | | 18" | | SILTY CLAY: Red-brown. | 0.0 | | |
| 1.0 | | | | | | | | | 1.0 | | |
| 2.0 | | | | | | | | | 2.0 | | |
| 3.0 | 7<br>10<br>12 | Ss | S2 | | | 14" | | SANDY CLAYEY SILT: White gray, brown and pink; abundant feldspar and mica; slightly plastic; trace quartz; relict granite structure at 13'. | 3.0 | | |
| 4.0 | | | | | | | | | 4.0 | | |
| 5.0 | | | | | | | | | 5.0 | | |
| 6.0 | | | | | | | | | 6.0 | | |
| 7.0 | | | | | | | | | 7.0 | | |
| 8.0 | 5<br>9<br>12 | Ss | S3 | | | 12" | | | 8.0 | | |
| 9.0 | | | | | | | | | 9.0 | | |
| 10.0 | | | | | | | | | 10.0 | | |
| 11.0 | | | | | | | | | 11.0 | | |
| 12.0 | | | | | | | | | 12.0 | | |
| 13.0 | 7<br>11<br>14 | Ss | S4 | | | 12" | | | 13.0 | | |
| 14.0 | | | | | | | | | 14.0 | | |
| 15.0 | | | | | | | | | 15.0 | | |
| 16.0 | | | | | | | | | 16.0 | | |
| 17.0 | | | | | | | | | 17.0 | | |
| 18.0 | | | | | | | | | 18.0 | | |

# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-5

PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: SOME CLOUDS, 34 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/5/95 DATE COMPLETED: 12/5/95

TOP OF CASING ELEVATION: --
TOTAL DEPTH: 40.0 FT
GROUND SURFACE ELEVATION: --
SHEET: 2 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | -- | -- |
| Time | -- | -- |
| Date: | -- | -- |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 19.0 | 5 8 11 | Ss | S5 | M | | 14" | | SANDY SILT: Relict Granite; moist to wet, pink to gray with weathered iron and Mn staining. |
| 23.0 | 5 7 11 | Ss | S6 | M | | 16" | | |
| 28.0 | 6 9 12 | Ss | S7 | W | | 12" | | |
| 33.0 | 5 9 15 | Ss | S8 | W | | 12" | | |
| 38.0 | 7 11 15 | Ss | S9 | W | | 10" | | |
| 40.0 | | | | | | | | Boring Terminated at 40.0 Feet. |

# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-6

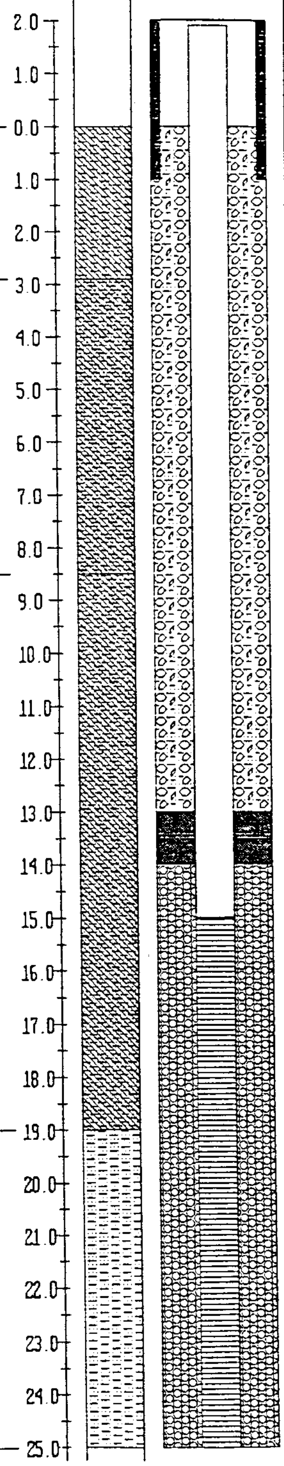
PROJECT NUMBER HALIFAX-5
PROJECT NAME HALIFAX COUNTY
LOCATION HALIFAX, NORTH CAROLINA
DRILLING COMPANY BORE AND CORE
RIG TYPE & NUMBER CME 450
DRILLING METHOD HOLLOW STEM AUGER
WEATHER CLOUDY, 45 DEGREES
FIELD PARTY L. FOSKEY
GEOLOGIST G. MILLS
DATE BEGUN 12/5/95 DATE COMPLETED 12/5/95

TOP OF CASING ELEVATION 317.28
TOTAL DEPTH 25.0 FT
GROUND SURFACE ELEVATION 315.0
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) WD=While Drilling AB=After Boring | | |
|---|---|---|
| Depth(ft) | 16.64 | 15.94 |
| Time | 9:45 am | 7:45 am |
| Date | 12/5/95 | 12/6/95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0 – 3.0 | 4 5 7 | Ss | S1 | | | | | SANDY SILTY CLAY: 6" of topsoil underlain by sandy silty clay; took a jar sample from 0 to 1.5 feet. |
| 3.0 – 8.5 | 6 7 9 | Ss | S2 | D | | | | SANDY CLAYEY SILT: Red-brown fine sandy clayey silt; took a jar sample from 3.5 to 5 feet. |
| 8.5 – 19.0 | 8 5 10 | Ss | S3 | D | | | | SANDY CLAYEY SILT: Red-brown fine sandy clayey silt; relict rock structure is evident at 8.5 feet; color becomes pink, texture is sandier at 13.5 feet; bulk sample taken between 13.5 and 19 feet. |
| | 3 4 6 | Ss | S4 | D | | | | |
| 19.0 – 25.0 | 3 6 9 | Ss | S5 | W | | | | SANDY SILT: Tan, slightly clayey sandy silt; wet at 19'; very wet at 23.5'. |
| | 3 6 9 | Ss | S6 | VW | | | | |

DEPTH | LITHOLOGY | WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-7

PROJECT NUMBER: HALIFAX-8
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, RAIN 60 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: P. MAY
DATE BEGUN: 4/29/97 DATE COMPLETED: 4/29/97

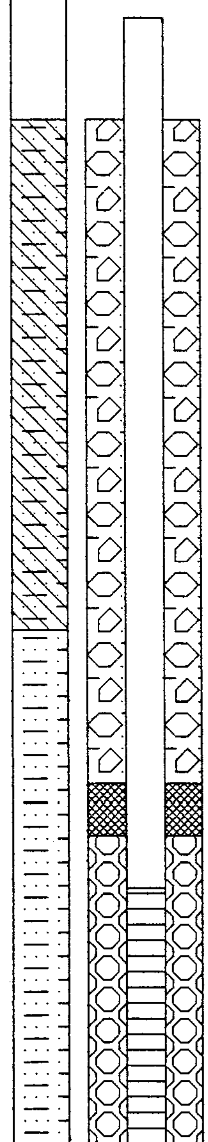
TOP OF CASING ELEVATION: NA
TOTAL DEPTH: 20.0 FT
GROUND SURFACE ELEVATION: NA
SHEET: 1 OF: 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 1.0 | 3.25 |
| Time | 5:00 pm | 2:00 pm |
| Date: | 4/29/97 | 4/30/97 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0 | 3 3 6 | Ss | S1 | M | | 16" | | CLAYEY SANDY SILT: 6" of topsoil underlain by tan soft clayey sandy silt; bulk sample 1-10'; |
| 3.0 | 4 5 6 | Ss | S2 | M | | 18" | | ML; |
| 5.0 | | | | | | | | iron banding from 3.5-5.0'; |
| 8.0 | 3 2 4 | Ss | S3 | W | | 14" | | manganese bands from 8.5-10.0'. |
| 10.0 | | | | | | | | SANDY SILT: Tan fine sandy silt with white feldspar; micaceous; |
| 12.0 | | | | | | | | MH; |
| 13.0 | 4 6 8 | Ss | S4 | W | | 16" | | |
| 18.0 | 8 9 11 | Ss | S5 | W | | 16" | | |
| 20.0 | | | | | | | | Boring terminated at 20.0'. |

DEPTH scale: 2.0, 1.0, 0.0, 1.0 … 25.0

LITHOLOGY / WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-8

PROJECT NUMBER: HALIFAX-8
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, RAIN 60 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: P. MAY
DATE BEGUN: 4/29/97    DATE COMPLETED: 4/29/97

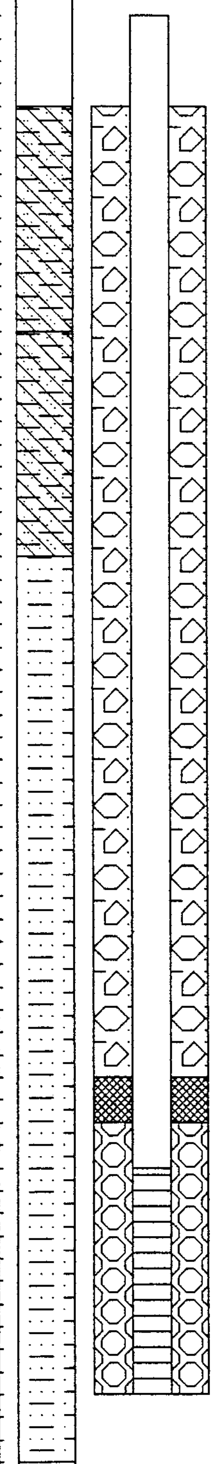
TOP OF CASING ELEVATION: NA
TOTAL DEPTH: 30.0 FT
GROUND SURFACE ELEVATION: NA
SHEET: 1    OF: 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 21.7 | 14.43 |
| Time | 2:00 pm | 2:00 pm |
| Date: | 4/29/97 | 4/30/97 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD |
|---|---|---|---|---|---|---|---|
| 0.0 | 2 6 10 | Ss | S1 | D | | 16" | |
| 3.0 | 10 12 18 | Ss | S2 | D | | 18" | |
| 8.0 | 10 13 18 | Ss | S3 | D | | 14" | |
| 13.0 | 4 7 11 | Ss | S4 | M | | 16" | |
| 18.0 | 6 7 12 | Ss | S5 | M | | 18" | |
| 23.0 | 5 8 13 | Ss | S6 | VM | | 16" | |
| 28.0 | 5 8 14 | Ss | S7 | VM | | 14" | |

| DEPTH | LITHOLOGY DESCRIPTION |
|---|---|
| 0.0–5.0 | SILTY SANDY CLAY: 6" of topsoil underlain by firm red-brown dry silty sandy clay; bulk sample 1-10'; MH-CL. |
| 5.0–10.0 | SANDY CLAYEY SILT: Tan fine dry sandy clayey silt; ML. |
| 10.0–30.0 | SANDY SILT: Red-purple moist fine sandy silt; trace clay; micaceous; MH; water at 18 feet; bands of white feldspar at 19-20 feet; manganese striations starting at 18-20 feet. |
| 30.0 | Boring terminated at 30.0 feet. |

LITHOLOGY / WELL INSTALLATION (depth 2.0 to 30.0)



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-9

PROJECT NUMBER: HALIFAX-B
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, RAIN 60 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: P. MAY
DATE BEGUN: 4/28/97 DATE COMPLETED: 4/28/97

TOP OF CASING ELEVATION: NA
TOTAL DEPTH: 35.0 FT
GROUND SURFACE ELEVATION: NA
SHEET: 1 OF: 2

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 18.4 | 18.88 |
| Time | 2:00 pm | 12:30 pm |
| Date: | 4/28/97 | 4/30/97 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0–1.5 | 2 4 7 | Ss | S1 | D | | 16" | | CLAYEY SILT: 6" of topsoil underlain by red-brown dry clayey silt; moderately plastic; MH-CL. |
| 3.0–4.5 | 6 10 14 | Ss | S2 | D | | 18" | | |
| 5.0 | | | | | | | | CLAYEY SILTY SAND: Tan moist F-M clayey silty sand; mottled with pink & white feldspar; quartz granules; SM-SC. |
| 8.0–9.5 | 5 8 9 | Ss | S3 | M | | 14" | | |
| 10.0 | | | | | | | | CLAYEY SANDY SILT: Mottled tan & pink & white moist M-C clayey sandy silt; some quartz; MH-CL. |
| 13.0–14.5 | 5 7 10 | Ss | S4 | M | | 16" | | |
| 15.0 | | | | | | | | SILTY CLAYEY SAND: Mottled tan moist silty clayey sand with pink & white feldspar; some quartz; manganese banding starts at 19.0'; SM-SC; |
| 18.0–19.5 | 7 7 11 | Ss | S5 | M | | 16" | | |
| 22.0 | | | | | | | | water at 20.0'; |
| 23.0–24.5 | 7 12 17 | Ss | S6 | M | | 12" | | mostly lateral manganese bands; micaceous; mostly pink feldspar; |

LITHOLOGY | WELL INSTALLATION

# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-9

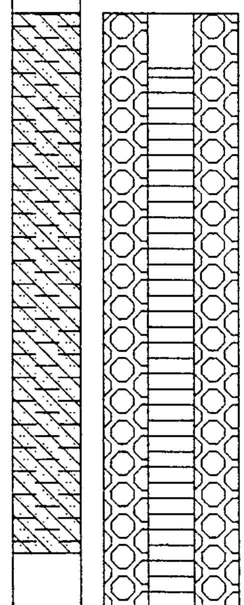
PROJECT NUMBER: **HALIFAX-B**
PROJECT NAME: **HALIFAX COUNTY**
LOCATION: **HALIFAX, NORTH CAROLINA**
DRILLING COMPANY: **BORE AND CORE**
RIG TYPE & NUMBER: **CME 450**
DRILLING METHOD: **HOLLOW STEM AUGER**
WEATHER: **CLOUDY, RAIN 60 DEGREES**
FIELD PARTY: **L. FOSKEY**
GEOLOGIST: **P. MAY**
DATE BEGUN: **4/28/97** DATE COMPLETED: **4/28/97**

TOP OF CASING ELEVATION: **NA**
TOTAL DEPTH: **35.0 FT**
GROUND SURFACE ELEVATION: **NA**
SHEET: **2** OF: **2**

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 18.4 | 18.88 |
| Time | 2:00 pm | 12:30 pm |
| Date: | 4/28/97 | 4/30/97 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 25.0 | | | | | | | | |
| 26.0 | | | | | | | | |
| 27.0 | | | | | | | | |
| 28.0 | 7<br>10<br>14 | Ss | S7 | M | | 16" | | |
| 29.0 | | | | | | | | white feldspar bands more evident. |
| 30.0 | | | | | | | | |
| 31.0 | | | | | | | | |
| 32.0 | | | | | | | | |
| 33.0 | 10<br>13<br>14 | Ss | S8 | M | | 14" | | |
| 34.0 | | | | | | | | |
| 35.0 | | | | | | | | Boring terminated at 36.0'. |
| 36.0 | | | | | | | | |
| 37.0 | | | | | | | | |
| 38.0 | | | | | | | | |
| 39.0 | | | | | | | | |
| 40.0 | | | | | | | | |
| 41.0 | | | | | | | | |
| 42.0 | | | | | | | | |
| 43.0 | | | | | | | | |
| 44.0 | | | | | | | | |
| 45.0 | | | | | | | | |
| 46.0 | | | | | | | | |
| 47.0 | | | | | | | | |
| 48.0 | | | | | | | | |
| 49.0 | | | | | | | | |
| 50.0 | | | | | | | | |

DEPTH / LITHOLOGY / WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-10

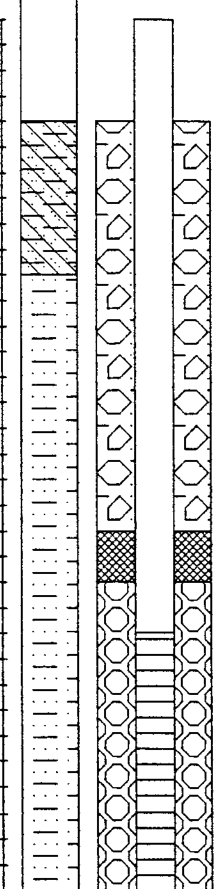
PROJECT NUMBER: HALIFAX-8
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, RAIN 60 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: P. MAY
DATE BEGUN: 4/30/97 DATE COMPLETED: 4/30/97

TOP OF CASING ELEVATION: NA
TOTAL DEPTH: 15.0 FT
GROUND SURFACE ELEVATION: NA
SHEET: 1 OF: 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 4.8 | 5.86 |
| Time | 2:00 pm | 1:45 pm |
| Date: | 4/30/97 | 5/1/97 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0–3.0 | 4 5 6 | Ss | S1 | D | | 14" | | SANDY CLAYEY SILT: 6" of topsoil underlain by tan dry C sandy clayey silt; some quartz; ML. |
| 3.0–15.0 | 3 4 5 | Ss | S2 | D | | 16" | | SANDY SILT: Tan-grey moist F-M sandy silt; iron banding; |
| | | | | | | | | MH; |
| | 2 3 4 | Ss | S3 | M | | 18" | | less sand at 8-10'; some manganese in vertical bands; mottled with white & gray granite; |
| | | | | | | | | water at 10'; |
| | 3 3 5 | Ss | S4 | W | | 10" | | turns brown-grey at 13'; more sand and mica; white feldspar striations. |
| 15.0 | | | | | | | | Boring terminated at 15.0'. |

DEPTH | LITHOLOGY | WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER G-13D

PROJECT NUMBER HALIFAX-5
PROJECT NAME HALIFAX COUNTY
LOCATION HALIFAX, NORTH CAROLINA
DRILLING COMPANY BORE AND CORE
RIG TYPE & NUMBER CME 450
DRILLING METHOD HOLLOW STEM AUGER, NQ CORE, ROLLER CONE
WEATHER CLOUDY, 45 DEGREES
FIELD PARTY L. FOSKEY
GEOLOGIST G. MILLS
DATE BEGUN 12/27/95 DATE COMPLETED 12/28/95

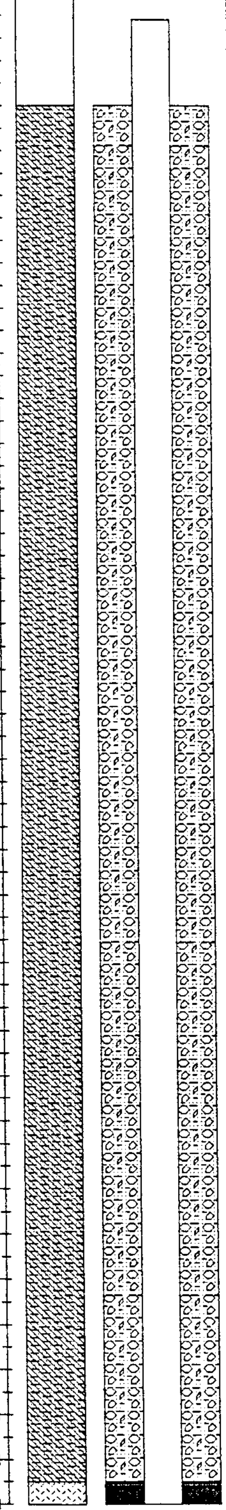
TOP OF CASING ELEVATION 252.12
TOTAL DEPTH 54.5 FT
GROUND SURFACE ELEVATION 250.1
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 8.60 | 8.50 |
| Time | - | - |
| Date | 1-23-95 | 1-24-95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0–30.5 | | | | | | | | CLAYEY SANDY SILT: Probed to auger refusal without sampling; lithology shlould be same as G-13, drilled 5 feet south. |
| 30.5 | | | | | | | | Auger Refusal at 30.5 feet; boring continued with NQ core. |

DEPTH 2.0 1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0 24.0 25.0 26.0 27.0 28.0 29.0 30.0 31.0

LITHOLOGY | WELL INSTALLATION



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: G-13D

PROJECT NUMBER HALIFAX-5
PROJECT NAME HALIFAX COUNTY
LOCATION HALIFAX, NORTH CAROLINA
DRILLING COMPANY BORE AND CORE
RIG TYPE & NUMBER CME 450
DRILLING METHOD HOLLOW STEM AUGER, NO CORE, ROLLER CONE
WEATHER CLOUDY, 45 DEGREES
FIELD PARTY L. FOSKEY
GEOLOGIST G. MILLS
DATE BEGUN 12/27/95 DATE COMPLETED 12/28/95

TOP OF CASING ELEVATION 252.12
TOTAL DEPTH 54.5 FT
GROUND SURFACE ELEVATION 250.1
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) WD=While Drilling AB=After Boring | | |
|---|---|---|
| Depth(Ft) | 8.60 | 8.50 |
| Time | - | - |
| Date | 1-23-95 | 1-24-95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION | DEPTH | LITHOLOGY | WELL INSTALLATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 31.0–41.5 | | | | | | | | WEATHERED GRANITE: 11 feet of NO core with no recovery. | | | |
| 41.5–54.5 | | | | | | | | WEATHERED GRANITE: Tri-cone roller with 2-15/16 inch bit through weathered rock until refusal. | | | |
| 54.5 | | | | | | | | Roller refusal at 54.5 feet. | | | |

Depth scale: 31.0 – 60.0

# FIELD BOREHOLE LOG

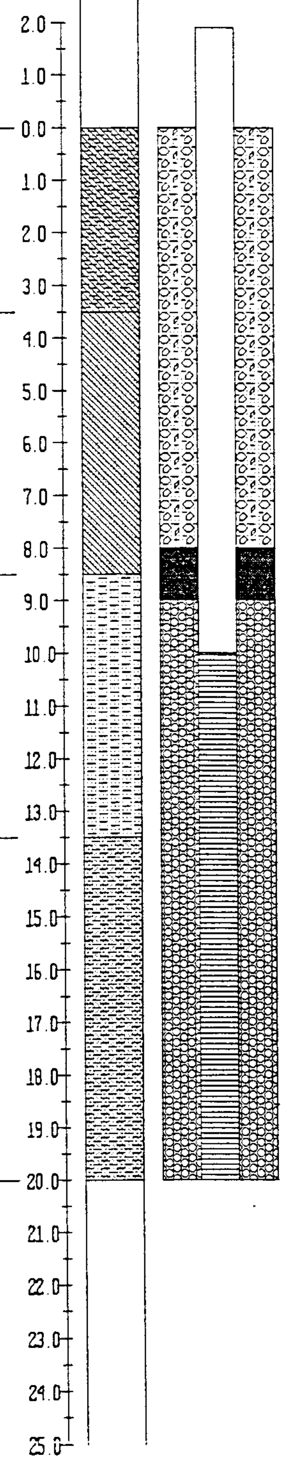
BOREHOLE NUMBER: G-13S

PROJECT NUMBER HALIFAX-5
PROJECT NAME HALIFAX COUNTY
LOCATION HALIFAX, NORTH CAROLINA
DRILLING COMPANY BORE AND CORE
RIG TYPE & NUMBER MOBILE B-53
DRILLING METHOD HOLLOW STEM AUGER
WEATHER CLOUDY, 45 DEGREES
FIELD PARTY L. FOSKEY
GEOLOGIST G. MILLS
DATE BEGUN 11/30/95 DATE COMPLETED 11/30/95

TOP OF CASING ELEVATION 252.34
TOTAL DEPTH 20.0 FT
GROUND SURFACE ELEVATION 249.9
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth (ft) | 8.9 | 8.8 |
| Time | 5:00 PM | 9:05 AM |
| Date | 11/30/95 | 12/1/95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0–3.5 | 4, 7, 4 | Ss | S1 | | | | | SILTY CLAY: Dark brown silty clay with some sand and organics; fill. |
| 3.5–8.5 | 6, 9, 6 | Ss | S2 | D | | 10" | | SANDY CLAY: Orange brown sandy clay; some mica and feldspar and quartz; dry. |
| 8.5–13.5 | 7, 10, 13 | Ss | S3 | M | | 16" | | SANDY SILT: Brown-orange slightly plastic sandy silt; some mica; iron stained; moist. |
| 13.5–20.0 | 13, 16, 18 | Ss | S4 | M | | 16" | | SILTY SAND: Brown-orange silty sand; iron stained; abundant mica; very moist; relict granite . some quartz; relict granite structure; k-spar abundant from 18.5' to 20'. |
| | 16, 23, 30 | Ss | S5 | W | | | | |
| 20.0 | | | | | | | | Boring Terminated at 20 feet. |



# FIELD BOREHOLE LOG

BOREHOLE NUMBER: B-4A

PROJECT NUMBER HALIFAX-5
PROJECT NAME HALIFAX COUNTY
LOCATION HALIFAX, NORTH CAROLINA
DRILLING COMPANY BORE AND CORE
RIG TYPE & NUMBER CME 450
DRILLING METHOD HOLLOW STEM AUGER/MUD ROTARY/NO CORE
WEATHER SUNNY, 55 DEGREES
FIELD PARTY L. FOSKEY
GEOLOGIST G. MILLS
DATE BEGUN 12/15/95 DATE COMPLETED 12/15/95

TOP OF CASING ELEVATION -
TOTAL DEPTH 24.0 FT
GROUND SURFACE ELEVATION 273
SHEET 1 OF 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(ft) | 4.3 | - |
| Time | WD | - |
| Date | 12/15/95 | - |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 0.0–8.5 | | | | | | | | SANDY CLAY: Brown; quite sandy; micaceous coarse quartz sand; shelby tube samples collected at 1.0' and 5.0'; rock ledge at 8.5' to 9.0'. |
| 1.0 | | St | | | | | | |
| 3.0–4.0 | 3 6 5 | Ss | S1 | D | | 12" | | |
| 5.0 | | St | | | | | | |
| 7.0–8.0 | 15 17 19 | Ss | S2 | W | | 14" | | |
| 8.5–16.0 | | | | | | | | SANDY SILT: Sandy silt to silty sand; even mix of sand and silt; brown orange in color; abundant mica; felsic quartz and gravel; drilled with tri-cone mud rotary. |
| 13.0–14.5 | 5 5 7 | Ss | S3 | W | | 14" | | |
| 16.0–24.0 | | | | | | | | SAND: Partially weathered rock; coarse sand; very iron stained; orange with white, gray and tan; abundant mica; |
| 18.0–19.5 | 35 35 21 | Ss | | | | 12" | | |
| 23.0 | 50/0.5 | Ss | S4 | | | 0" | | tri-cone refusal at 24.0 feet. |
| 24.0–27.0 | | | | | | | | GRANITE: NO core run through granite; 3 ft run with 2 ft recovery; casing lost its seal; abandoned hole; offset 5 feet to redrill. |
| 27.0 | | | | | | | | Boring Terminated at 27 feet. |

Depth scale: 2.0, 1.0, 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0, 26.0, 27.0, 28.0, 29.0, 30.0

LITHOLOGY | WELL INSTALLATION

# FIELD BOREHOLE LOG

BOREHOLE NUMBER: B-4D

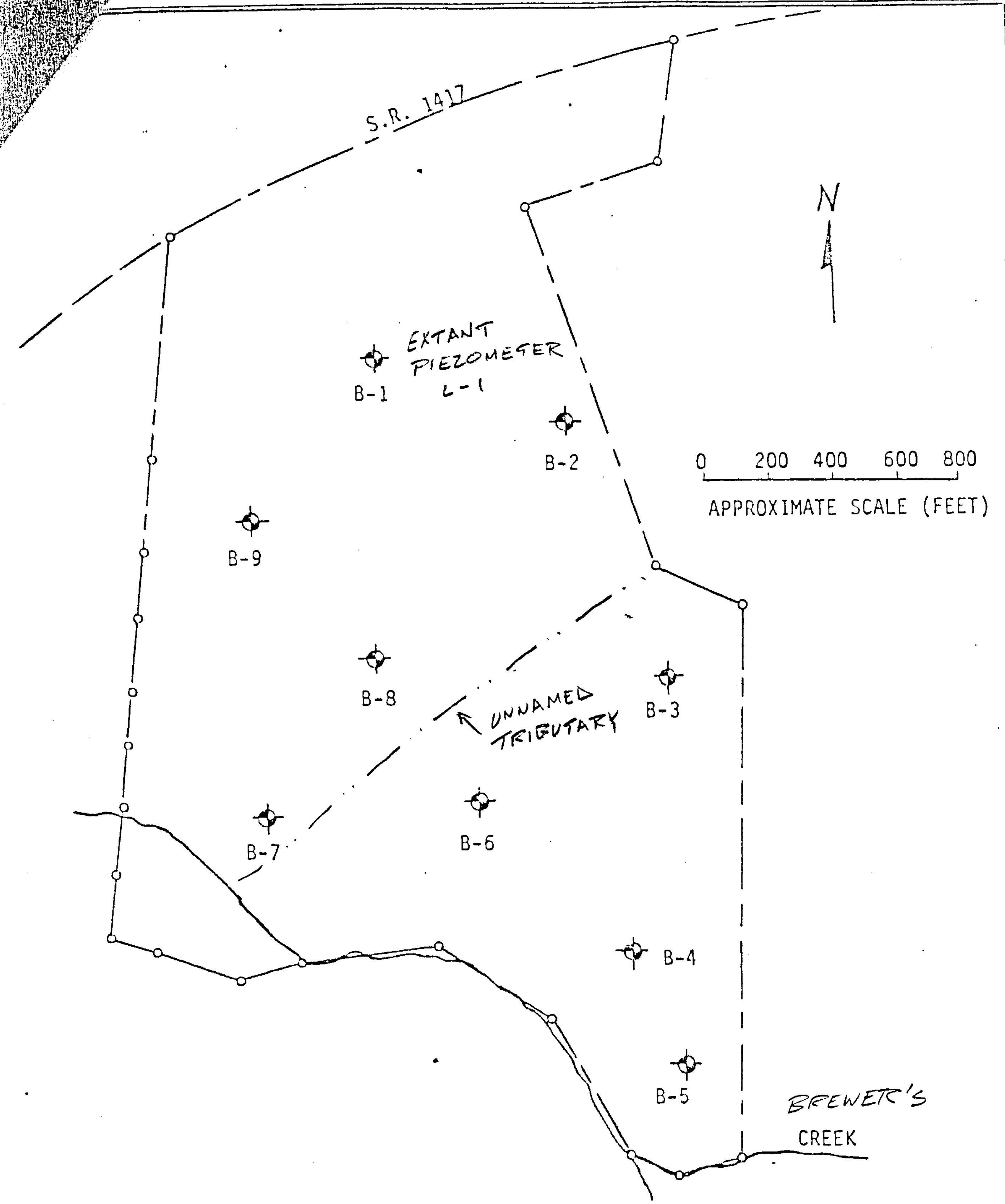
PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER, NO CORE
WEATHER: SUNNY, 30 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/20/95 DATE COMPLETED: 12/21/95

TOP OF CASING ELEVATION: 274.69
TOTAL DEPTH: 28 FT
GROUND SURFACE ELEVATION: 272.6
SHEET: 1 OF: 1

| STATIC WATER LEVEL (BLS) | | |
|---|---|---|
| WD=While Drilling AB=After Boring | | |
| Depth(Ft) | 2.47 | 1.27 |
| Time | - | - |
| Date: | 12-27-95 | 1-24-95 |

| DEPTH | BLOW COUNTS | SAMPLING METHOD | SAMPLE NUMBER | MOISTURE | CONSISTANCY | SAMPLE RECOVERY | DRILL METHOD | LITHOLOGY DESCRIPTION | DEPTH | LITHOLOGY | WELL INSTALLATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0–18.0 | | | | | | | | SANDY SILT: Probed to auger refusal without sampling and cored 10 feet; lithology should be the same as B-4A, drilled 10 feet south; took a U.D. sample from 1 to 3 feet. | 0.0–18.0 | | |
| 18.0–28.0 | | | | | | | | GRANITE: Cored through granite for 10 feet. REC=84% RQD=60% | 18.0–28.0 | | |
| 28.0 | | | | | | | | Boring Terminated at 28 feet. | 28.0 | | |

Depth scale: 2.0, 1.0, 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0, 26.0, 27.0, 28.0, 29.0, 30.0




BORING LOCATION PLAN

HALIFAX COUNTY LANDFILL 42-04

HALIFAX COUNTY, NORTH CAROLINA

LAW ENGINEERING TESTING CO.
RALEIGH, NORTH CAROLINA

| SCALE | Drawn: JRR | Job No. RA-1673 |
|---|---|---|
| AS SHOWN | Checked: JAT | |
| | Date: 2/3/81 | Dwg. No. 2 |

**LAW ENGINEERING TESTING COMPANY**
geotechnical, environmental & construction materials consultants
3301 WINTON ROAD
P.O. BOX 18288 • RALEIGH, NORTH CAROLINA 27619
(919) 876-0416

# RECORD OF AUGER BORING

JOB NO. RA-1673 BORING NO. B-1

| DEPTH - FT. FROM | TO | SOIL DESCRIPTION AND REMARKS | BAG AND JAR SAMPLES NO. | FROM | TO |
|---|---|---|---|---|---|
| 0.0 | 0.3 | Topsoil with grass roots | 1 | 0 | 2' |
| 0.3 | 5½ | Red-tan silty sandy CLAY (CL) | 2 | 2 | 3' |
| 5½ | 16 | Light tan fine to coarse very sandy SILT (ML) | 3 | 3 | 5½' |
| 16 | 35 | Light tan fine sandy SILT, trace coarse sand (ML) | 4 | 5½ | 7' |
| | | (Wet below 25± ft.) | 5 | 7 | 11' |
| | | Boring terminated @ 35.0 ft. | 6 | 11 | 13' |
| | | | 7 | 13 | 16½' |
| | | Piezometer set @ 35± ft. | 8 | 16½ | 23' |
| | | Water level @ 26 ft. after 24 hours (1/28/81) | 9 | 23 | 30' |
| | | | 10 | 30 | 35' |

**LAW ENGINEERING TESTING COMPANY**

geotechnical, environmental & construction materials consultants

3301 WINTON ROAD
P.O. BOX 18288 • RALEIGH, NORTH CAROLINA 27619
(919) 876-0416

## RECORD OF AUGER BORING

JOB NO. RA-1673 BORING NO. B-2

| DEPTH - FT. FROM | TO | SOIL DESCRIPTION AND REMARKS | BAG AND JAR SAMPLES NO. | FROM | TO |
|---|---|---|---|---|---|
| 0.0 | 0.4 | Topsoil with organics | 1 | 0 | 4' |
| 0.4 | 4 | Red silty sandy CLAY (CL/ML) | 2 | 4' | 6' |
| 4 | 7½ | Red-tan slightly clayey sandy SILT (ML) | 3 | 6' | 7½' |
| 7½ | 12½ | Weathered rock fragments and silty SAND | 4 | 7½' | 9' |
| 12½ | 29 | Light tan sandy SILT (ML) | 5 | 9' | 12½' |
| | | (Wet below 22± ft.) | 6 | 12½' | 17' |
| | | Boring terminated @ 29.0 ft. | 7 | 17 | 22½' |
| | | Water level @ 21 ft. after 24 hours (1/28/81) | 8 | 22½' | 29' |

**LAW ENGINEERING TESTING COMPANY**

geotechnical, environmental & construction materials consultants

3301 WINTON ROAD
P.O. BOX 18288 • RALEIGH, NORTH CAROLINA 27619
(919) 876-0416

# RECORD OF AUGER BORING

JOB NO. RA-1673 BORING NO. B-8

| DEPTH - FT. FROM | DEPTH - FT. TO | SOIL DESCRIPTION AND REMARKS | BAG AND JAR SAMPLES NO. | FROM | TO |
|---|---|---|---|---|---|
| 0.0 | 0.6 | Topsoil - Brown SAND with some gravel | 1 | 0 | 4' |
| 0.6 | 4 | Red-tan fine to coarse sandy silty CLAY, trace mica | 2 | 4' | 10' |
| | | some coarse rounded gravel (CL) | 3 | 10' | 15' |
| 4 | 20 | Light tan and gray coarse sandy SILT, trace mica (ML) | 4 | 15' | 20' |
| | | (Wet below 10± ft.) | | | |
| | | Boring terminated @ 20.0 ft. | | | |
| | | Water level @ 11± ft. after 24 hours (1/28/81) | | | |

**LAW ENGINEERING TESTING COMPANY**
geotechnical, environmental & construction materials consultants
3301 WINTON ROAD
P.O. BOX 18288 • RALEIGH, NORTH CAROLINA 27619
(919) 876-0416

# RECORD OF AUGER BORING

JOB NO. RA-1673 BORING NO. B-9

| DEPTH - FT. FROM | TO | SOIL DESCRIPTION AND REMARKS | BAG AND JAR SAMPLES NO. | FROM | TO |
|---|---|---|---|---|---|
| 0.0 | 0.8 | Topsoil with heavy root matter | 1 | 0 | 4½' |
| 0.8 | 4½ | Red-tan sandy very silty CLAY (CL) | 2 | 4½' | 7' |
| 4½ | 15 | Light tan micaceous fine to coarse sandy SILT (ML) | 3 | 7' | 12' |
| | | Boring terminated @ 15.0 ft. | 4 | 12' | 15' |
| | | Piezometer set @ 10 ft. | | | |
| | | Water level @ 6± ft. after 24 hours (1/28/81) | | | |

LAW ENGINEERING TESTING COMPANY
3301 WINTON ROAD
RALEIGH, NORTH CAROLINA
SOIL DATA SUMMARY-JOB NO. RA-1673

| BORING NO. | DEPTH, FEET | SAMPLE TYPE | CLASSIFICATION | UNIT WEIGHT, pcf | | % FINER NO. 200 SIEVE | SPECIFIC GRAVITY | VOID RATIO | NATURAL MOISTURE | ATTERBERG LIMITS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | WET | DRY | | | | | LL | PL | PI |
| B-3 | 0-4.5 | 1 | MH | | | | | | 30.8 | 77 | 42 | 35 |
| B-3 | 7.0-10.5 | 3 | SM | | | 46.8 | | | 25.8 | 43 | 35 | 8 |
| B-4 | 5.0-7.0 | 2 | MH | | | | | | 26.9 | 69 | 38 | 31 |

SS- SPLIT SPOON
UD- UNDISTURBED SAMPLE



472-05

# Appendix E

# *GeoTechnologies, Inc., P.A.*

**3200 Wellington Court, Suite G**
**Raleigh, North Carolina 27615**
**Phone: (919) 954-1514 Fax: (919) 954-1428**

5/20/97

G.N. Richardson & Associates
417 North Boylan Avenue
Raleigh, NC 27603

Attention: Project Manager

Attached for your review are the results of construction material testing performed on the G.N. Richardson & Assoc. Lab Services project which is located in Raleigh, North Carolina.

Very truly yours,

GeoTechnologies, Inc.

R. Sherwood Core, CET
Construction Services Manager

Edward B. Hearn, P.E.
President

Project No. 1-95-0084-CA
RSC-EBH/fgo
Enclosures

c:

GeoTechnologies, Inc.

# PERMEABILITY TEST

| Job Number: | 1-96-0084 CA | Job Name: | G N RICHARDSON | | |
|---|---|---|---|---|---|
| Date: | 5/19/97 | Sample I.D. | BP - 8 | Depth: | |

Soil Description: TAN SANDY SILT

## SAMPLE DATA

| | | | | | |
|---|---|---|---|---|---|
| type | | | standard proctor | | |
| remolded | ( X ) | | Max. Dry Density | 98.1 | lbs/cu.ft. |
| undisturbed | () | | Moisture Content | 24 | % |
| | | | Compaction | 94.7 | % |

| | inches | cm. | | | | |
|---|---|---|---|---|---|---|
| | | | | Moisture Content | 24.4 | % |
| | | | | Wet Density | 115.5 | lbs./cu.ft. |
| Length | 3.013 | 7.653 | | Dry Density | 92.9 | lbs./cu.ft. |
| Diameter | 2.869 | 7.287 | | Initial Saturation | 79.1 | % |
| Area | 6.465 | 41.708 | | Final Saturation | 100.0 | % |
| Volume | 19.478 | 319.191 | | Initial Void Ratio | 0.8 | |
| Wet Mass | 1.302 | 590.64 | grams | Porosity | 45.9 | |
| Dry Mass | 1.0467 | 474.8 | grams | Specific Gravity | 2.75 | apparent |

## TEST DATA

| | | | |
|---|---|---|---|
| | L = | 7.65 cm. | length of sample |
| hi = inflow burette | A = | 41.708 sq.cm. | area of sample |
| ho = outflow burette | a = | 0.852 sq.cm. | area of burettes |
| t = time | h1 = | head loss across specimen at t1 | |
| | h2 = | head loss across specimen at t2 | |

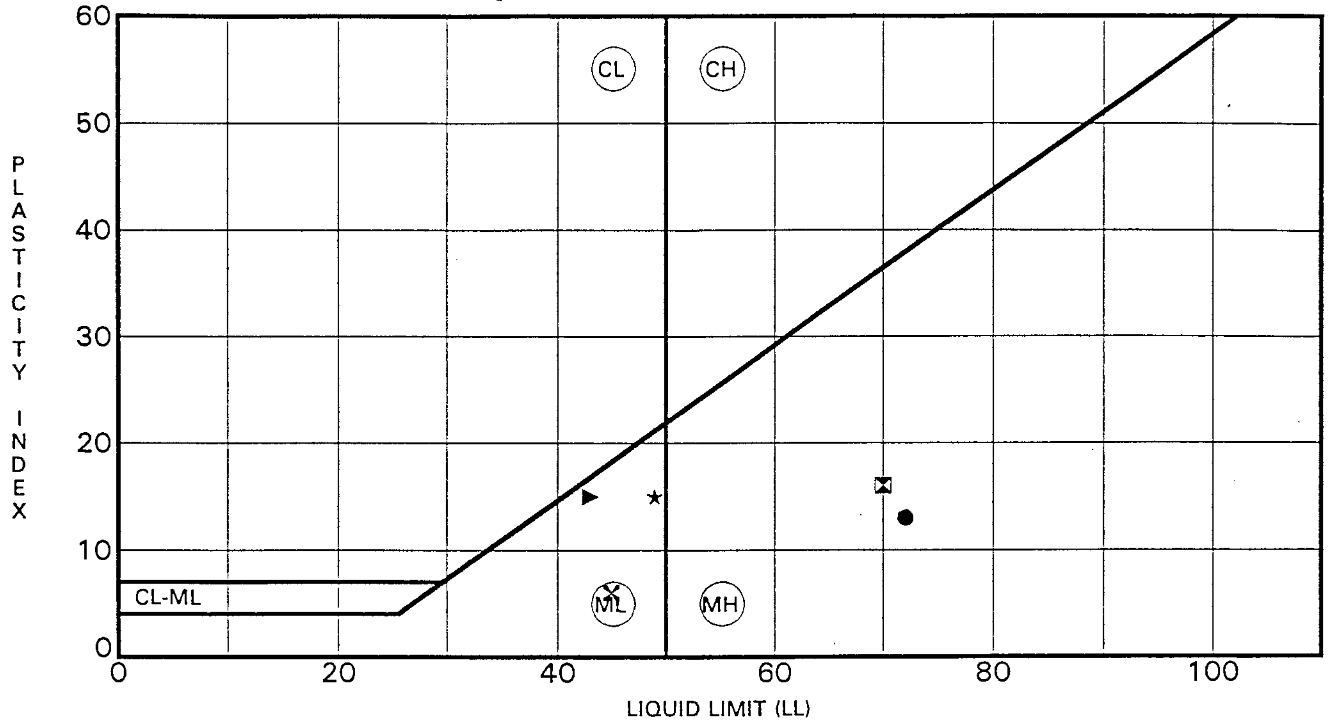
| t1 | t2 | ho1 | hi1 | h1 | ho2 | hi2 | h2 |
|---|---|---|---|---|---|---|---|
| 0 | 2400 | 94 | 0.7 | 93.3 | 93.6 | 1.2 | 92.4 |
| 0 | 3120 | 93.6 | 1.2 | 92.4 | 93 | 1.6 | 91.4 |
| 0 | 2580 | 93 | 1.6 | 91.4 | 92.5 | 2.1 | 90.4 |
| 0 | 4320 | 92.5 | 2.1 | 90.4 | 91.8 | 2.7 | 89.1 |
| | | | | | | | |

ASTM D 5084

k = ((aaL/(At(a+a)))*ln(h1/h2)

| | | |
|---|---|---|
| 1 | k = | 3.16E-07 |
| 2 | k = | 2.73E-07 |
| 3 | k = | 3.33E-07 |
| 4 | k = | 2.62E-07 |

Average k = 2.96E-07 cm/sec




| | Specimen Identification | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|
| ● | BP-12 | 72 | 59 | 13 | | Orange Brown Clayey SILT (MH) |
| ⧗ | BP-13 | 70 | 54 | 16 | | Light Green Yellow Sandy SILT (MH) |
| ▶ | BP-7 | 43 | 28 | 15 | | Light Brown Fine Sandy Slightly Clayey SILT (ML) |
| ★ | BP-8 | 49 | 34 | 15 | | Orange Brown Slightly Clayey SILT (ML) |
| ✕ | BP-9 | 45 | 39 | 6 | | Tan Brown Sandy SILT (ML) |

PROJECT G.N. Richardson & Associates Lab Services - Raleigh, North Carolina

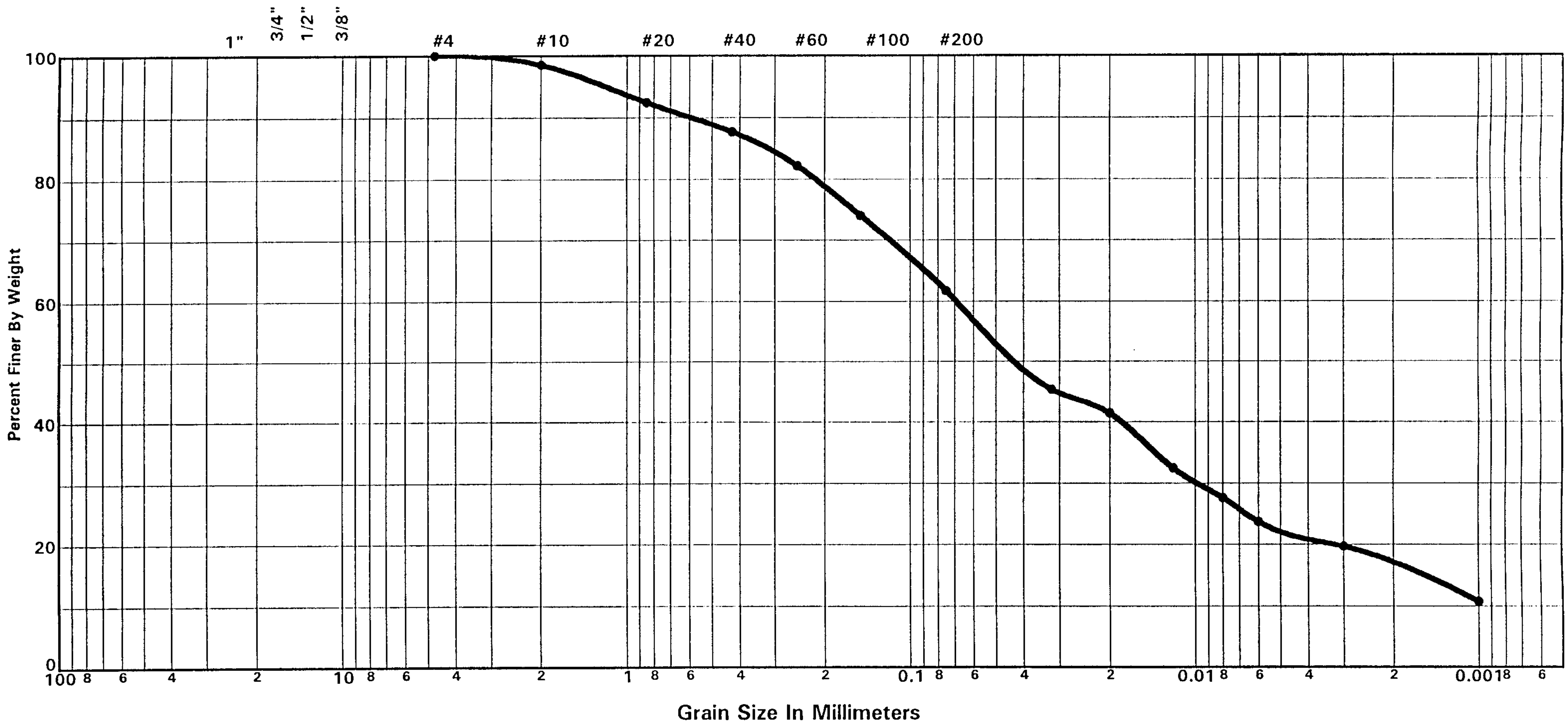
JOB NO. 1-95-0084 CA

DATE 5/19/97

# ATTERBERG LIMITS' RESULTS

GeoTechnologies, Inc.

Raleigh, North Carolina




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP-7 | | | | | | Mustard Yellow Slightly Sandy SILT |

**Project:**

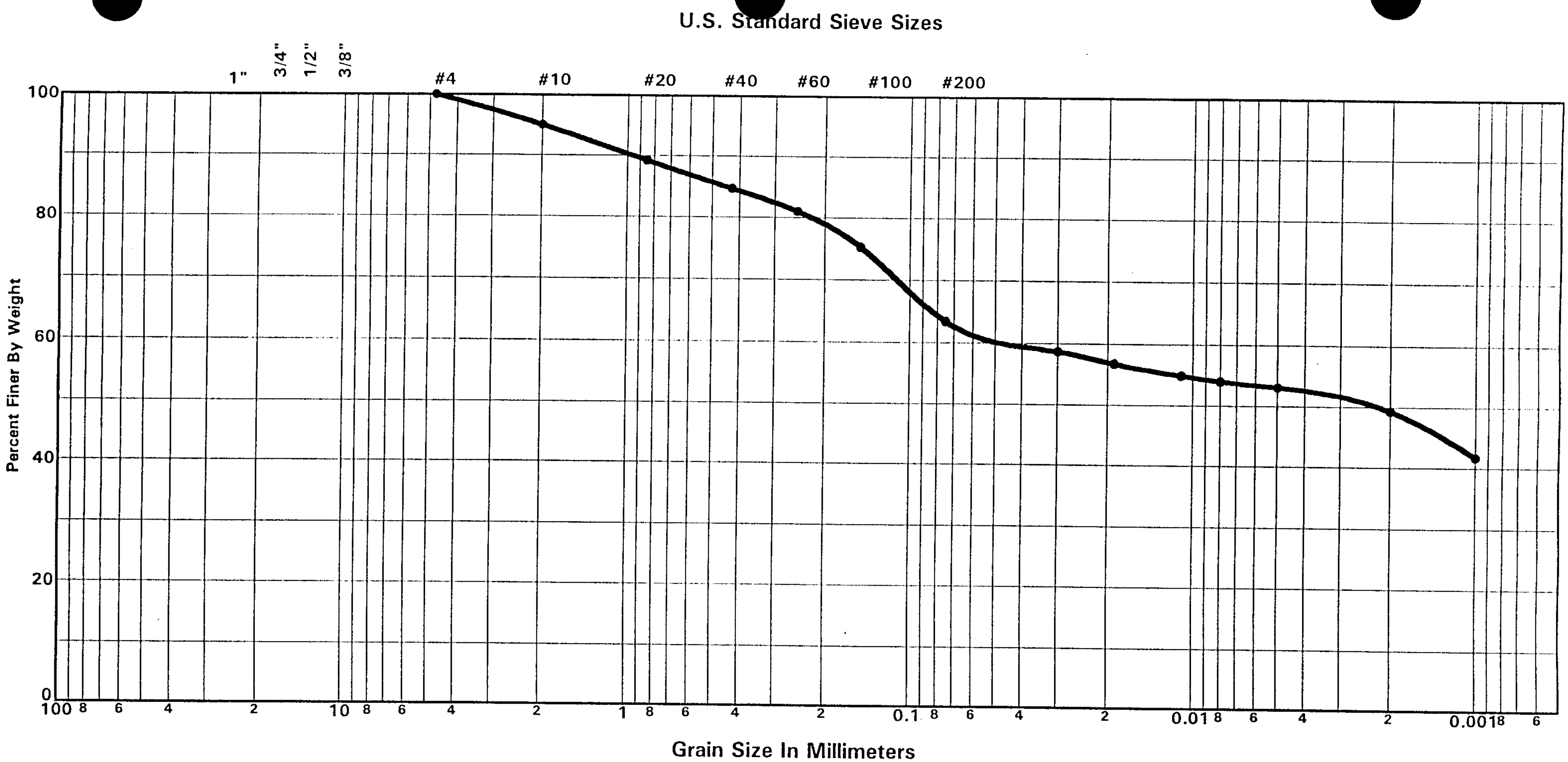
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

**Job No.:** 1-95-0084 CA

**Date:** 5/19/97

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP-8 | | | | | | Tan Sandy SILT |

**Project:**

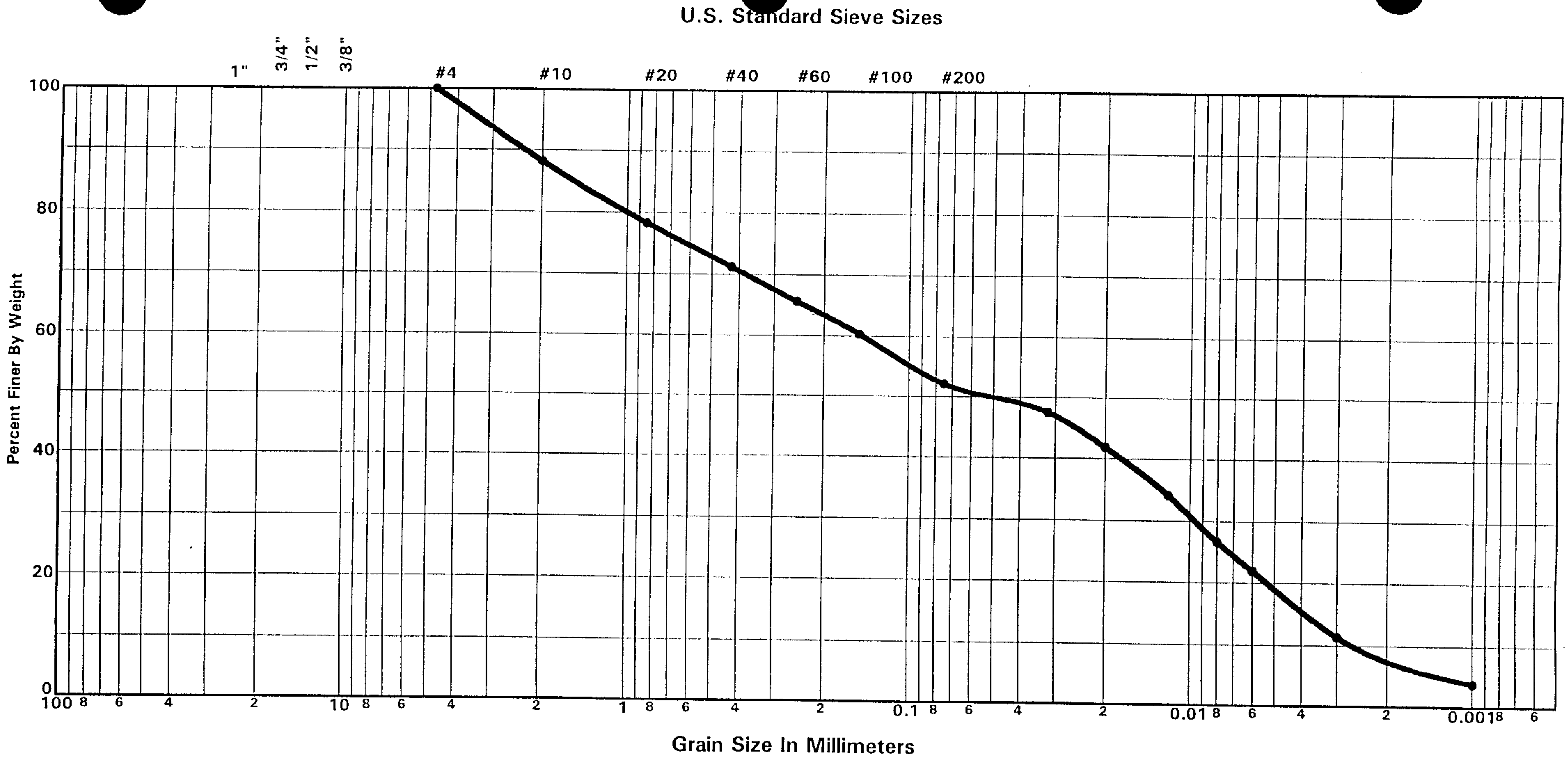
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

**Job No.:** 1-95-0084 CA

**Date:** 5/19/97

## GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP-9 | | | | | | Micaceous Sandy SILT |

**Project:**

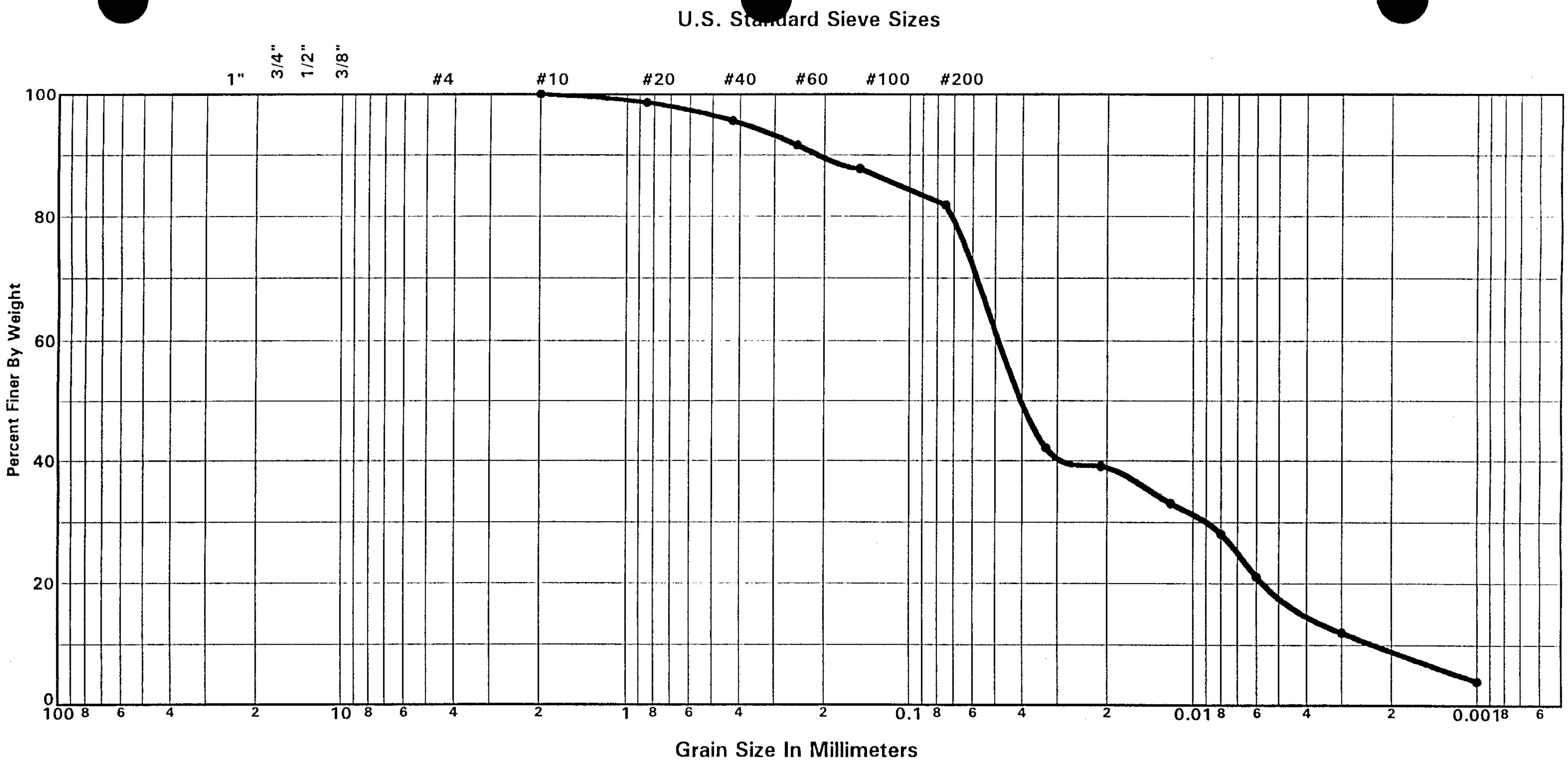
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

**Job No.:** 1-95-0084 CA

**Date:** 5/19/97

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP-12 | | | | | | Light Yellow Slightly Sandy SILT |

**Project:**

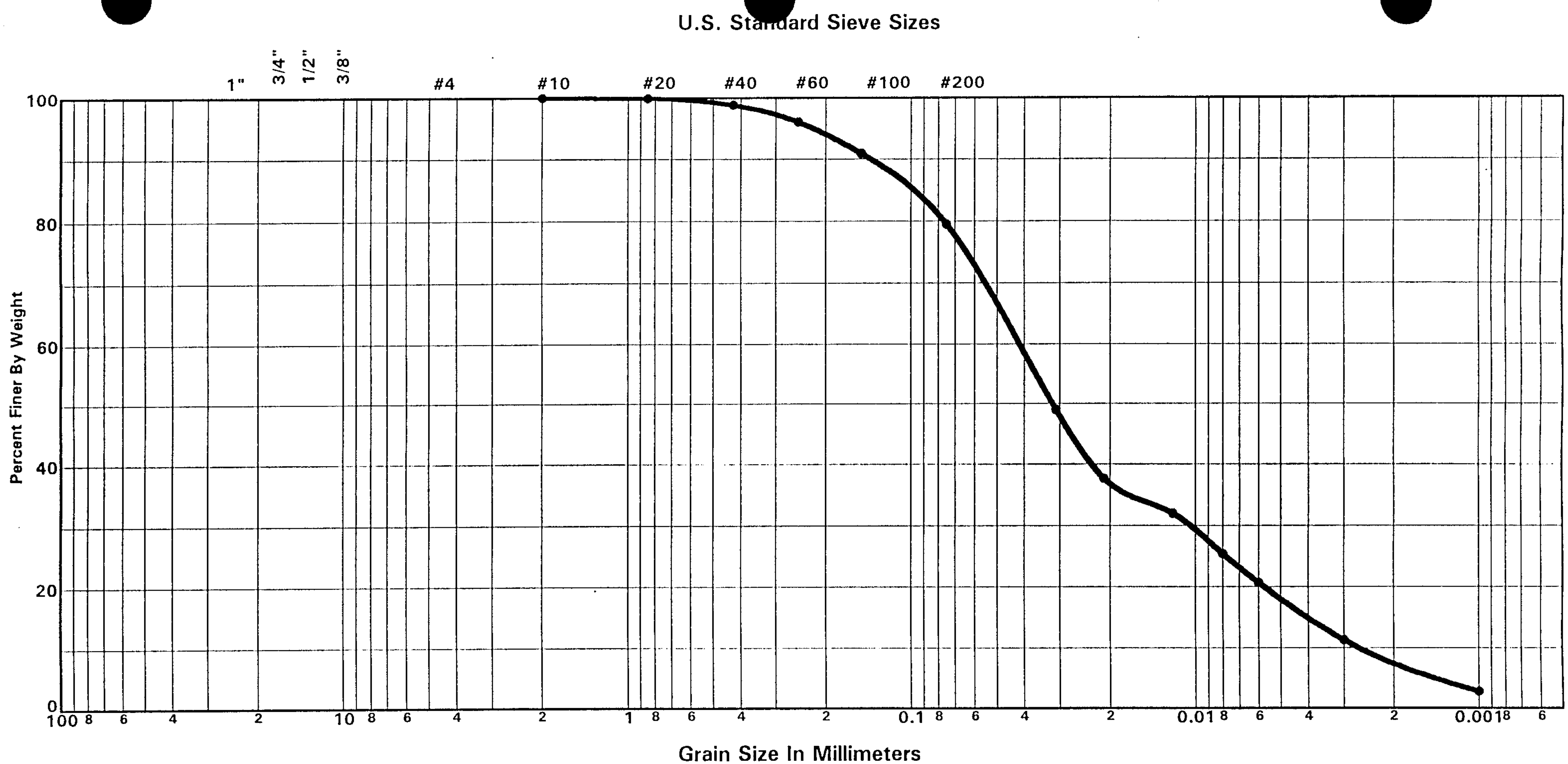
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

**Job No.:** 1-95-0084 CA

**Date:** 5/19/97

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP-13 | | | | | | Yellow Slightly Sandy SILT |

**Project:**

G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

**Job No.:** 1-95-0084 CA

**Date:** 5/19/97

## GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

GeoTechnologies, Inc.

Job No: 1-95-0084 CA Date: 5/19/97

Job Name: G.N. Richardson & Associates Lab Services

Job Location: Raleigh, North Carolina

Boring No:

Sample No: BP-8

Depth:

## TEST RESULTS

Method of Test: ASTM D 698

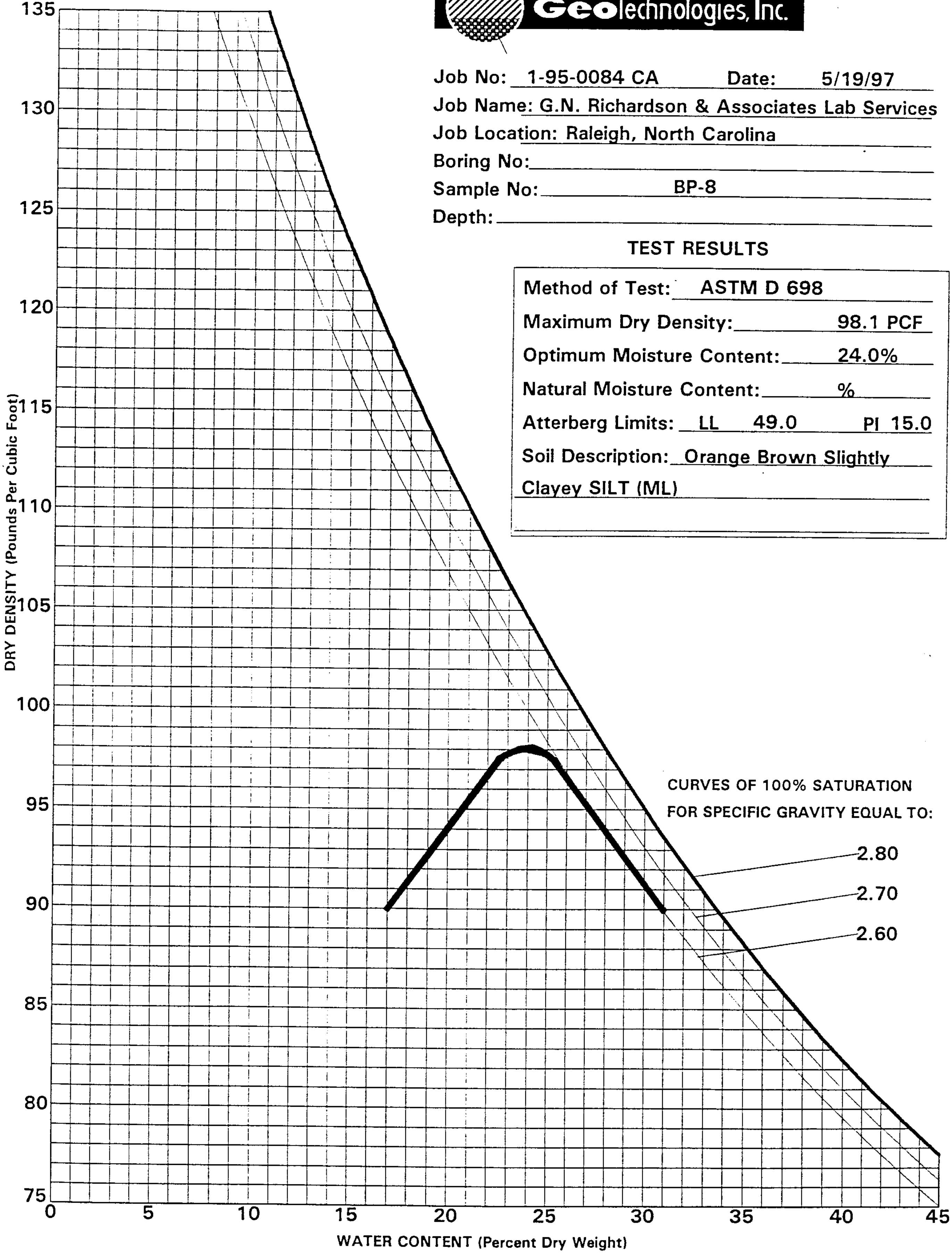
Maximum Dry Density: 98.1 PCF

Optimum Moisture Content: 24.0%

Natural Moisture Content: %

Atterberg Limits: LL 49.0 PI 15.0

Soil Description: Orange Brown Slightly Clayey SILT (ML)




# MOISTURE-DENSITY RELATIONSHIP

GeoTechnologies, Inc.

Raleigh, North Carolina

...ologies, Inc.

# MOISTURE CONTENT DATA SHEET

...b #: 1-95-0084 CA Job Name: G.N. Richardson

Date:

| | Sample I.D. | Tare # | Tare Wt | Wet Wt + Tare | Dry Wt + Tare | Water Wt [illegible] | Dry Wt [illegible] | Moisture Content [illegible] |
|---|---|---|---|---|---|---|---|---|
| 1 | BP-7 | TRI | 100.71 | 326.97 | 266.23 | 60.74 | 165.52 | 36.7 |
| 2 | BP-12 | J-6 | 106.53 | 260.53 | 196.05 | 64.48 | 89.52 | 72.0 |
| 3 | BP-9 | URG | 100.83 | 332.78 | 276.84 | 55.94 | 176.01 | 31.8 |
| 4 | BP-13 | PET | 100.58 | 263.80 | 204.04 | 59.76 | 103.46 | 57.8 |
| 5 | BP-8 | JAR | 97.86 | 369.74 | 315.20 | 54.54 | 217.34 | 25.1 |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |
| 12 | | | | | | | | |
| 13 | | | | | | | | |
| 14 | | | | | | | | |
| 15 | | | | | | | | |
| 16 | | | | | | | | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| 21 | | | | | | | | |
| 22 | | | | | | | | |
| 23 | | | | | | | | |
| 24 | | | | | | | | |
| 25 | | | | | | | | |
| 26 | | | | | | | | |
| 27 | | | | | | | | |
| 28 | | | | | | | | |
| 29 | | | | | | | | |
| 30 | | | | | | | | |
| 31 | | | | | | | | |
| 32 | | | | | | | | |
| 33 | | | | | | | | |
| 34 | | | | | | | | |
| 35 | | | | | | | | |

GeoTechnologies, Inc.

3200 Wellington Court, Suite G
Raleigh, North Carolina 27615
919-954-1514
Fax 919-954-1428

January 3, 1996

JAN 10 1996

G.N. Richardson & Associates
317 North Boylan Avenue
Raleigh, NC 27603

Attention: Mr. Gregg Richardson

Reference: Natural Moisture, Atterberg Limits, & Permeability Test Results
Halifax - 6
Halifax, North Carolina
GeoTechnologies Project No. 1-95-1181-CA

Gentlemen:

GeoTechnologies, Inc. has completed laboratory testing on the two samples received in our laboratory on December 14, 1995. As requested, natural moisture, Atterberg limits, sieve analysis, and permeability (remolded) tests were performed. Presented in the following attachment are results of the tests.

GeoTechnologies, Inc. appreciates the opportunity to have provided you with our services on this phase of the project. Please contact us if you should have questions regarding this information or if we may be of any further assistance.

Very truly yours,

GeoTechnologies, Inc.

R. Sherwood Core, CET
Construction Services Manager

Edward B. Hearn, P.E.
President

RSC/fgo
Attachments

GeoTechnologies, Inc.

# PERMEABILITY TEST

**Job Number:** 1-95-1181 CA **Job Name:** HALIFAX - 6

**Date:** 12/23/95 **Sample I.D.** BP 3 **Depth:** 3-5'

**Soil Description:** ORANGE BROWN SILTY SAND

## SAMPLE DATA

**type**
remolded ( )
undisturbed ( X )

standard proctor

| | | |
|---|---|---|
| Max. Dry Density | 107.5 | lbs/cu.ft. |
| Moisture Content | 19 | % |
| Compaction | 95.4 | % |

| | inches | cm. | | | | |
|---|---|---|---|---|---|---|
| | | | | Moisture Content | **22** | % |
| | | | | Wet Density | **125.1** | lbs./cu.ft. |
| Length | **2.861** | **7.267** | | Dry Density | **102.5** | lbs./cu.ft. |
| Diameter | **2.852** | **7.244** | | Initial Saturation | **89.7** | % |
| Area | **6.388** | **41.214** | | Final Saturation | **100.0** | % |
| Volume | **18.277** | **299.504** | | Initial Void Ratio | **0.7** | |
| Wet Mass | **1.323** | **600.16** | grams | Porosity | **40.3** | % |
| Dry Mass | **1.0845** | **491.9** | grams | Specific Gravity | **2.75** | apparent |

## TEST DATA

| | | | |
|---|---|---|---|
| | L = | 7.27 cm. | length of sample |
| hi = inflow burette | A = | 41.214 sq.cm. | area of sample |
| ho = outflow burette | a = | 0.852 sq.cm. | area of burettes |
| t = time | h1 = | head loss across specimen at t1 | |
| | h2 = | head loss across specimen at t2 | |

| t1 | t2 | ho1 | hi1 | h1 | ho2 | hi2 | h2 |
|---|---|---|---|---|---|---|---|
| 0 | **5460** | 94.3 | 1.5 | **92.8** | 94.1 | 1.6 | **92.5** |
| 0 | **3900** | 94.1 | 1.6 | **92.5** | 94 | 1.7 | **92.3** |
| 0 | **4440** | 94 | 1.7 | **92.3** | 93.9 | 1.8 | **92.1** |
| | **74400** | 93.9 | 1.8 | **92.1** | 92.3 | 3.4 | **88.9** |
| | | | | | | | |

**ASTM D 5084**

**k = ((aaL/(At(a+a)))*ln(h1/h2)**

| | | |
|---|---|---|
| 1 | k = | 4.45E-08 |
| 2 | k = | 4.17E-08 |
| 3 | k = | 3.67E-08 |
| 4 | k = | 3.57E-08 |

**Average** **k=** **3.97E-08** cm/sec

GeoTechnologies, Inc.

# PERMEABILITY TEST

| Job Number: | 1-95-1181 CA | Job Name: | HALIFAX - 6 | | |
|---|---|---|---|---|---|
| Date: | 12/23/95 | Sample I.D. | BP 6 | Depth: | 15' |

**Soil Description:** RED ORANGE SANDY SILT

## SAMPLE DATA

| | | | | |
|---|---|---|---|---|
| **type** | | standard proctor | | |
| remolded | ( ) | Max. Dry Density | 102.6 | lbs/cu.ft. |
| undisturbed | ( X ) | Moisture Content | 21.5 | % |
| | | Compaction | 95.1 | % |

| | inches | cm. | | | | |
|---|---|---|---|---|---|---|
| | | | | Moisture Content | **24.5** | % |
| | | | | Wet Density | **121.5** | lbs./cu.ft. |
| Length | **2.936** | **7.457** | | Dry Density | **97.6** | lbs./cu.ft. |
| Diameter | **2.863** | **7.272** | | Initial Saturation | **88.8** | % |
| Area | **6.438** | **41.534** | | Final Saturation | **100.0** | % |
| Volume | **18.901** | **309.735** | | Initial Void Ratio | **0.8** | |
| Wet Mass | **1.329** | **602.85** | grams | Porosity | **43.2** | % |
| Dry Mass | **1.0675** | **484.2** | grams | Specific Gravity | **2.75** | apparent |

## TEST DATA

hi = inflow burette

ho = outflow burette

t = time

L = 7.46 cm. length of sample

A = 41.534 sq.cm. area of sample

a = 0.852 sq.cm. area of burettes

h1 = head loss across specimen at t1

h2 = head loss across specimen at t2

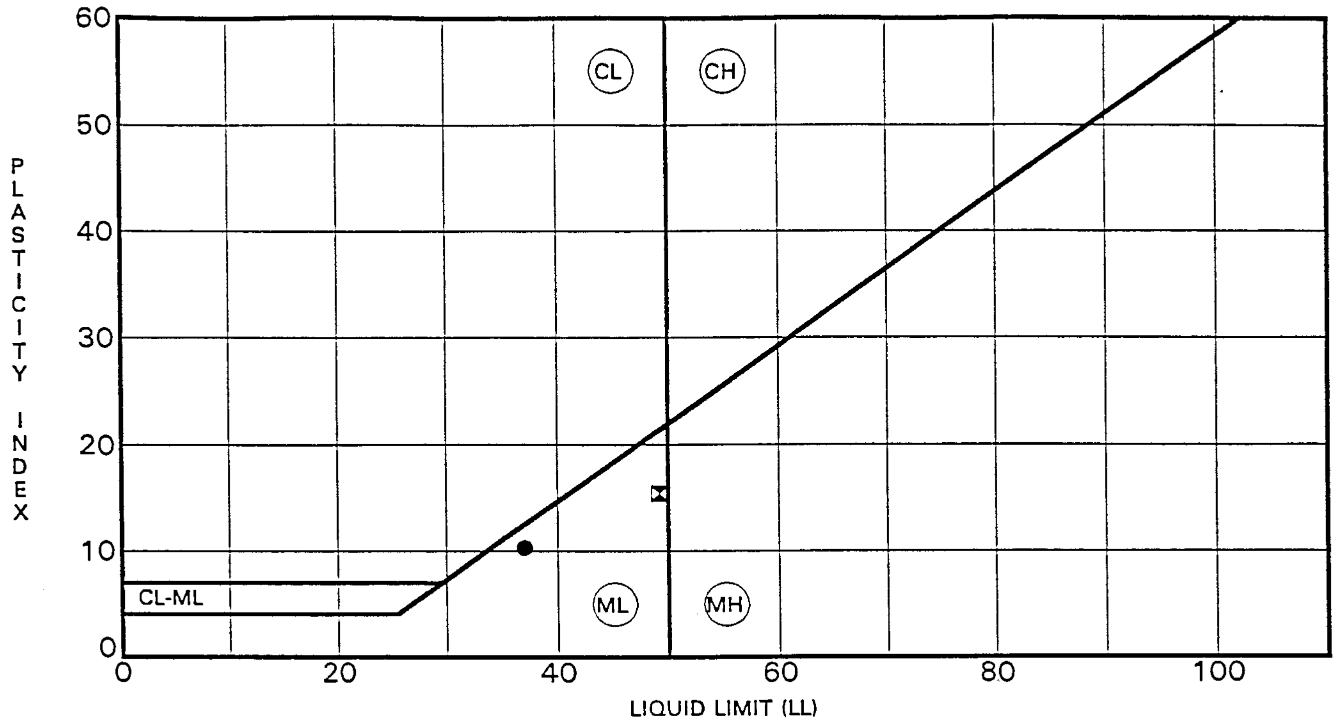
| t1 | t2 | ho1 | hi1 | h1 | ho2 | hi2 | h2 |
|---|---|---|---|---|---|---|---|
| 0 | **5700** | 93.9 | 0.9 | **93** | 93.4 | 1.4 | **92** |
| 0 | **3900** | 93.4 | 1.4 | **92** | 93.1 | 1.8 | **91.3** |
| 0 | **4500** | 93.1 | 1.8 | **91.3** | 92.7 | 2.1 | **90.6** |
| | **74400** | 92.7 | 2.1 | **90.6** | 86.5 | 8.5 | **78** |
| | | | | | | | |

**ASTM D 5084**

**k = ((aaL/(At(a+a)))*ln(h1/h2)**

| | | |
|---|---|---|
| 1 | k = | 1.45E-07 |
| 2 | k = | 1.50E-07 |
| 3 | k = | 1.31E-07 |
| 4 | k = | 1.54E-07 |

**Average** k= **1.45E-07** cm/sec



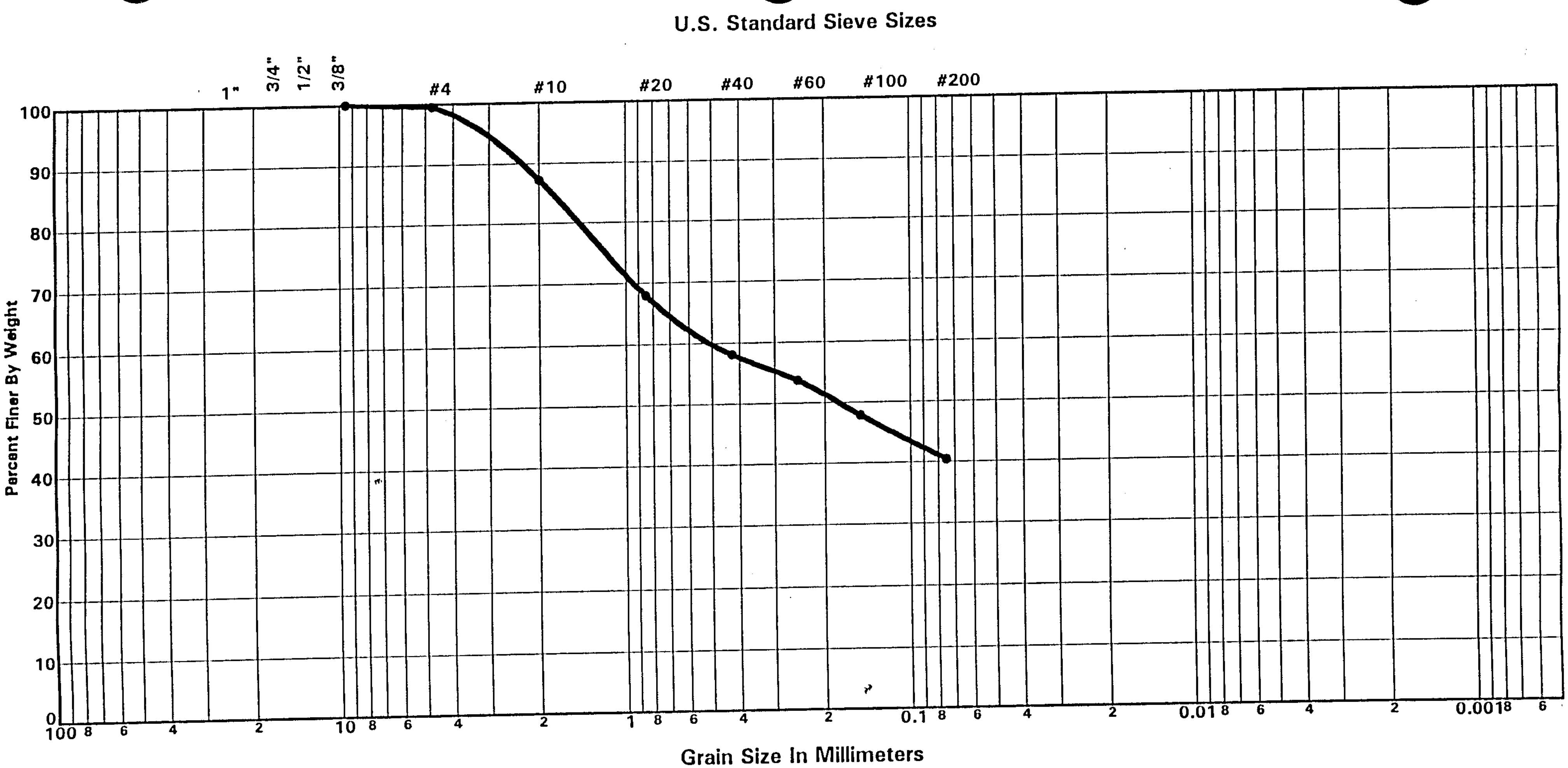

| Specimen Identification | | | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | BP #3 | 3.0-5.0' | 37 | 27 | 10 | 40.4 | Brown-Orange Silty SAND (SM) |
| ⧗ | BP #6 | 15.0' | 49 | 34 | 15 | 52.8 | Red Orange Sandy SILT (ML) |

PROJECT Halifax-6 - Halifax, North Carolina

JOB NO. 1-95-1181-CA
DATE 1/2/96

# ATTERBERG LIMITS' RESULTS

Geotechnologies, Inc.
Raleigh, North Carolina




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP #3 | 3.0-5.0' | 13.8 | 37.1 | 26.8 | 10.3 | Brown-Orange Silty SAND (SM) |

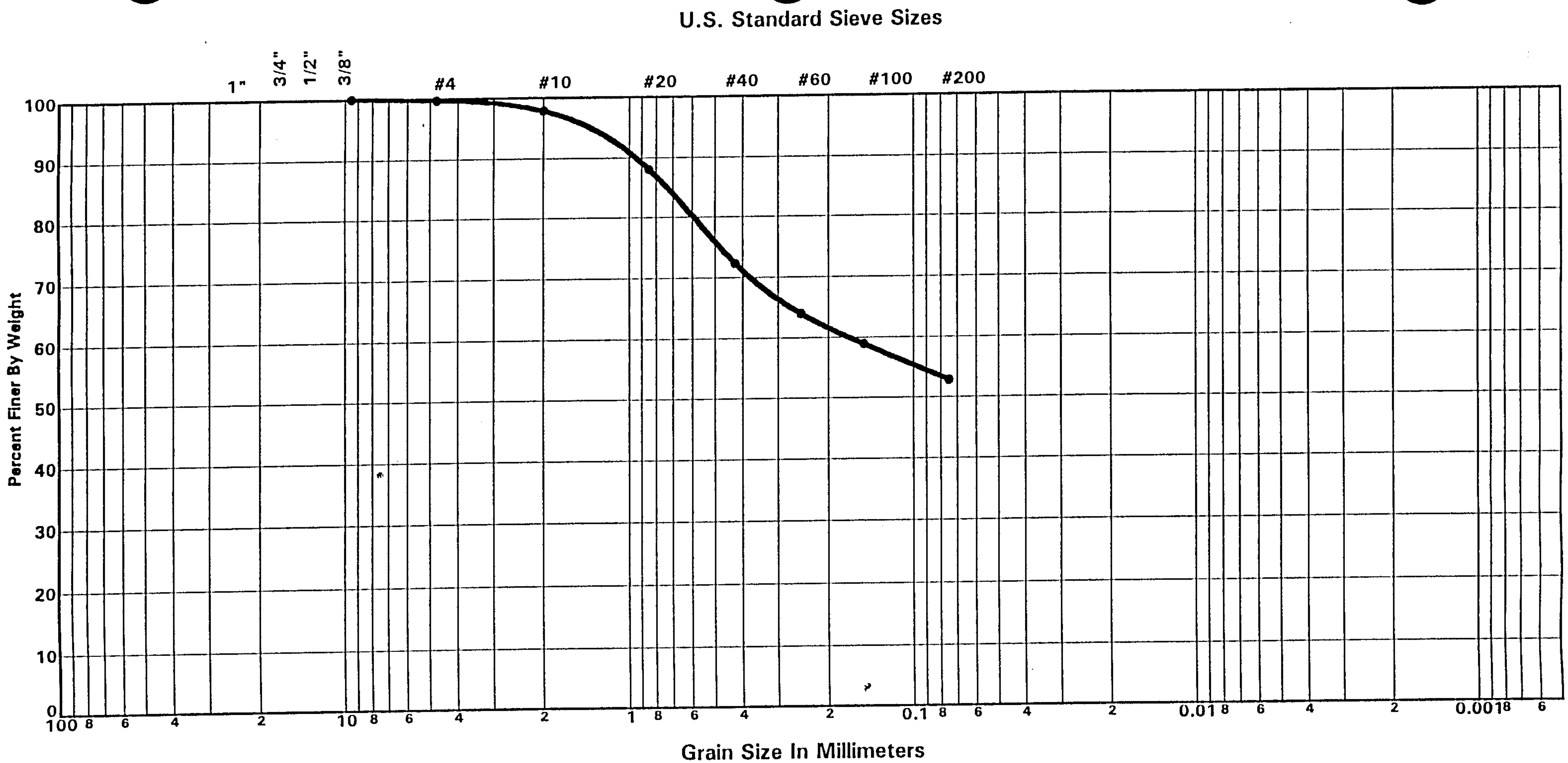
**Project:**
Halifax-6
Halifax, North Carolina

**Job No.:** 1-95-1181-CA

**Date:** 1/2/96

## GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP #6 | 15.0' | 34.2 | 49.3 | 33.9 | 15.4 | Red Orange Sandy SILT (ML) |

**Project:**
Halifax-6
Halifax, North Carolina

**Job No.:** 1-95-1181-CA

**Date:** 1/2/96

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

GeoTechnologies, Inc.

Job No: 1-95-1181-CA Date: 1/2/96

Job Name: Halifax-6

Job Location: Halifax, North Carolina

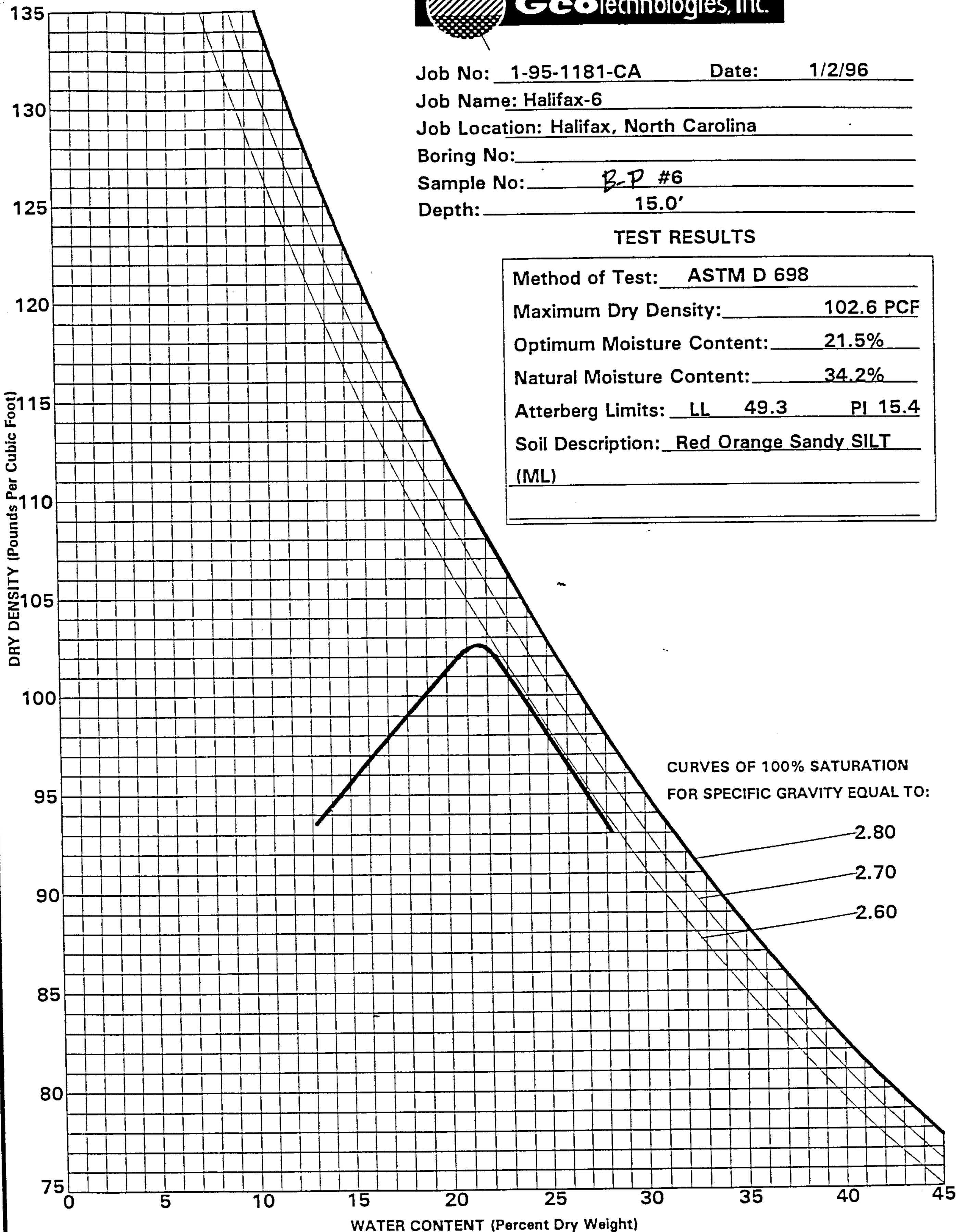
Boring No:

Sample No: B-P #6

Depth: 15.0'

## TEST RESULTS

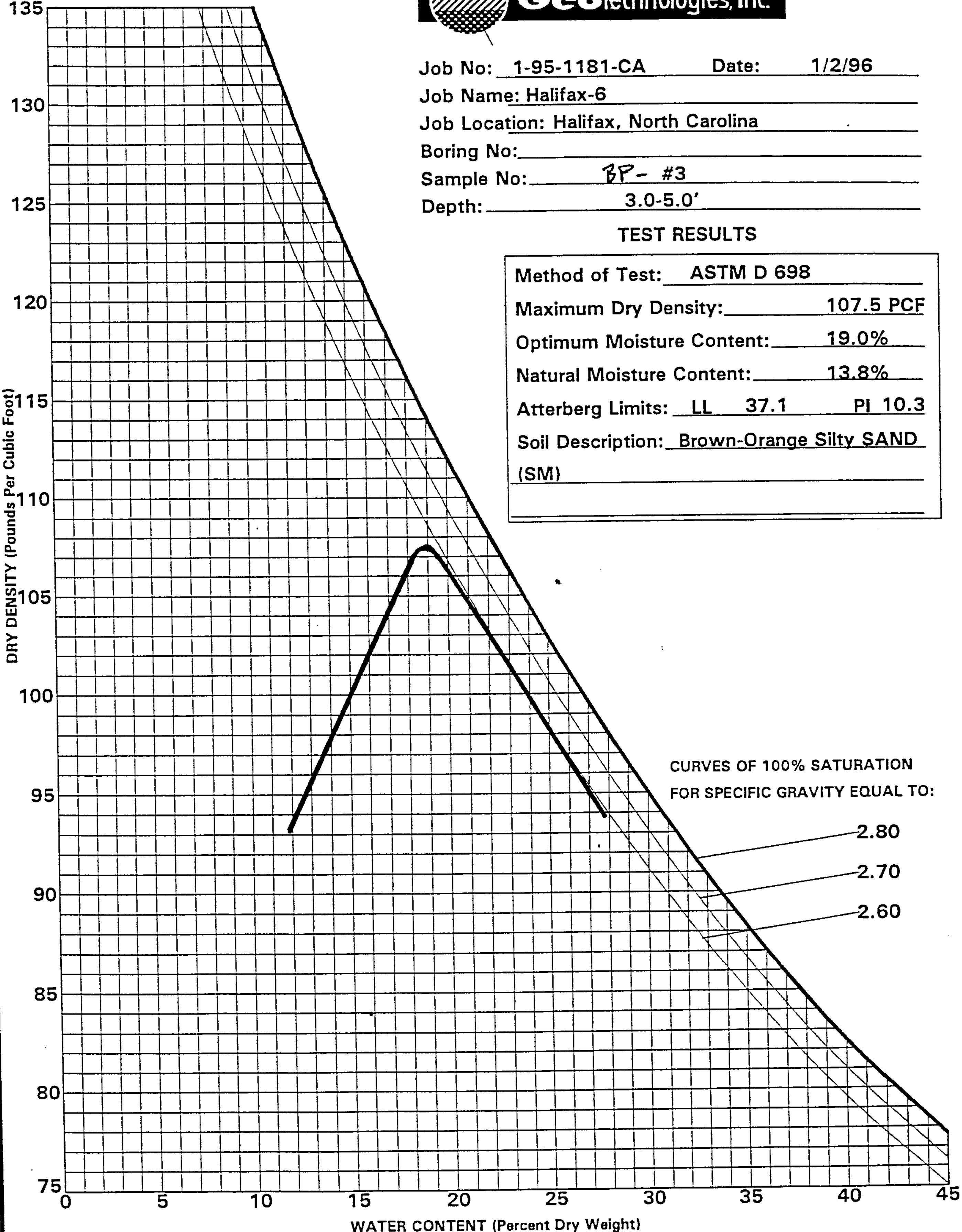
| | |
|---|---|
| Method of Test: | ASTM D 698 |
| Maximum Dry Density: | 102.6 PCF |
| Optimum Moisture Content: | 21.5% |
| Natural Moisture Content: | 34.2% |
| Atterberg Limits: | LL 49.3 PI 15.4 |
| Soil Description: | Red Orange Sandy SILT (ML) |




# MOISTURE-DENSITY RELATIONSHIP

Geotechnologies, Inc.

Raleigh, North Carolina




**GeoTechnologies, Inc.**

Job No: 1-95-1181-CA Date: 1/2/96

Job Name: Halifax-6

Job Location: Halifax, North Carolina

Boring No:

Sample No: BP- #3

Depth: 3.0-5.0'

TEST RESULTS

Method of Test: ASTM D 698

Maximum Dry Density: 107.5 PCF

Optimum Moisture Content: 19.0%

Natural Moisture Content: 13.8%

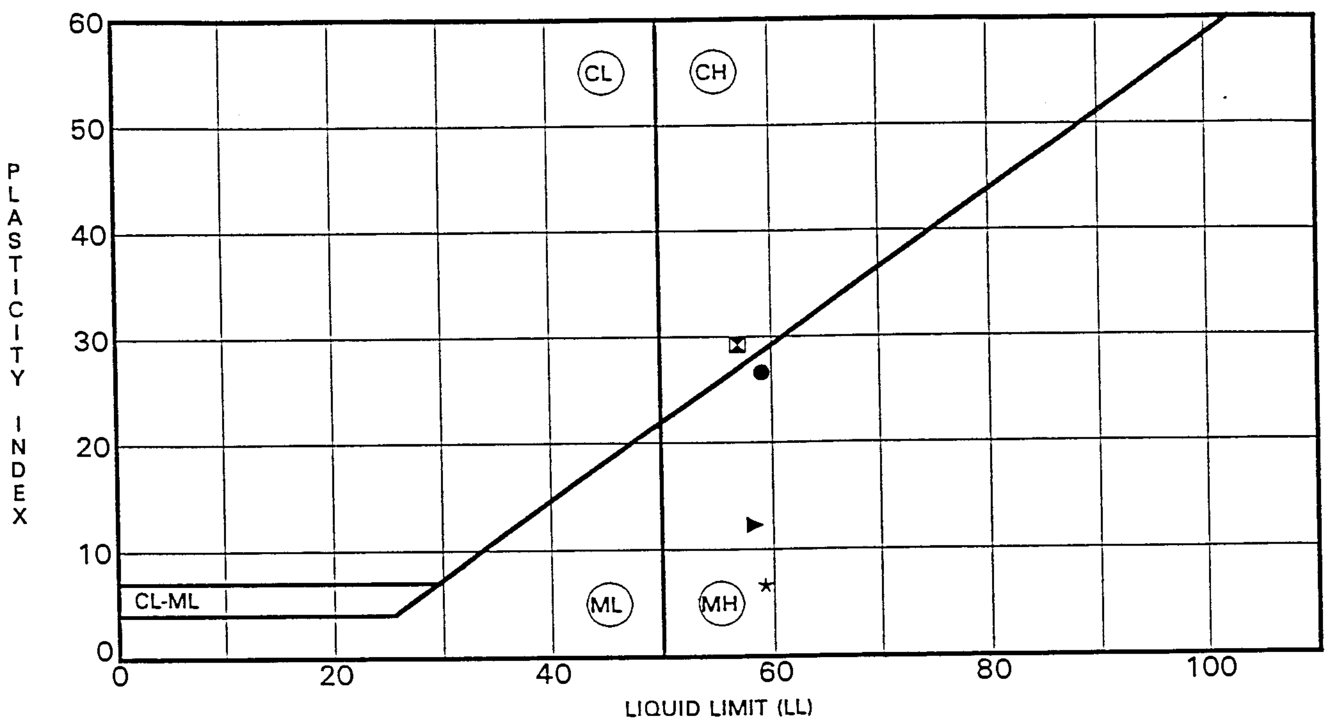
Atterberg Limits: LL 37.1 PI 10.3

Soil Description: Brown-Orange Silty SAND (SM)

# MOISTURE-DENSITY RELATIONSHIP

Geotechnologies, Inc.

Raleigh, North Carolina



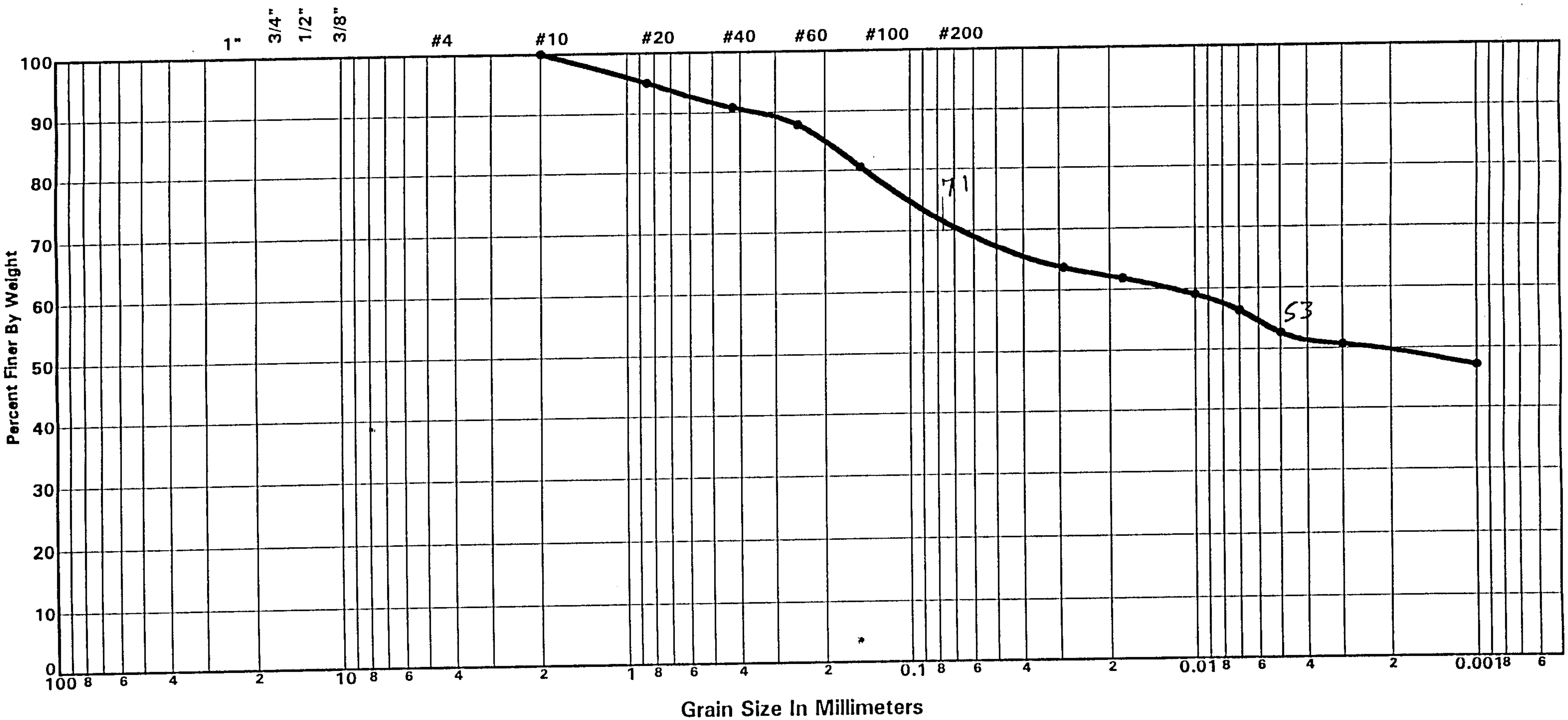

| | Specimen Identification | | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | BP #1 - 1 | 0-1.5' | 59 | 33 | 27 | | Tan Slightly Sandy CLAY (MH) |
| ⧗ | BP #2 - 1 | 0-1.5' | 57 | 28 | 29 | | Tan-Orange Slightly Sandy CLAY (CH) |
| ▶ | BP #6-1 | 0-1.5' | 58 | 46 | 12 | | Brown Orange Slightly Fine Sandy SILT (MH) |
| ★ | BP #6-2 | 3.5-5.0' | 59 | 53 | 7 | | Brown Micaceous Slightly Clayey SILT (MH) |

PROJECT Halifax-6 - Halifax, North Carolina

JOB NO. 1-95-1181-CA
DATE 1/2/96

# ATTERBERG LIMITS' RESULTS

Geotechnologies, Inc.
Raleigh, North Carolina




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP #1 | 0-1.5' | | 59.1 | 32.5 | 26.6 | Tan Slightly Sandy CLAY (MH) |

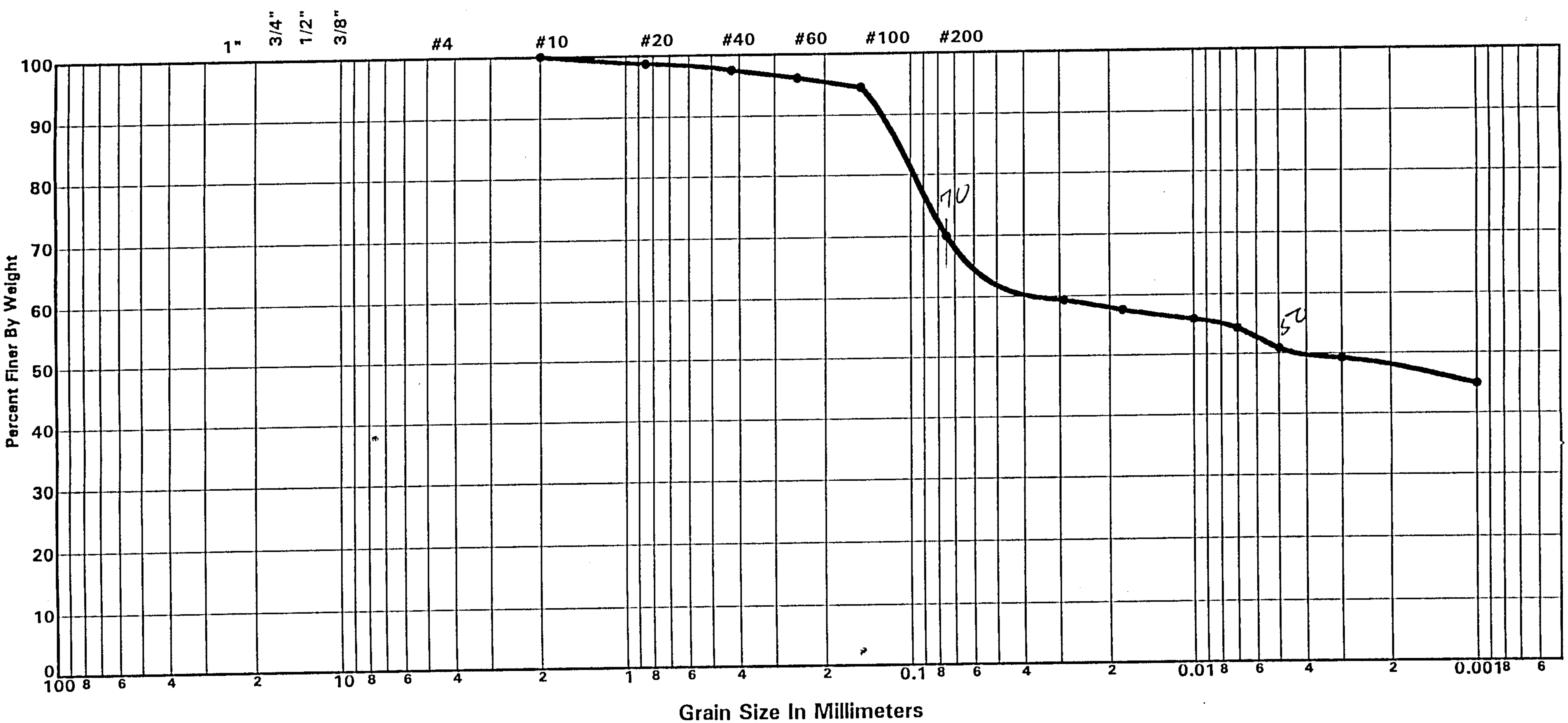
**Project:**
Halifax-6
Halifax, North Carolina

**Job No.:** 1-95-1181-CA

**Date:** 1/4/96

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP #2 | 0-1.5' | | 57.0 | 27.8 | 29.2 | Tan-Orange Slightly Sandy CLAY (CH) |

**Project:**
Halifax-6
Halifax, North Carolina

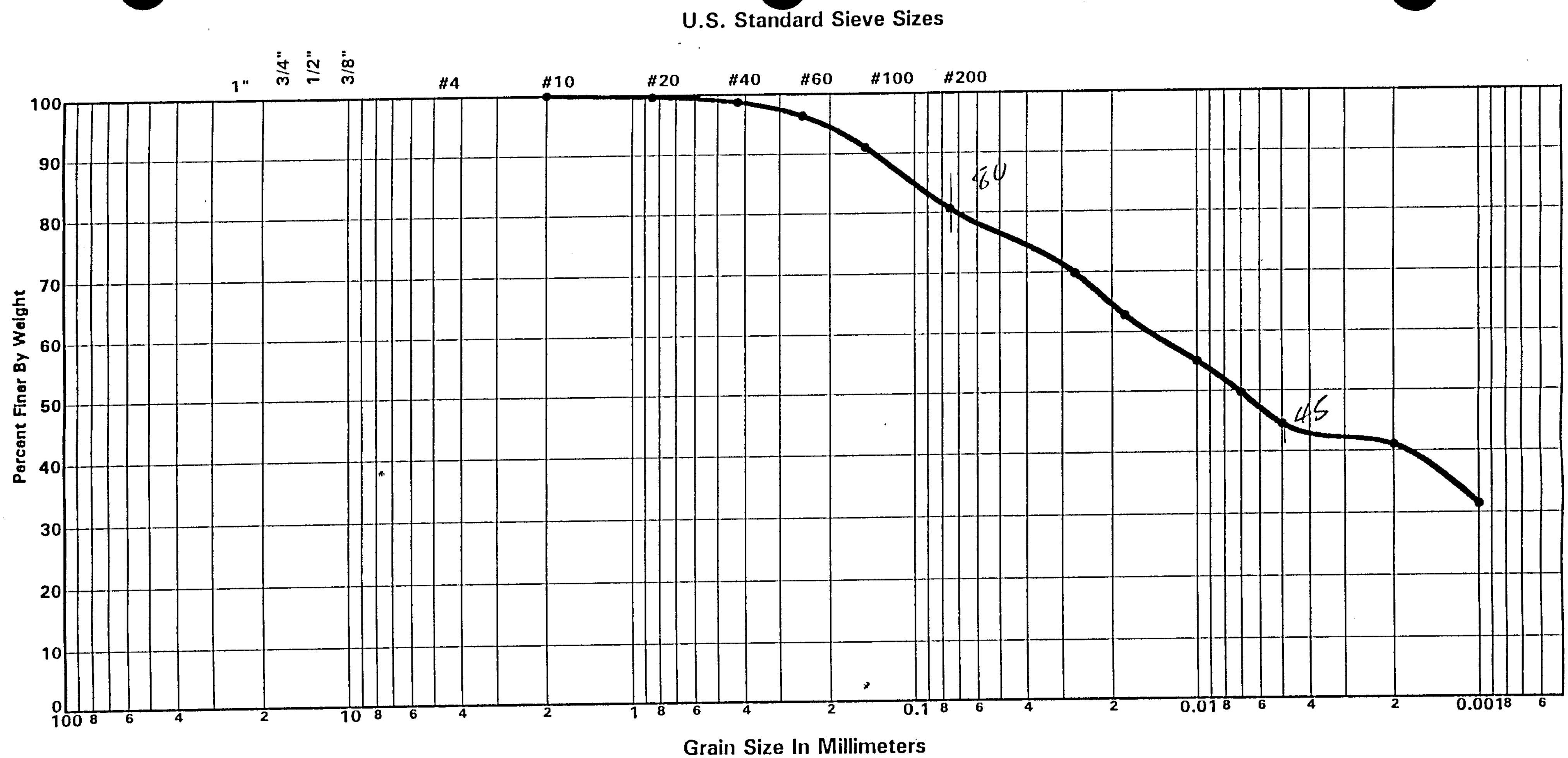
**Job No.:** 1-95-1181-CA

**Date:** 1/2/96

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

# GRAIN SIZE DISTRIBUTION




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

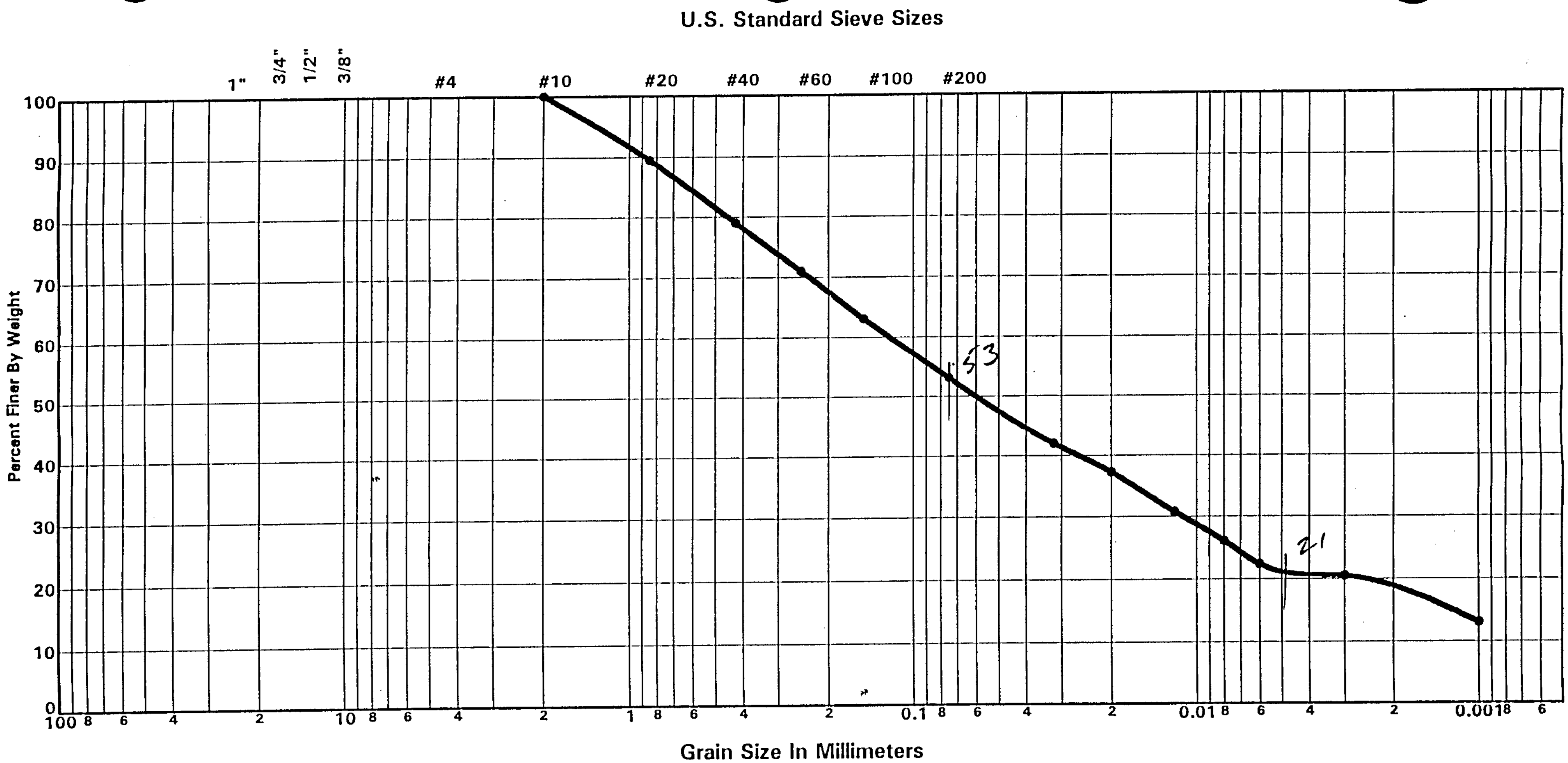
| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP #6-1 | 0-1.5' | | 58.3 | 46.0 | 12.3 | Brown Orange Slightly Fine Sandy SILT (MH) |

**Project:**
Halifax-6
Halifax, North Carolina

**Job No.:** 1-95-1181-CA

**Date:** 1/2/96

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| BP #6-2 | 3.5-5.0' | | 59.2 | 52.5 | 6.7 | Brown Micaceous Slightly Clayey SILT (MH) |

**Project:**
Halifax-6
Halifax, North Carolina

**Job No.:** 1-95-1181-CA

**Date:** 1/2/96

# GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

GeoTechnologies, Inc.

# PERMEABILITY TEST

| Job Number: | 1-95-1181 CB | Job Name: | HALIFAX - 5 | |
|---|---|---|---|---|
| Date: | 3/25/96 | Sample I.D. | B - 4 | Depth: |

**Soil Description:** RED ORANGE CLAYEY SILT

## SAMPLE DATA

**type**

remolded ( )

undisturbed ( X )

standard proctor

| | | |
|---|---|---|
| Max. Dry Density | | lbs/cu.ft. |
| Moisture Content | | % |
| Compaction | #DIV/0! | % |

| | inches | cm. | |
|---|---|---|---|
| Length | 6.007 | 15.258 | |
| Diameter | 2.896 | 7.356 | |
| Area | 6.587 | 42.497 | |
| Volume | 39.568 | 648.404 | |
| Wet Mass | 2.971 | 1347.69 | grams |
| Dry Mass | 2.5329 | 1148.9 | grams |

| | | |
|---|---|---|
| Moisture Content | 17.3 | % |
| Wet Density | 129.8 | lbs./cu.ft. |
| Dry Density | 110.6 | lbs./cu.ft. |
| Initial Saturation | 86.2 | % |
| Final Saturation | 100.0 | % |
| Initial Void Ratio | 0.6 | |
| Porosity | 35.6 | |
| Specific Gravity | 2.75 | apparent |

## TEST DATA

hi = inflow burette

ho = outflow burette

t = time

L = 15.26 cm. length of sample

A = 42.497 sq.cm. area of sample

a = 0.852 sq.cm. area of burettes

h1 = head loss across specimen at t1

h2 = head loss across specimen at t2

| t1 | t2 | ho1 | hi1 | h1 | ho2 | hi2 | h2 |
|---|---|---|---|---|---|---|---|
| 0 | 1860 | 91.3 | 3.3 | 88 | 86.7 | 7.9 | 78.8 |
| 0 | 1440 | 86.7 | 7.9 | 78.8 | 85.5 | 9 | 76.5 |
| 0 | 2760 | 85.5 | 9 | 76.5 | 83.3 | 11.1 | 72.2 |
| 0 | 2640 | 83.3 | 11.1 | 72.2 | 81.4 | 13.1 | 68.3 |
| | | | | | | | |

ASTM D 5084

k = ((aaL/(At(a+a)))*ln(h1/h2)

| | | |
|---|---|---|
| 1 | k = | 9.08E-06 |
| 2 | k = | 3.15E-06 |
| 3 | k = | 3.21E-06 |
| 4 | k = | 3.22E-06 |

AVG. = $3.19 \times 10^{-6}$

**Average** k = 4.66E-06 cm/sec

GeoTechnologies, Inc.

# PERMEABILITY TEST

| Job Number: | 1-95-1181 CB | Job Name: | HALIFAX - 5 | | |
|---|---|---|---|---|---|
| Date: | 3/25/96 | Sample I.D. | B - 8 | Depth: | |

Soil Description: RED ORANGE CLAYEY SILT

## SAMPLE DATA

type
remolded ( )
undisturbed ( X )

standard proctor

| | | |
|---|---|---|
| Max. Dry Density | | lbs/cu.ft. |
| Moisture Content | | % |
| Compaction | #DIV/0! | % |

| | inches | cm. | |
|---|---|---|---|
| Length | 5.949 | 15.110 | |
| Diameter | 2.869 | 7.287 | |
| Area | 6.465 | 41.708 | |
| Volume | 38.459 | 630.226 | |
| Wet Mass | 2.743 | 1244.07 | grams |
| Dry Mass | 2.2154 | 1004.9 | grams |

| | | |
|---|---|---|
| Moisture Content | 23.8 | % |
| Wet Density | 123.2 | lbs./cu.ft. |
| Dry Density | 99.5 | lbs./cu.ft. |
| Initial Saturation | 90.3 | % |
| Final Saturation | 100.0 | % |
| Initial Void Ratio | 0.7 | |
| Porosity | 42.0 | |
| Specific Gravity | 2.75 | apparent |

## TEST DATA

hi = inflow burette
ho = outflow burette
t = time

L = 15.11 cm. length of sample
A = 41.708 sq.cm. area of sample
a = 0.852 sq.cm. area of burettes
h1 = head loss across specimen at t1
h2 = head loss across specimen at t2

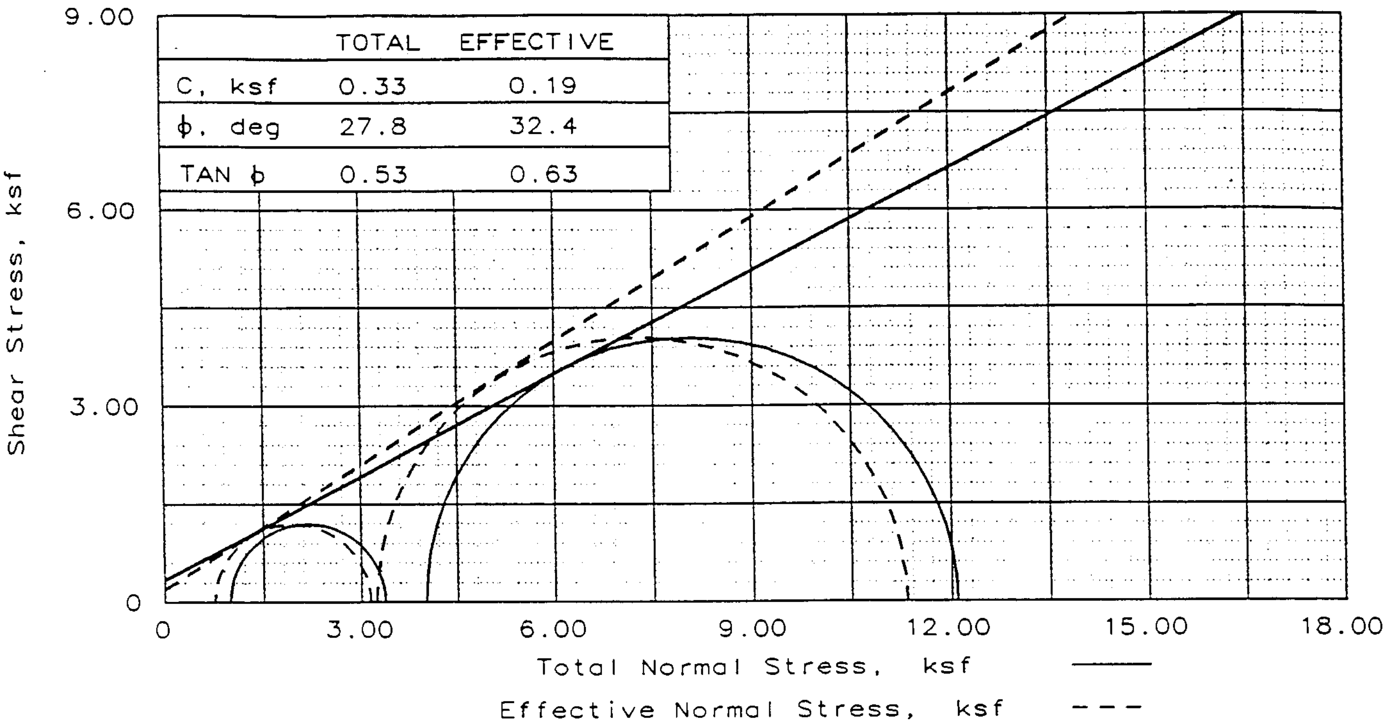
| t1 | t2 | ho1 | hi1 | h1 | ho2 | hi2 | h2 |
|---|---|---|---|---|---|---|---|
| 0 | 1800 | 94.5 | 0.5 | 94 | 87.1 | 7.6 | 79.5 |
| 0 | 1440 | 87.1 | 7.6 | 79.5 | 81.5 | 13.2 | 68.3 |
| 0 | 2700 | 81.5 | 13.2 | 68.3 | 71.9 | 23 | 48.9 |
| 0 | 2700 | 94.5 | 0.8 | 93.7 | 83.7 | 11.5 | 72.2 |
| | | | | | | | |

ASTM D 5084

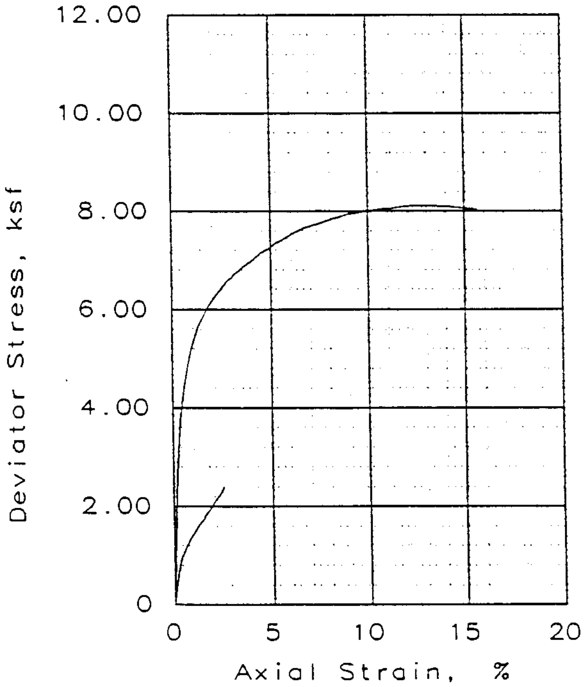
k = ((aaL/(At(a+a)))*ln(h1/h2)

1 k = 1.44E-05
2 k = 1.63E-05
3 k = 1.91E-05
4 k = 1.49E-05

Average k = 1.62E-05 cm/sec




| | TOTAL | EFFECTIVE |
|---|---|---|
| C, ksf | 0.33 | 0.19 |
| ϕ, deg | 27.8 | 32.4 |
| TAN ϕ | 0.53 | 0.63 |




| | SAMPLE NO. | 1 | 2 |
|---|---|---|---|
| INITIAL | WATER CONTENT, % | 14.3 | 14.3 |
| | DRY DENSITY, pcf | 115.8 | 119.7 |
| | SATURATION, % | 88.3 | 99.2 |
| | VOID RATIO | 0.429 | 0.382 |
| | DIAMETER, in | 2.79 | 2.79 |
| | HEIGHT, in | 5.55 | 5.37 |
| AT TEST | WATER CONTENT, % | 14.9 | 14.5 |
| | DRY DENSITY, pcf | 118.5 | 119.7 |
| | SATURATION, % | 99.9 | 100.5 |
| | VOID RATIO | 0.396 | 0.382 |
| | DIAMETER, in | 2.77 | 2.79 |
| | HEIGHT, in | 5.51 | 5.37 |
| | Strain rate, %/min | 0.120 | 0.120 |
| | BACK PRESSURE, ksf | 10.48 | 10.47 |
| | CELL PRESSURE, ksf | 11.48 | 14.47 |
| | FAILURE STRESS, ksf | 2.38 | 8.08 |
| | PORE PRESSURE, ksf | 10.71 | 11.23 |
| | ULTIMATE STRESS, ksf | 2.38 | 8.08 |
| | PORE PRESSURE, ksf | 10.71 | 11.23 |
| | $\bar{\sigma}_1$ FAILURE, ksf | 3.14 | 11.32 |
| | $\bar{\sigma}_3$ FAILURE, ksf | 0.76 | 3.24 |

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: UNDISTURBED TUBE
DESCRIPTION: RED ORANGE CLAYEY SILT
LL= 31.0 PL= 17.0 PI= 14.0
SPECIFIC GRAVITY= 2.65
REMARKS:

FIG. NO.

CLIENT: RICHARDSON AND ASSOCIATES

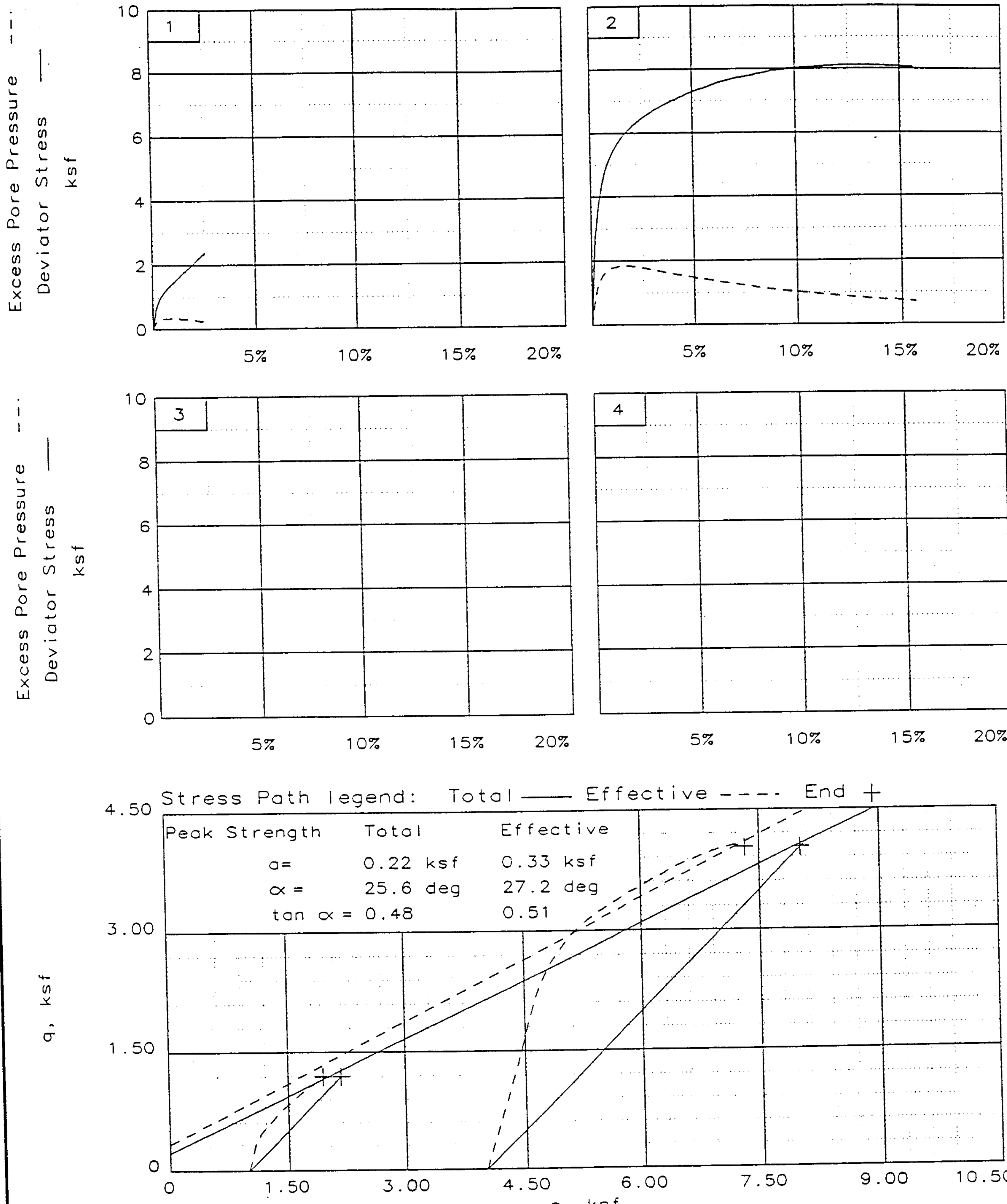
PROJECT: HALIFAX - 5

SAMPLE LOCATION: B - 4

PROJ. NO.: 1-95-1181CB DATE: 4-4-96

TRIAXIAL SHEAR TEST REPORT

GEOTECHNOLOGIES, INC., P.A.

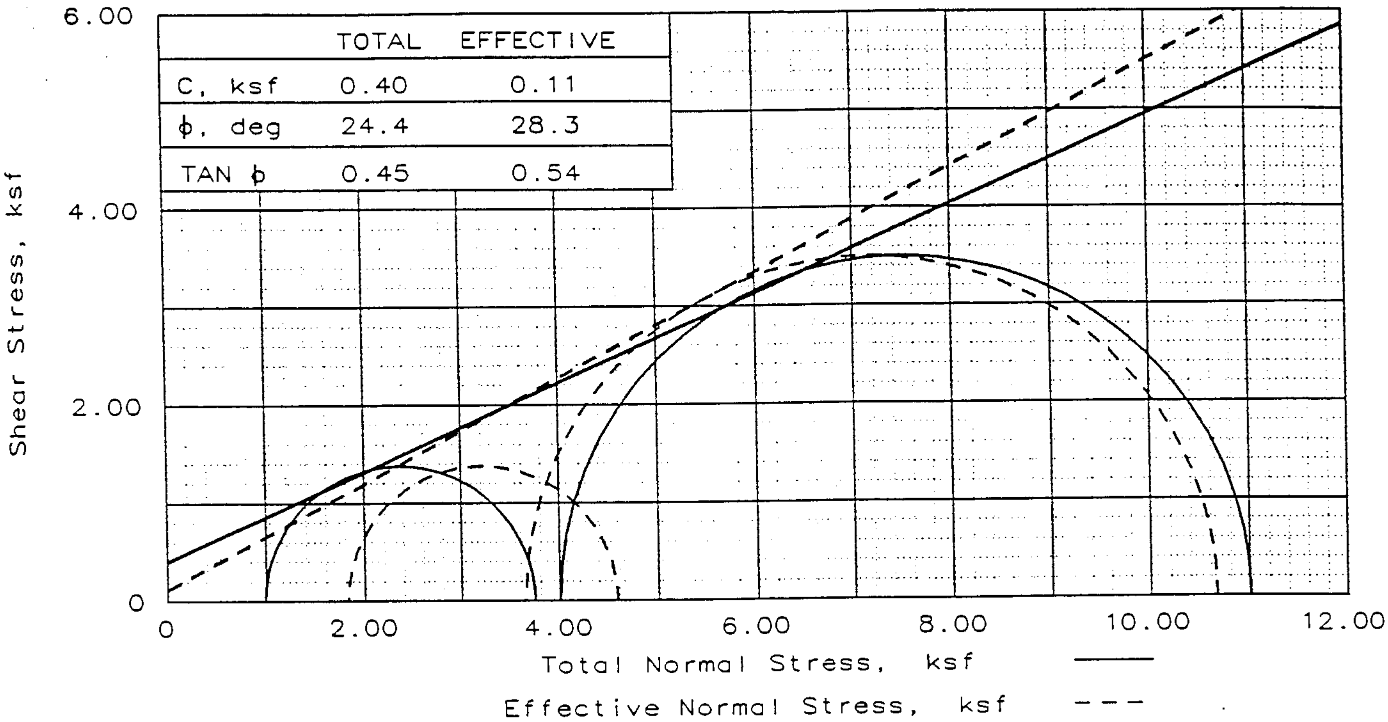



Client: RICHARDSON AND ASSOCIATES

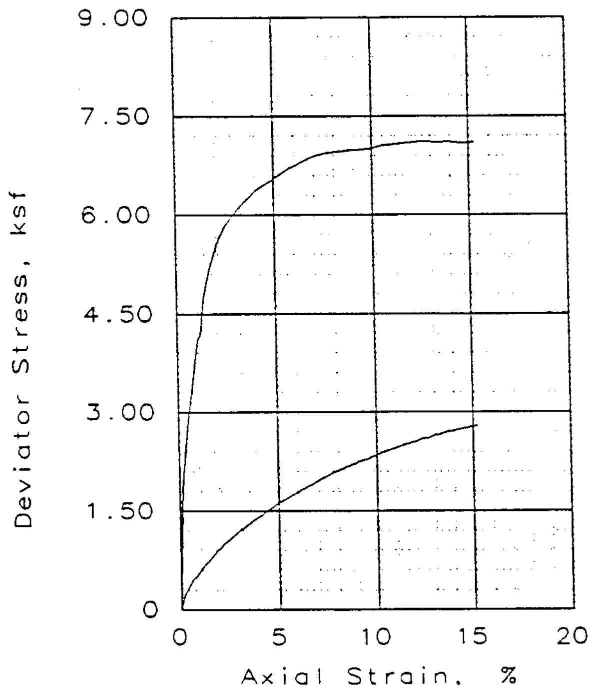
Project: HALIFAX - 5

Location: B - 4

File: HPL    Project No.: 1-95-1181CB    Page 2/2    Fig. No. ____




| | TOTAL | EFFECTIVE |
|---|---|---|
| C, ksf | 0.40 | 0.11 |
| ϕ, deg | 24.4 | 28.3 |
| TAN ϕ | 0.45 | 0.54 |




| SAMPLE NO. | | 1 | 2 |
|---|---|---|---|
| INITIAL | WATER CONTENT, % | 23.7 | 23.7 |
| | DRY DENSITY, pcf | 88.3 | 99.7 |
| | SATURATION, % | 71.7 | 95.0 |
| | VOID RATIO | 0.874 | 0.660 |
| | DIAMETER, in | 2.88 | 2.87 |
| | HEIGHT, in | 6.41 | 5.95 |
| AT TEST | WATER CONTENT, % | 30.3 | 23.5 |
| | DRY DENSITY, pcf | 91.9 | 102.1 |
| | SATURATION, % | 100.4 | 100.2 |
| | VOID RATIO | 0.799 | 0.620 |
| | DIAMETER, in | 2.84 | 2.85 |
| | HEIGHT, in | 6.32 | 5.90 |
| Strain rate, %/min | | 0.120 | 0.120 |
| BACK PRESSURE, ksf | | 9.99 | 11.06 |
| CELL PRESSURE, ksf | | 10.99 | 15.06 |
| FAILURE STRESS, ksf | | 2.76 | 7.01 |
| PORE PRESSURE, ksf | | 9.16 | 11.40 |
| ULTIMATE STRESS, ksf | | 2.76 | 7.01 |
| PORE PRESSURE, ksf | | 9.16 | 11.40 |
| $\bar{\sigma}_1$ FAILURE, ksf | | 4.58 | 10.66 |
| $\bar{\sigma}_3$ FAILURE, ksf | | 1.83 | 3.66 |

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE: UNDISTURBED TUBE
DESCRIPTION: RED ORANGE CLAYEY SILT
LL= 50.0 PL= 22.0 PI= 28.0
SPECIFIC GRAVITY= 2.65
REMARKS:

FIG. NO.

CLIENT: G.N. RICHARDSON & ASSOC

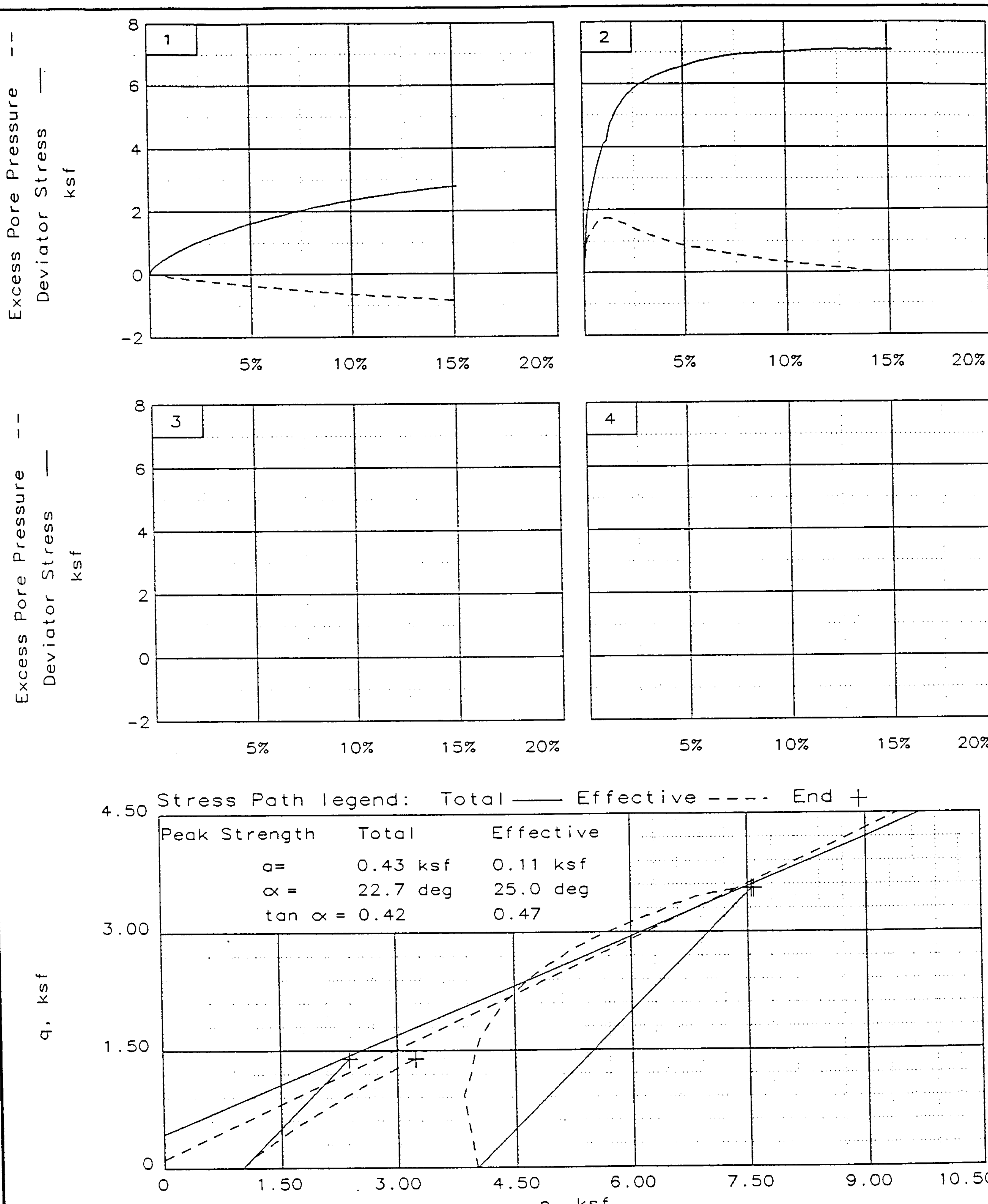
PROJECT: HALIFAX 5

SAMPLE LOCATION: B - 8

PROJ. NO.: 1-95-1181CB DATE: 4-4-96

TRIAXIAL SHEAR TEST REPORT

GEOTECHNOLOGIES, INC., P.A.




Client: G.N. RICHARDSON & ASSOC

Project: HALIFAX 5

Location: B - 8

File: HAL4 Project No.: 1-95-1181CB Page 2/2 Fig. No. ____

GeoTechnologies, Inc.

## CONSOLIDATION TEST

**Job Name:** HALIFAX 5 — Date: 4/16/96

**Job Number:** 1-95-1181 CB

Sample I.D. B - 4 — Depth: 1 - 3'

Soil Description: RED ORANGE CLAYEY SILT

Notes: PRELOAD 500 \ SATURATED \ UNDISTURBED

| RING PROPERTIES | | |
|---|---|---|
| Diameter | 2.5 | inches |
| Height | 1 | inches |
| Volume | 0.00284 | cu.ft. |
| Weight | 110.48 | grams |
| Ring + Soil | 257.63 | grams |

| SOIL PROPERTIES | | |
|---|---|---|
| Init. Moisture | 17.4 | % |
| Soil Weight. | 147.2 | grams |
| Wet Density | 114.2 | lbs./cu.ft. |
| Dry Density | 97.3 | lbs./cu.ft. |
| Specific Gravity | 2.68 | Apparent |
| Final Moisture | 19.1 | % |

| | |
|---|---|
| Initial Reading | .0000 |
| Preload Rebound Reading | .0294 |

| LOAD / psf | R0 | R6 | R100 | T50 | R50 |
|---|---|---|---|---|---|
| 100 | .0000 | .0036 | .0040 | | |
| 500 | .0040 | .0277 | .0294 | | |
| 100 | .0294 | .0262 | .0254 | | |
| 500 | .0254 | .0326 | .0347 | | |
| 1000 | .0347 | .0548 | .0576 | 0.9 | 0.0461 |
| 2000 | .0576 | .0856 | .0883 | 1.35 | 0.0729 |
| 4000 | .0883 | .1215 | .1241 | 0.45 | 0.1062 |
| 8000 | .1241 | .1549 | .1599 | 0.675 | 0.142 |

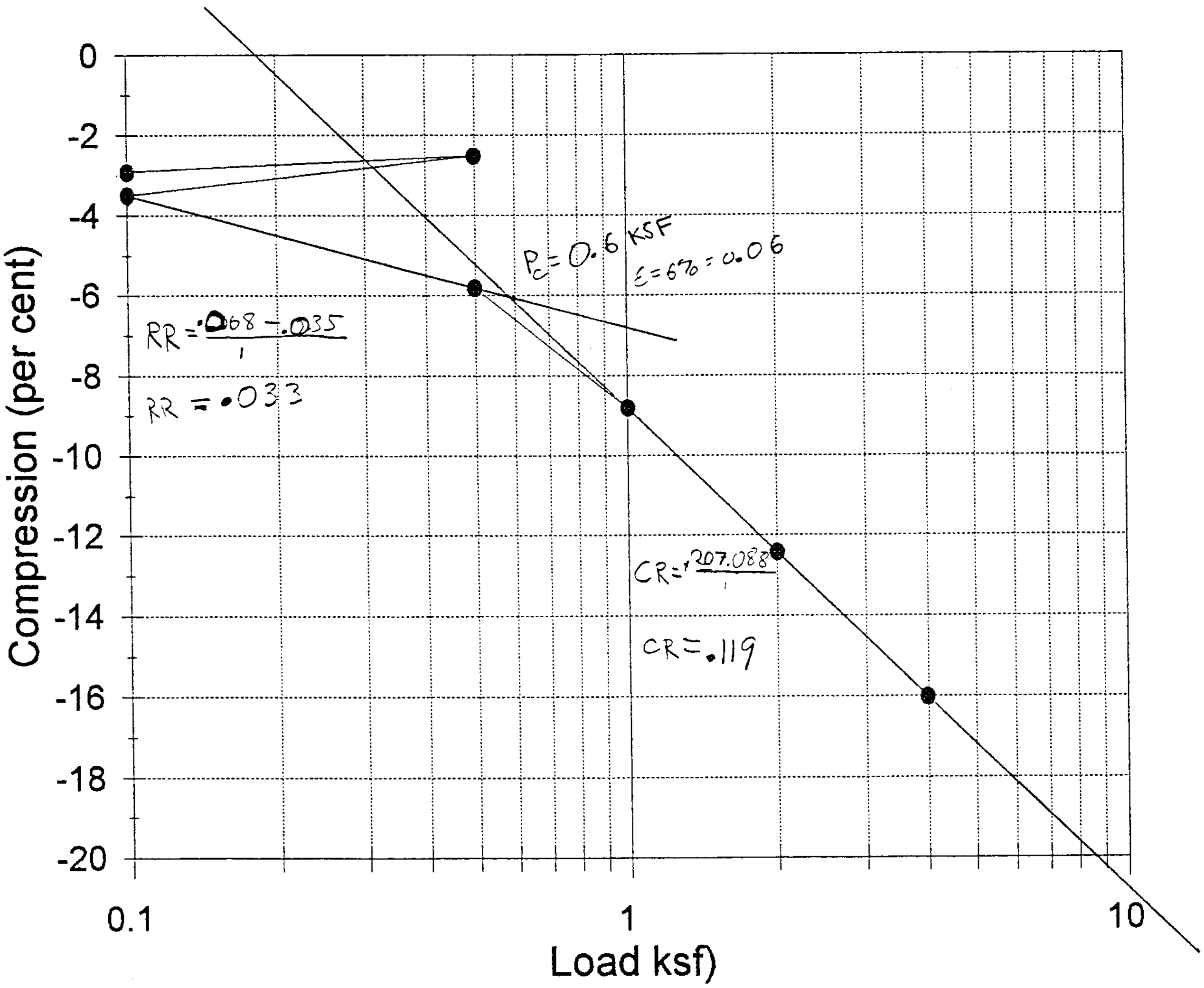
| LOAD / psf | %E | Con. Coef. | %IC |
|---|---|---|---|
| 100 | 0.4 | | 90.0 |
| 500 | 2.9 | | 93.3 |
| 100 | 2.5 | | 80.0 |
| 500 | 3.5 | | 77.4 |
| 1000 | 5.8 | 4.979 | 87.8 |
| 2000 | 8.8 | 3.136 | 91.2 |
| 4000 | 12.4 | 8.743 | 92.7 |
| 8000 | 16.0 | 5.371 | 86.0 |
| 16000 | | | |

NOTE: Consolidation Coefficient in Square Feet Per Day

| | |
|---|---|
| Initial Void Ratio | 0.720 |
| Final Void Ratio | 0.445 |
| Initial Saturation, % | 64.8 |
| Final Saturation, % | 109.9 |

# Consolidation Test

B-4, 1'-3'



GeoTechnologies, Inc.

# CONSOLIDATION TEST

Job Name: HALIFAX 5 Date: 4/16/96

Job Number: 1-95-1181 CB

Sample I.D. B - 8 - 1 Depth: 5 - 7'

Soil Description: RED ORANGE CLAYEY SAND

Notes: PRELOAD 500 \ SATURATED \ UNDISTURBED

| RING PROPERTIES | | |
|---|---|---|
| Diameter | 2.5 | inches |
| Height | 1 | inches |
| Volume | 0.00284 | cu.ft. |
| Weight | 110.48 | grams |
| Ring + Soil | 262.34 | grams |

| SOIL PROPERTIES | | |
|---|---|---|
| Init. Moisture | 23.0 | % |
| Soil Weight. | 151.9 | grams |
| Wet Density | 117.9 | lbs./cu.ft. |
| Dry Density | 95.8 | lbs./cu.ft. |
| Specific Gravity | 2.68 | Apparent |
| Final Moisture | 24.9 | % |

| | |
|---|---|
| Initial Reading | .0000 |
| Preload Rebound Reading | .0032 |

| LOAD / psf | R0 | R6 | R100 | T50 | R50 |
|---|---|---|---|---|---|
| 100 | .0000 | .0004 | .0005 | | |
| 500 | .0005 | .0030 | .0032 | | |
| 100 | .0032 | .0008 | .0006 | | |
| 500 | .0006 | .0029 | .0030 | | |
| 1000 | .0030 | .0060 | .0064 | 0.9 | 0.0047 |
| 2000 | .0064 | .0142 | .0151 | 0.45 | 0.01075 |
| 4000 | .0151 | .0269 | .0285 | 0.9 | 0.0218 |
| 8000 | .0285 | .0457 | .0479 | 0.45 | 0.0382 |

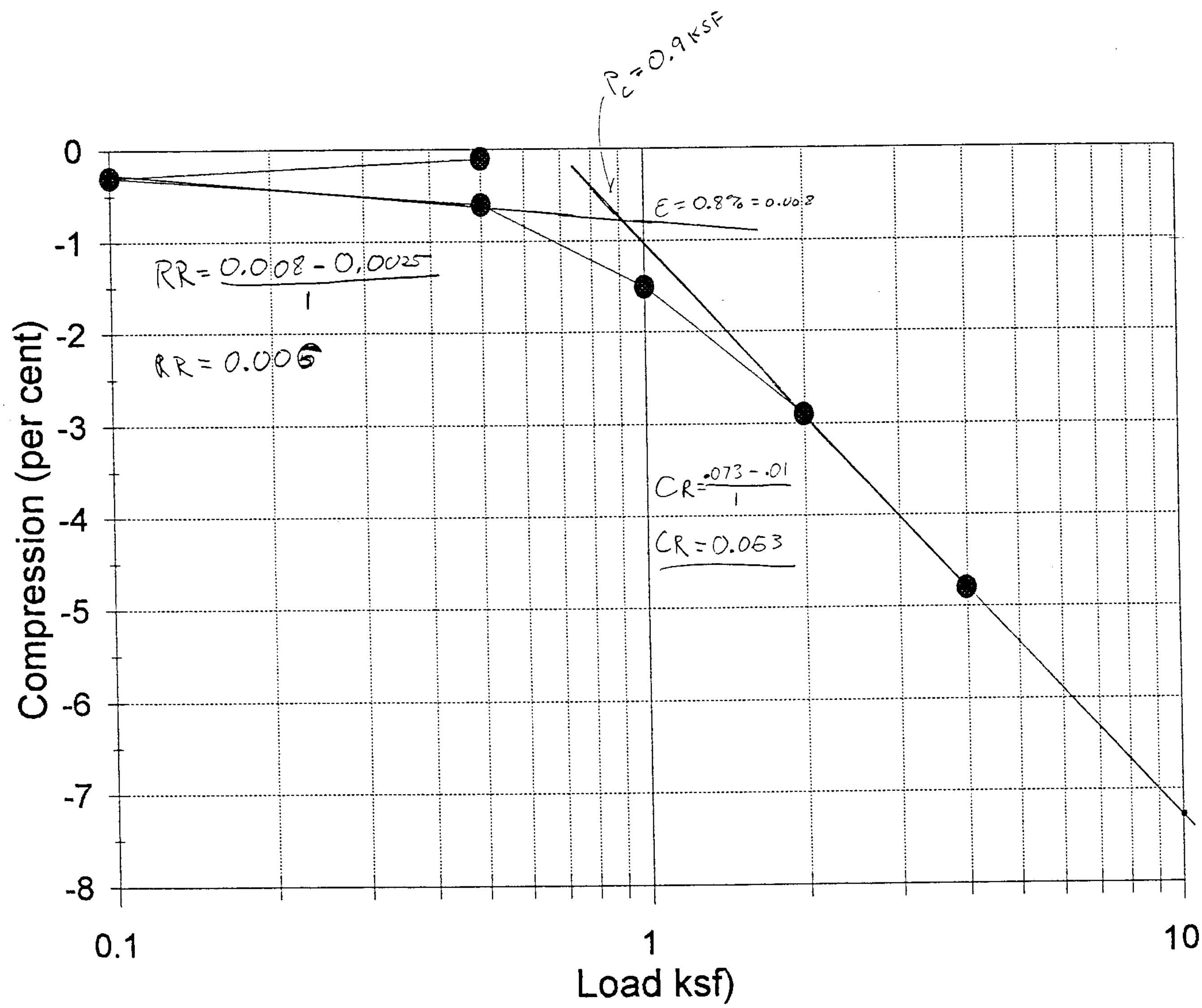
| LOAD / psf | %E | Con. Coef. | %IC |
|---|---|---|---|
| 100 | 0.1 | | 80.0 |
| 500 | 0.3 | | 92.6 |
| 100 | 0.1 | | 92.3 |
| 500 | 0.3 | | 95.8 |
| 1000 | 0.6 | 5.421 | 88.2 |
| 2000 | 1.5 | 10.710 | 89.7 |
| 4000 | 2.9 | 5.236 | 88.1 |
| 8000 | 4.8 | 10.124 | 88.7 |
| 16000 | | | |

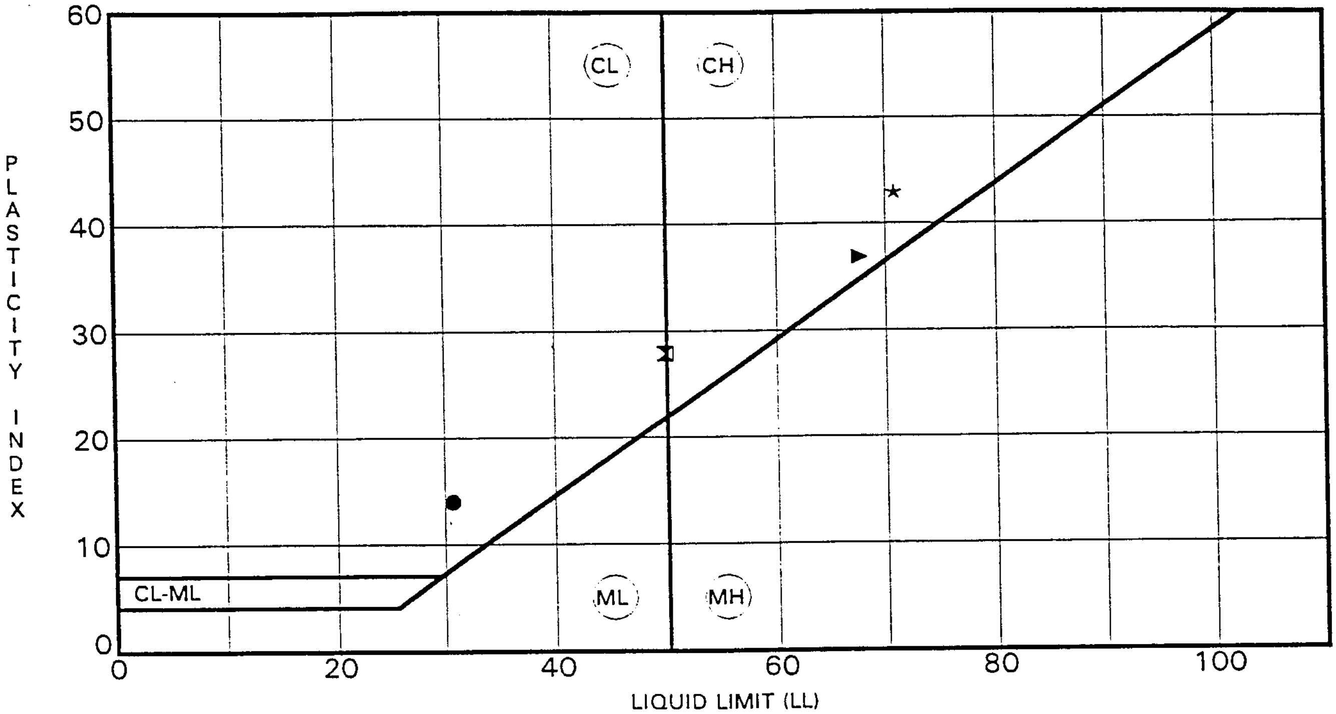
NOTE: Consolidation Coefficient in Square Feet Per Day

| | |
|---|---|
| Initial Void Ratio | 0.746 |
| Final Void Ratio | 0.662 |
| Initial Saturation, % | 82.6 |
| Final Saturation, % | 97.0 |

# Consolidation Test

B-8, 5'-7'





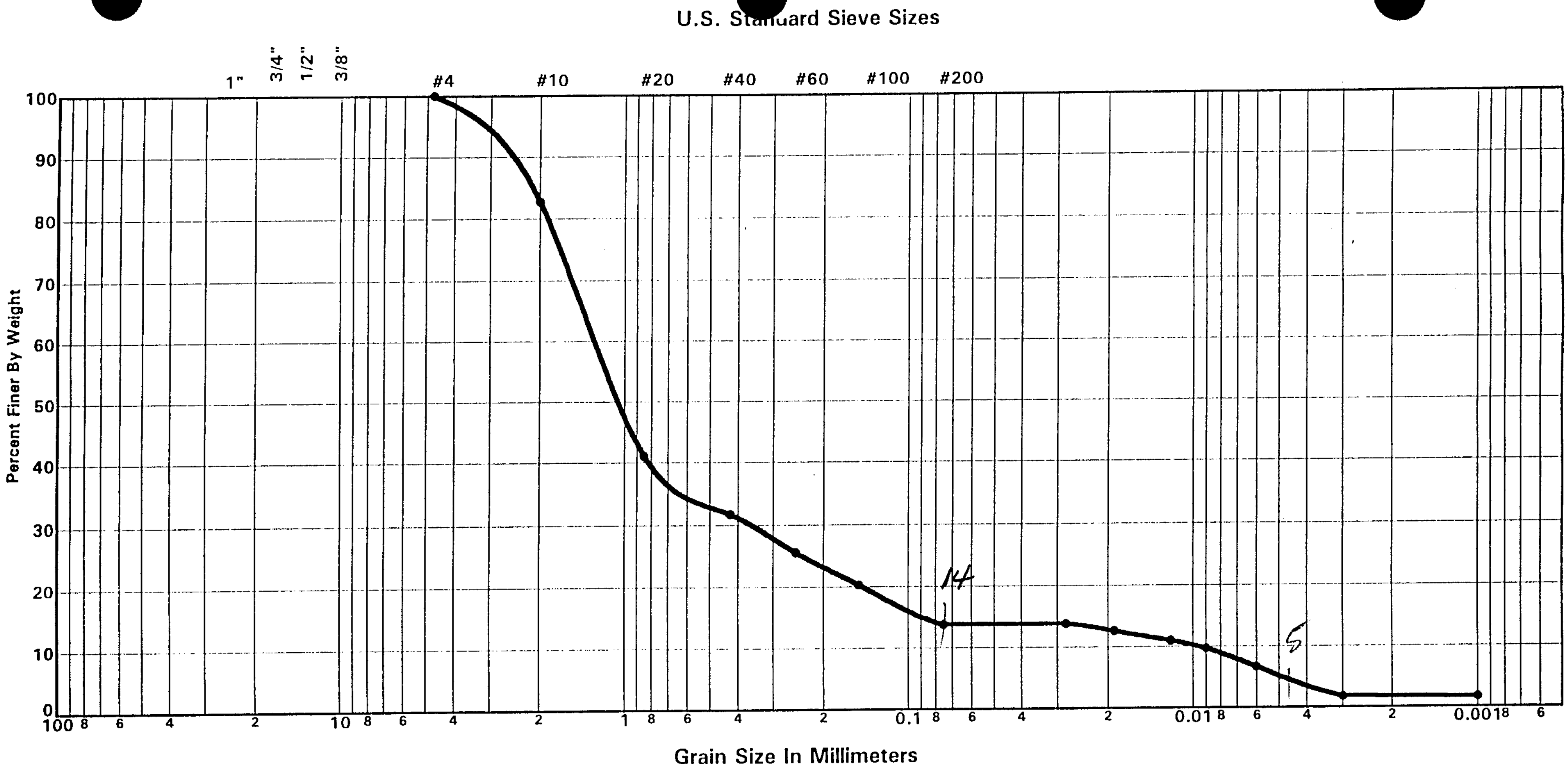

| | Specimen Identification | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|
| ● | B-4 | 31 | 17 | 14 | 13.8 | Red Orange [FINE SANDY] Clayey SILT ~~(CL)~~ (SM/ML) |
| ⧗ | B-8-1 | 50 | 22 | 28 | 48.8 | Red Orange Clayey ~~SILT (CL/CH)~~ [SILTY FINE SAND] (SM/CL) |
| ▶ | G-2-A | 68 | 31 | 37 | 43.8 | Very Gravelly Reddish Brown Silty CLAY (CH) |
| ★ | G-6-A | 71 | 28 | 43 | 43.2 | Orange Slightly Sandy Silty CLAY (CH) |

PROJECT Halifax-5 - Halifax, North Carolina

JOB NO. 1-95-1181-CB
DATE 4/16/96

# ATTERBERG LIMITS' RESULTS

Raleigh, North Carolina




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| B-4 | | | 30.7 | 16.7 | 14.0 | Red Orange FINE SANDY Clayey SILT ~~(CL)~~ SM/ML |

**Project:**

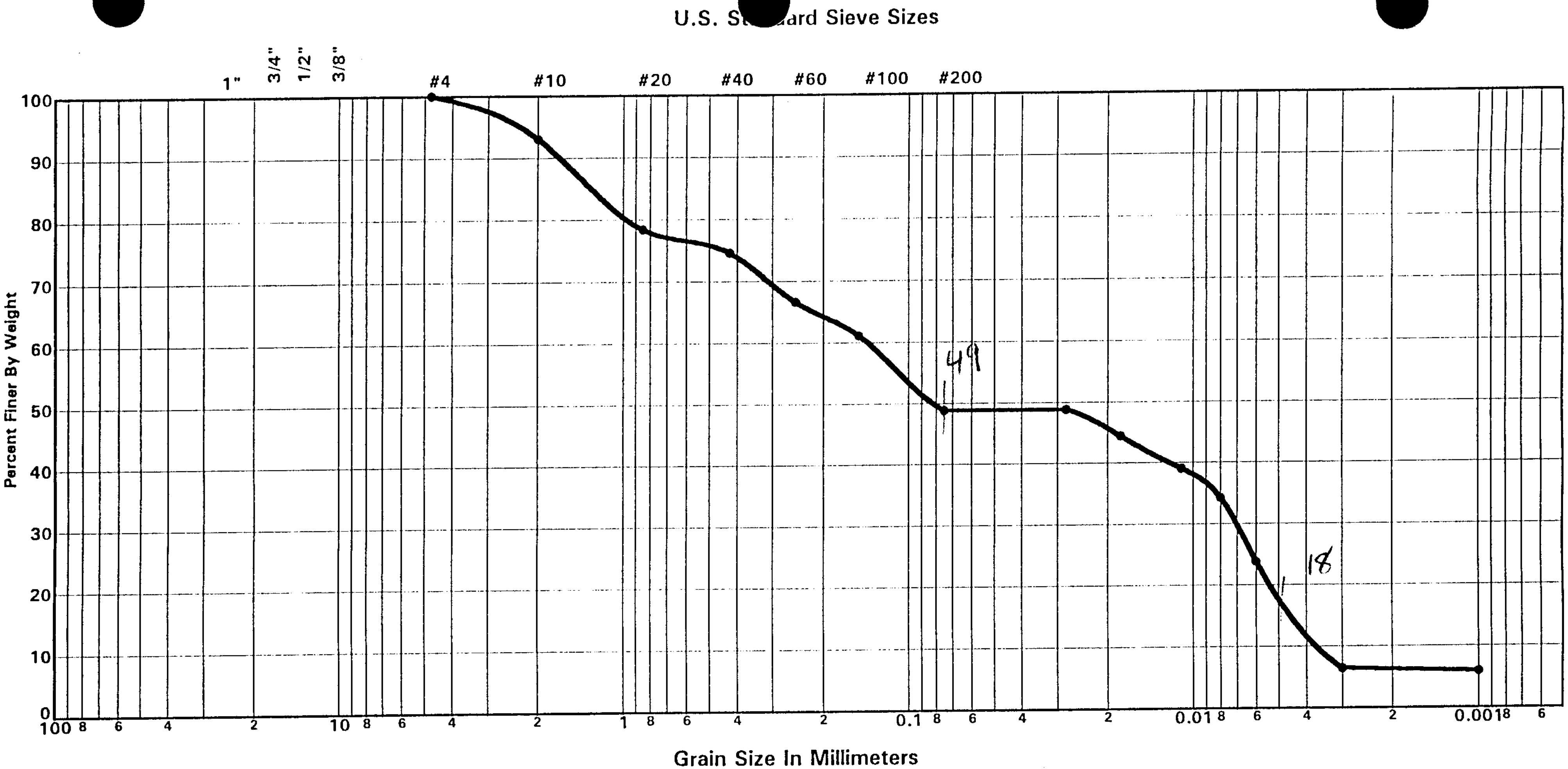
Halifax-5
Halifax, North Carolina

**Job No.:** 1-95-1181-CB

**Date:** 4/16/96

## GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.




| GRAVEL | | SAND | | | FINES | |
|---|---|---|---|---|---|---|
| COARSE | FINE | COARSE | MEDIUM | FINE | SILT SIZES | CLAY SIZES |

| Boring No. | Elev./Depth | Nat. W.C. | L.L. | P.L. | P.I. | Soil Description or Classification |
|---|---|---|---|---|---|---|
| B-8-1 | | | 49.9 | 22.0 | 27.9 | Red Orange Clayey ~~SILT (CL/CH)~~ Silty Fine Sand SM/CL |

**Project:**

Halifax-5
Halifax, North Carolina

**Job No.:** 1-95-1181-CB

**Date:** 4/16/96

## GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

# Appendix F

**Slug Test Analysis**
**Halifax County Landfill**

Aquifer porosities were established using published data (Driscoll, Ground Water and Wells p.67) and an evaluation of both the field soil classifications, and total porosity and grain size analysis (where available). The classifications of soil types were quite similar across the site with most of the borings being classified with silty sand in the screened interval, or the grain size analysis indicating clayey silty sand. Total porosities ranged from 36% in the bedrock aquifer to 45.9% in the upper aquifer. Based upon these classifications, effective porosities were evaluated.

Upon evaluating the porosities, the aquifer (slug) tests were analyzed using the Bouwer method. This method of aquifer test analysis is based upon the curve of water level data of the recovering aquifer over time. This method does take into account a "correction for sandpack" which includes porosity of the aquifer, and radius of the well with the sand pack. Where the water level is above the screened interval this correction is set to a radius of 1" (for a 2"diameter well). The porosities used and conductivities calculated are shown in Table 1b.

Since the Bouwer equation does not take porosity into account (other than in the correction for sandpack), several of these values did not change. Of the values that did change, BP-3a had a conductivity variation of 0.023 feet/day between porosities of 0.2 and 0.17, MW-2a recorded a change of 0.62 ft/day between porosities of 0.2 and 0.12, and MW-16a recorded a difference of 0.021 ft/day between porosities of 0.2 and 0.12. For these three wells, both calculation sets are shown for review.

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-2a |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 11.44 |
| | Le = Screened Interval Open to Aquifer = | 11.44 |
| | Rw = Radius of Well Including Sand Pack = | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zero | 0.18 |
| | Yt = Relative Height of Water at Time t = | 0.03 |
| | n = Porosity = | 0.12 |
| | Time Tt (in minutes) = | 1 |
| | H - Lw = | 23.56 |
| | Yo/Yt = | 6 |
| | Lw/Rw = | 26.60465 |
| | ln(H-Lw)/Rw = | 4.00352 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.029904

**Req =** 0.172927

**Evaluation of A and B:**

Le/Rw = 26.60465

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.4 |
| **B =** | 0.3 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

ln Re/Rw= 2.780399 exp-1

**ln Re/Rw=** 0.359661

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.000842 Ft/Min or 0.000428 CM/Sec

**K =** 1.21284 Ft/Day

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-2a |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 11.44 |
| | Le = Screened Interval Open to Aquifer = | 11.44 |
| | Rw = Radius of Well Including Sand Pack | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zer | 0.18 |
| | Yt = Relative Height of Water at Time t = | 0.03 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 1 |
| | H - Lw = | 23.56 |
| | Yo/Yt = | 6 |
| | Lw/Rw = | 26.60465 |
| | ln(H-Lw)/Rw = | 4.00352 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 26.60465

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.4 |
| **B =** | 0.3 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp**

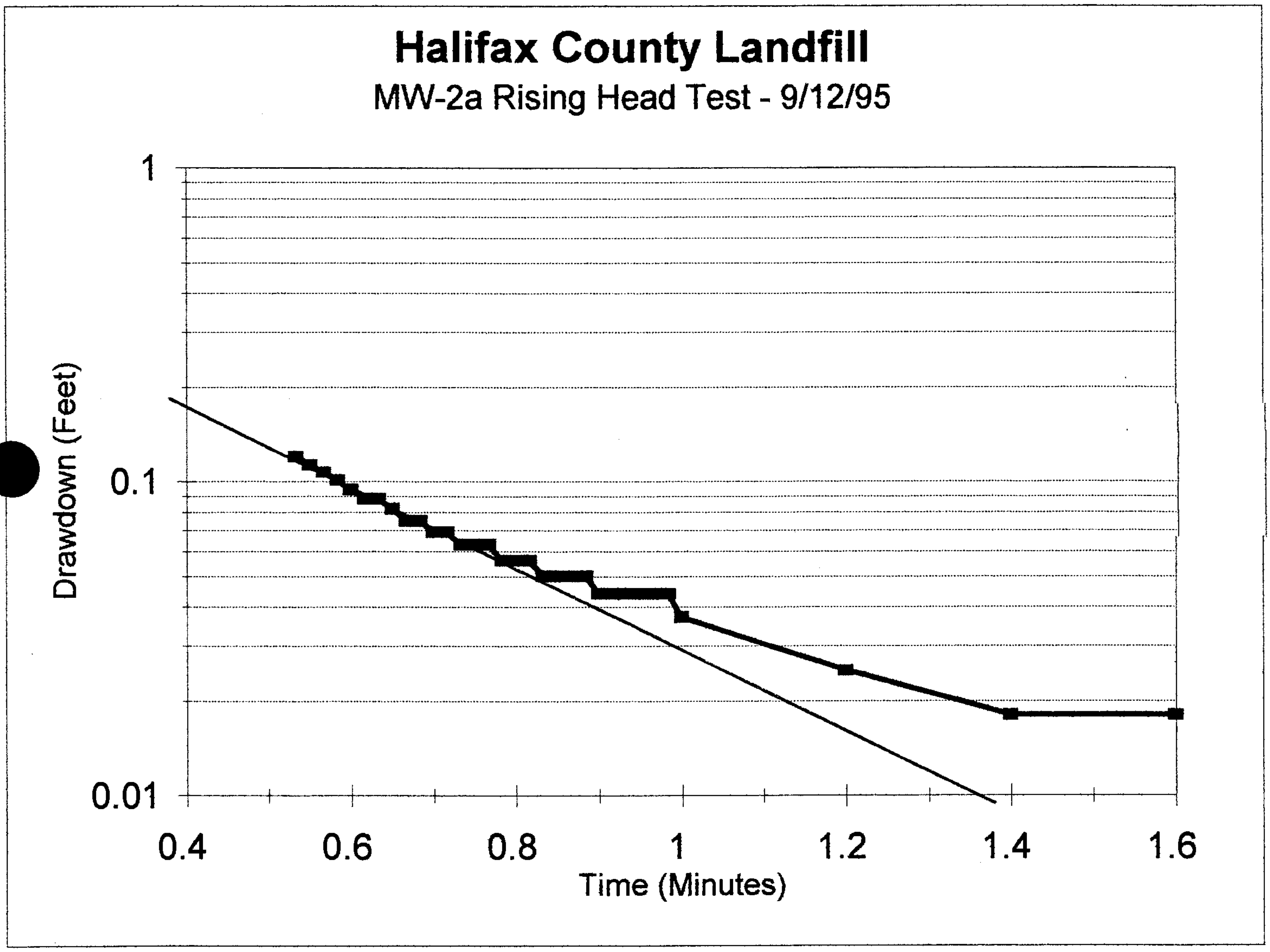
ln Re/Rw= 2.780399 exp-1

**ln Re/Rw=** 0.359661

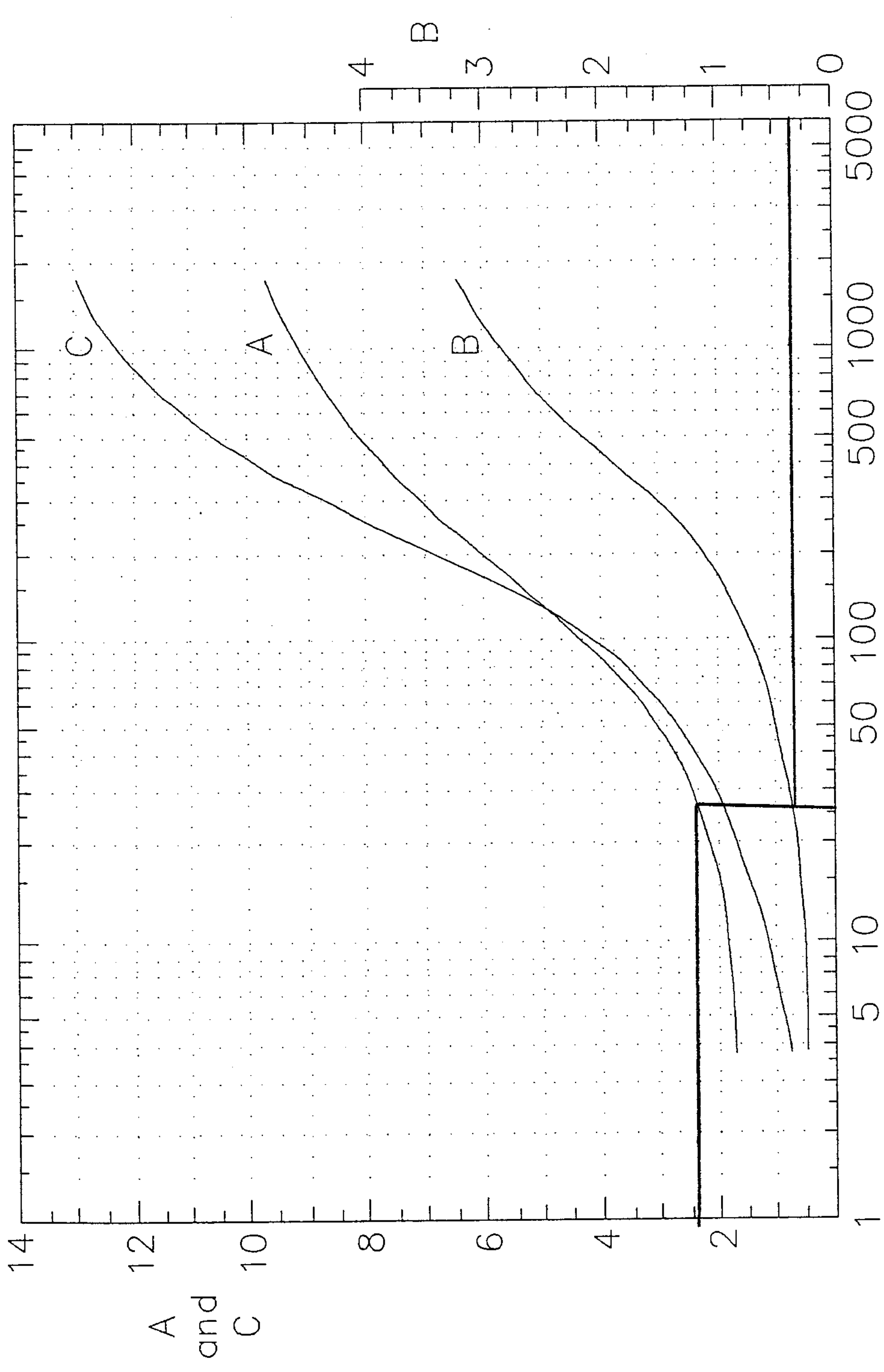
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.001274 Ft/Min or 0.000647 CM/Sec

**K =** 1.83513 Ft/Day



Halifax County Landfill
MW-2a Rising Head Test - 9/12/95
Drawdown (Feet)
1
0.1
0.01
0.4
0.6
0.8
1
1.2
1.4
1.6
Time (Minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Landfill
MW-2a

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-3as |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 3.78 |
| | Le = Screened Interval Open to Aquifer = | 3.78 |
| | Rw = Radius of Well Including Sand Pack | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zer | 0.3 |
| | Yt = Relative Height of Water at Time t = | 0.025 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 4 |
| | H - Lw = | 31.22 |
| | Yo/Yt = | 12 |
| | Lw/Rw = | 8.790698 |
| | ln(H-Lw)/Rw = | 4.285029 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 8.790698

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 1.8 |
| **B =** | 0.25 |

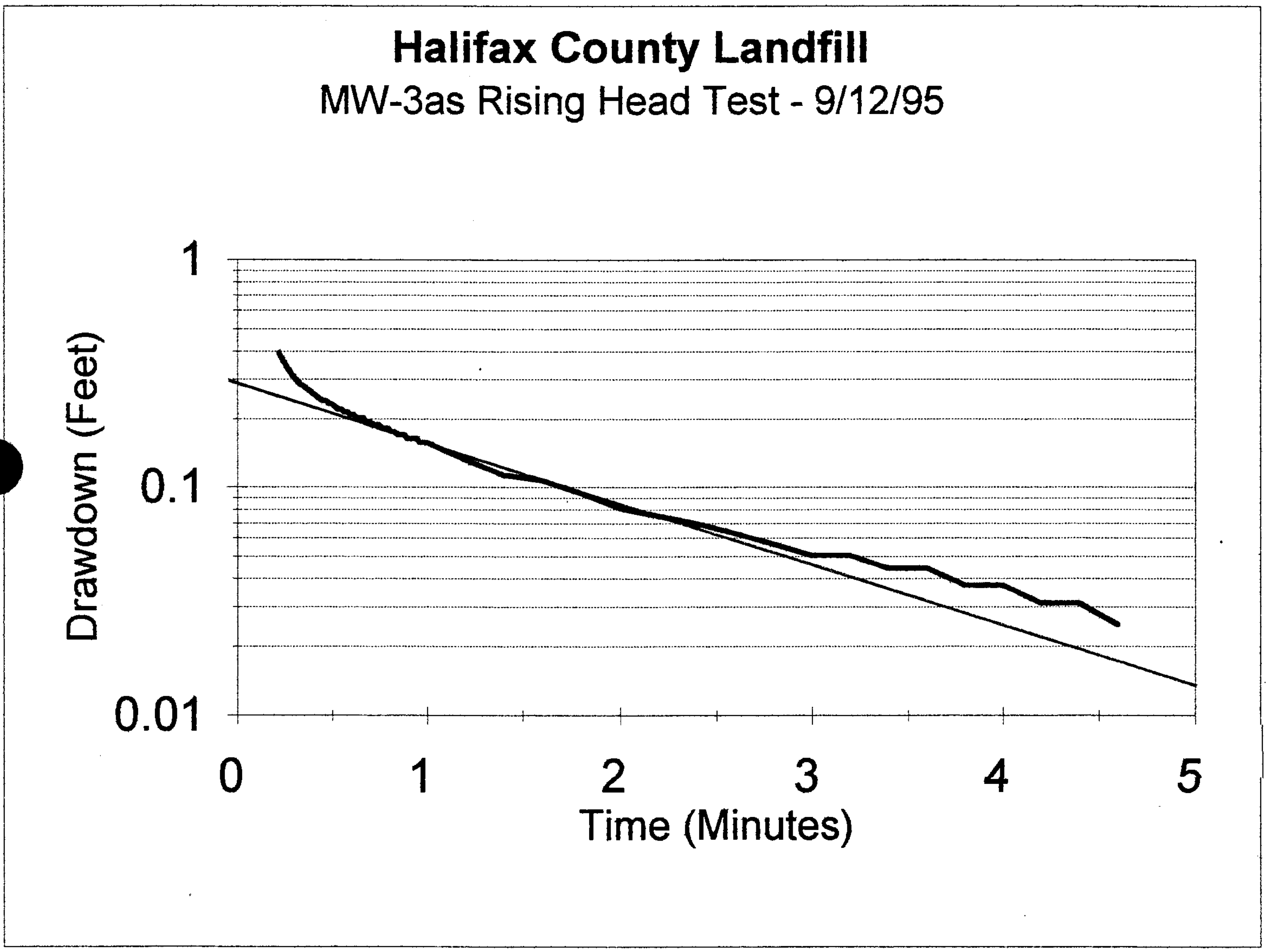
**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp**

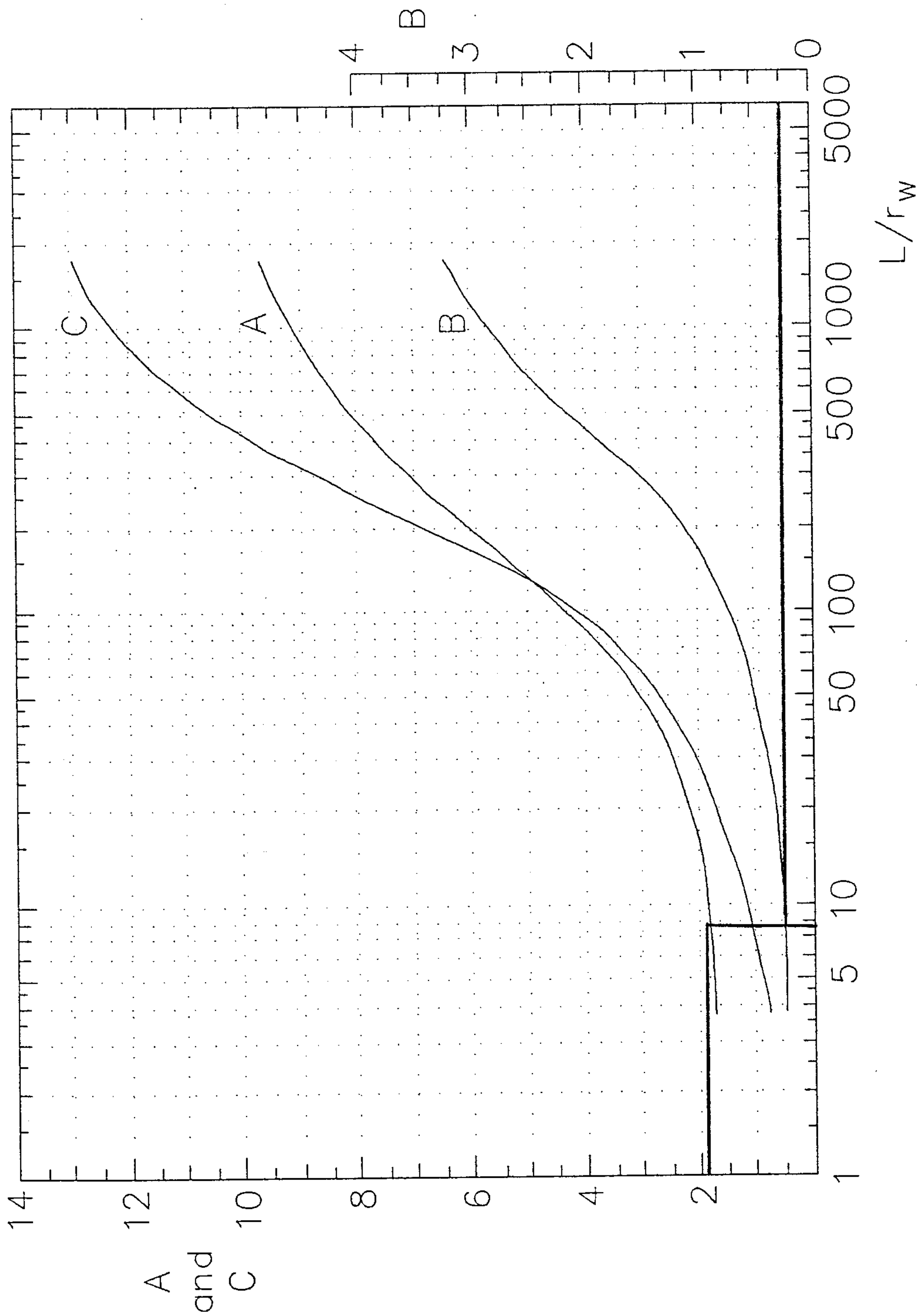
ln Re/Rw= 2.427914 exp-1

**ln Re/Rw=** 0.411876

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

| | | | | | |
|---|---|---|---|---|---|
| **K =** | 0.001531 | Ft/Min | or | 0.000778 | CM/Sec |
| **K =** | 2.205187 | Ft/Day | | | |


Halifax County Landfill
MW-3as Rising Head Test - 9/12/95
Drawdown (Feet)
1
0.1
0.01
0
1
2
3
4
5
Time (Minutes)




Curves relating coefficients A, B, and C to L/$r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919–828–0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Landfill
MW-3as

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-3ad |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 12.27 |
| | Le = Screened Interval Open to Aquifer = | 12.27 |
| | Rw = Radius of Well Including Sand Pack | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zer | 3.5 |
| | Yt = Relative Height of Water at Time t = | 0.12 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 10 |
| | H - Lw = | 22.73 |
| | Yo/Yt = | 29.16667 |
| | Lw/Rw = | 28.53488 |
| | ln(H-Lw)/Rw = | 3.967656 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 28.53488

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.5 |
| **B =** | 0.35 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp**

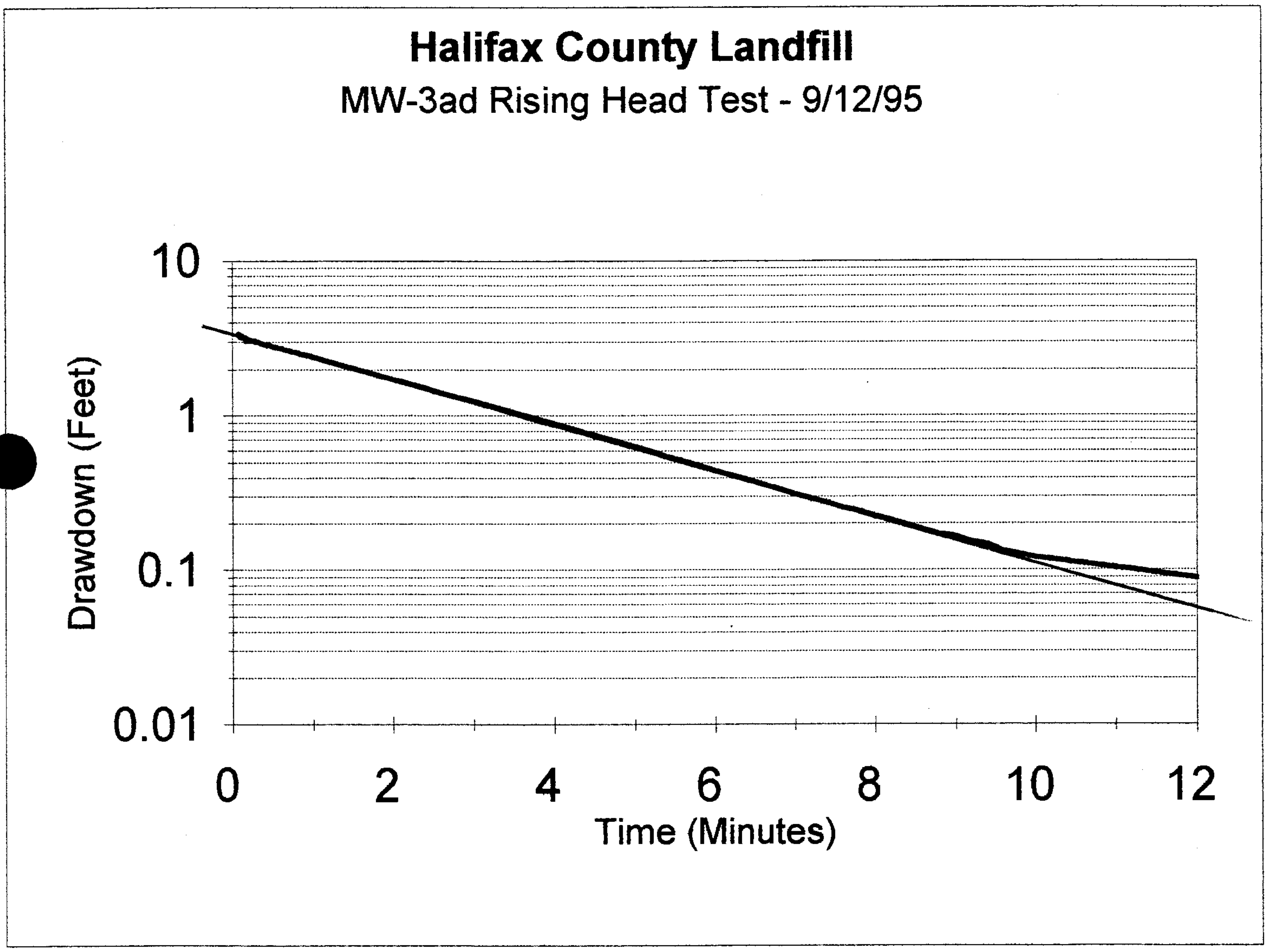
ln Re/Rw= 2.876914 exp-1

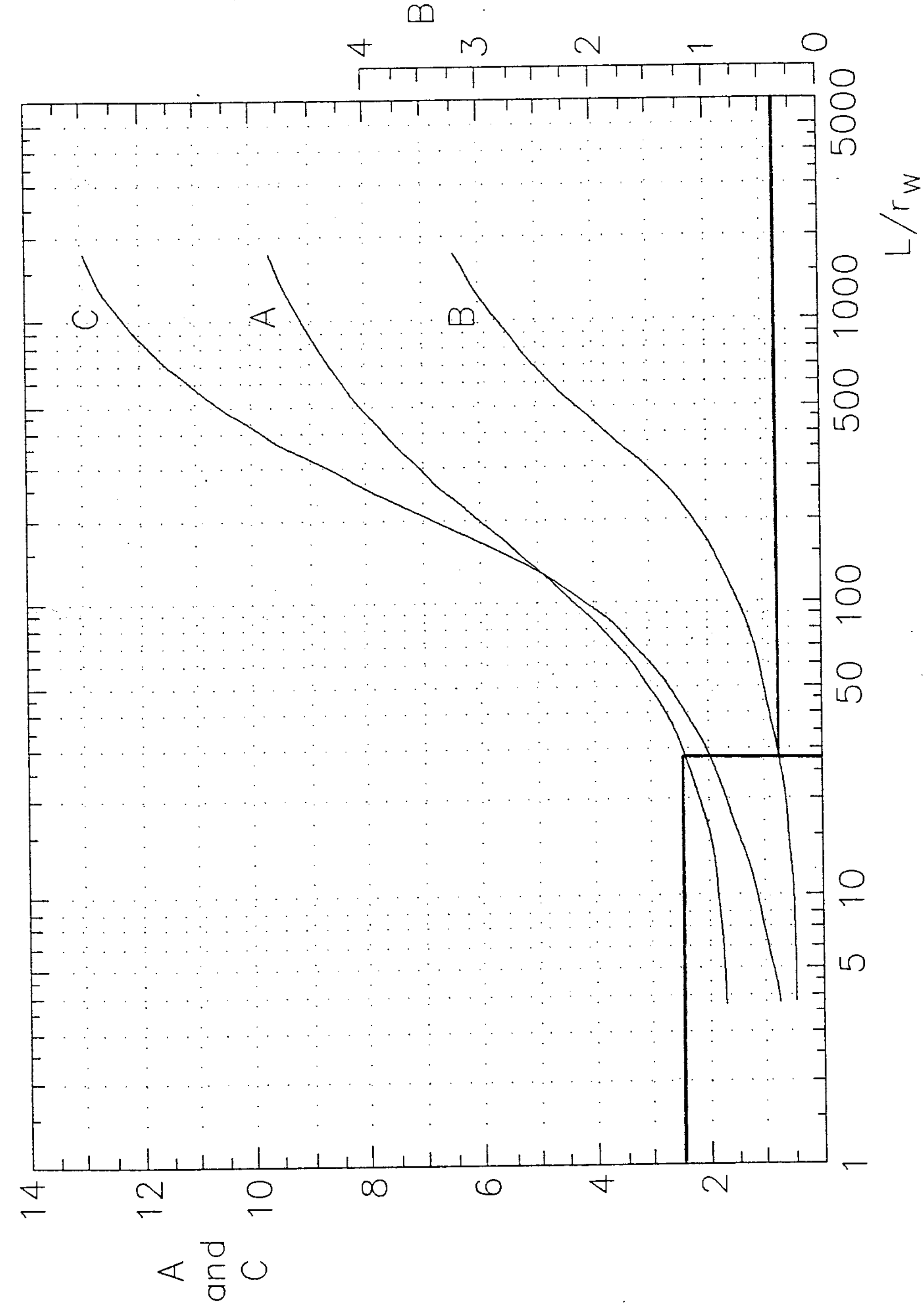
**ln Re/Rw=** 0.347595

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.000216 Ft/Min or 0.00011 CM/Sec

**K =** 0.311293 Ft/Day


Halifax County Landfill
MW-3ad Rising Head Test - 9/12/95
10
1
0.1
0.01
Drawdown (Feet)
0
2
4
6
8
10
12
Time (Minutes)




Curves relating coefficients A, B, and C to $L/r_W$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Landfill
MW-3ad

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-6 5 |
| | | **Reference:** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 9.2 |
| Le = Screened Interval Open to Aquifer = | 9.2 |
| Rw = Radius of Well Including Sand Pack = | 0.43 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 35 |
| Yo = Relative Height of Water at Time Zero = | 0.55 |
| Yt = Relative Height of Water at Time t = | 0.02 |
| n = Porosity = | 0.2 |
| Time Tt (in minutes) = | 3.5 |
| H - Lw = | 25.8 |
| Yo/Yt = | 27.5 |
| Lw/Rw = | 21.395349 |
| ln(H-Lw)/Rw = | 4.0943446 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 21.39535

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.2 |
| **B =** | 0.3 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-1**

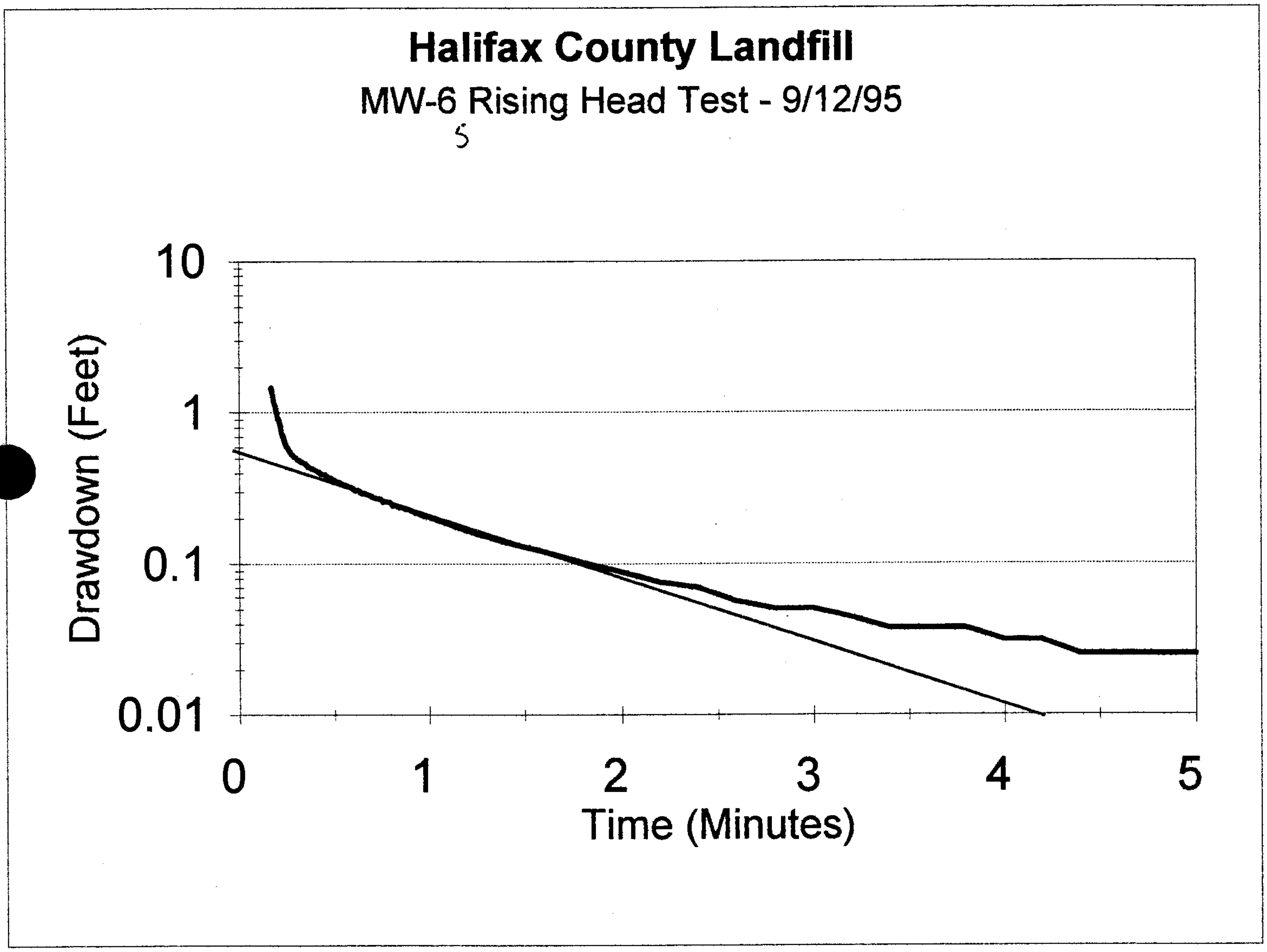
ln Re/Rw= 2.53158003 exp-1

**ln Re/Rw=** 0.39501023

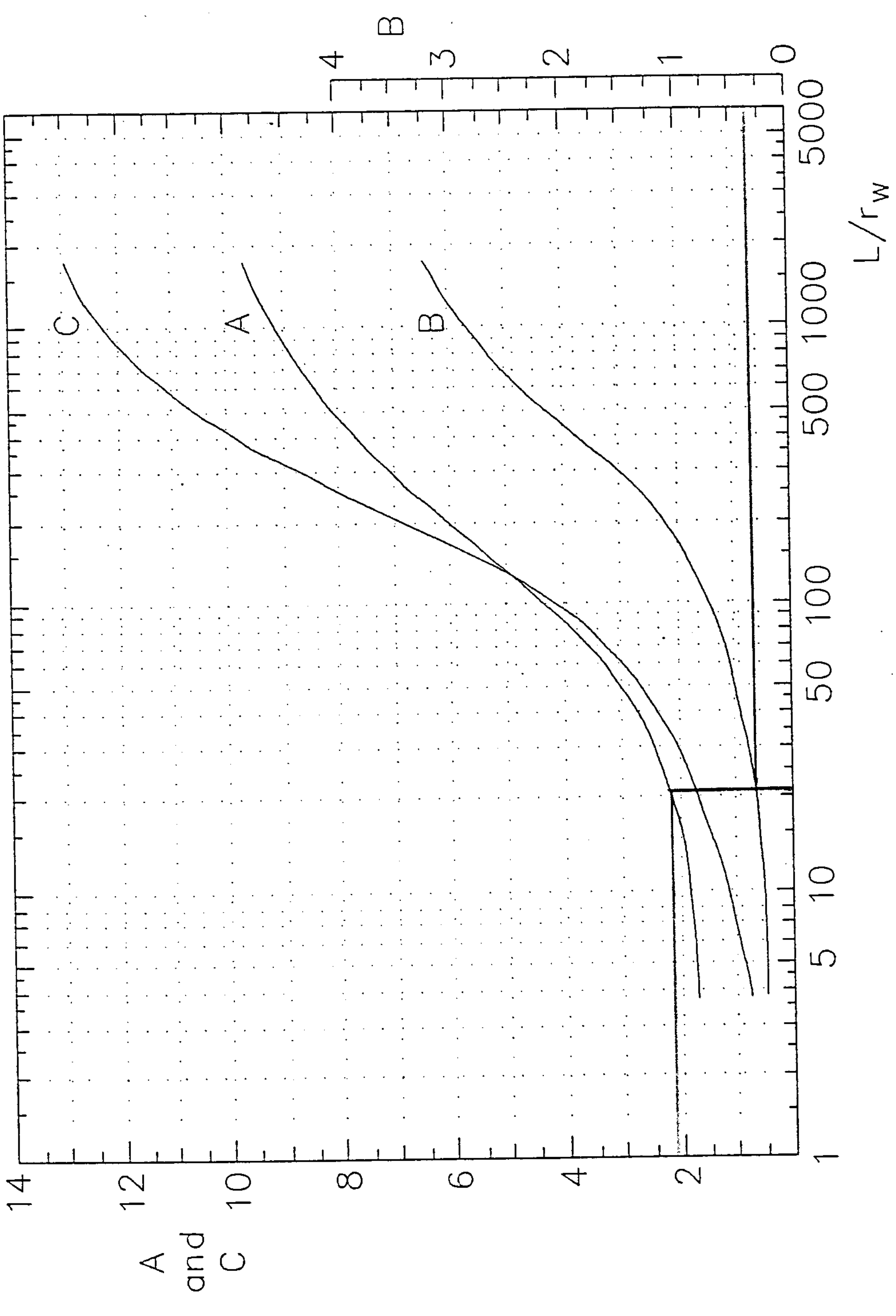
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 8.49E-05 Ft/Min or 4.32E-05 CM/Sec

**K =** 0.122328 Ft/Day



Halifax County Landfill
MW-6 Rising Head Test - 9/12/95
5
Drawdown (Feet)
10
1
0.1
0.01
0
1
2
3
4
5
Time (Minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Landfill
MW-6S

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-7 5 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 12.19 |
| | Le = Screened Interval Open to Aquifer = | 12.919 |
| | Rw = Radius of Well Including Sand Pack | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zer | 0.7 |
| | Yt = Relative Height of Water at Time t = | 0.05 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 2 |
| | H - Lw = | 22.81 |
| | Yo/Yt = | 14 |
| | Lw/Rw = | 28.34884 |
| | ln(H-Lw)/Rw = | 3.971169 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req = 0.212713**

**Evaluation of A and B:**

Le/Rw = 28.34884

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.4 |
| **B =** | 0.35 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

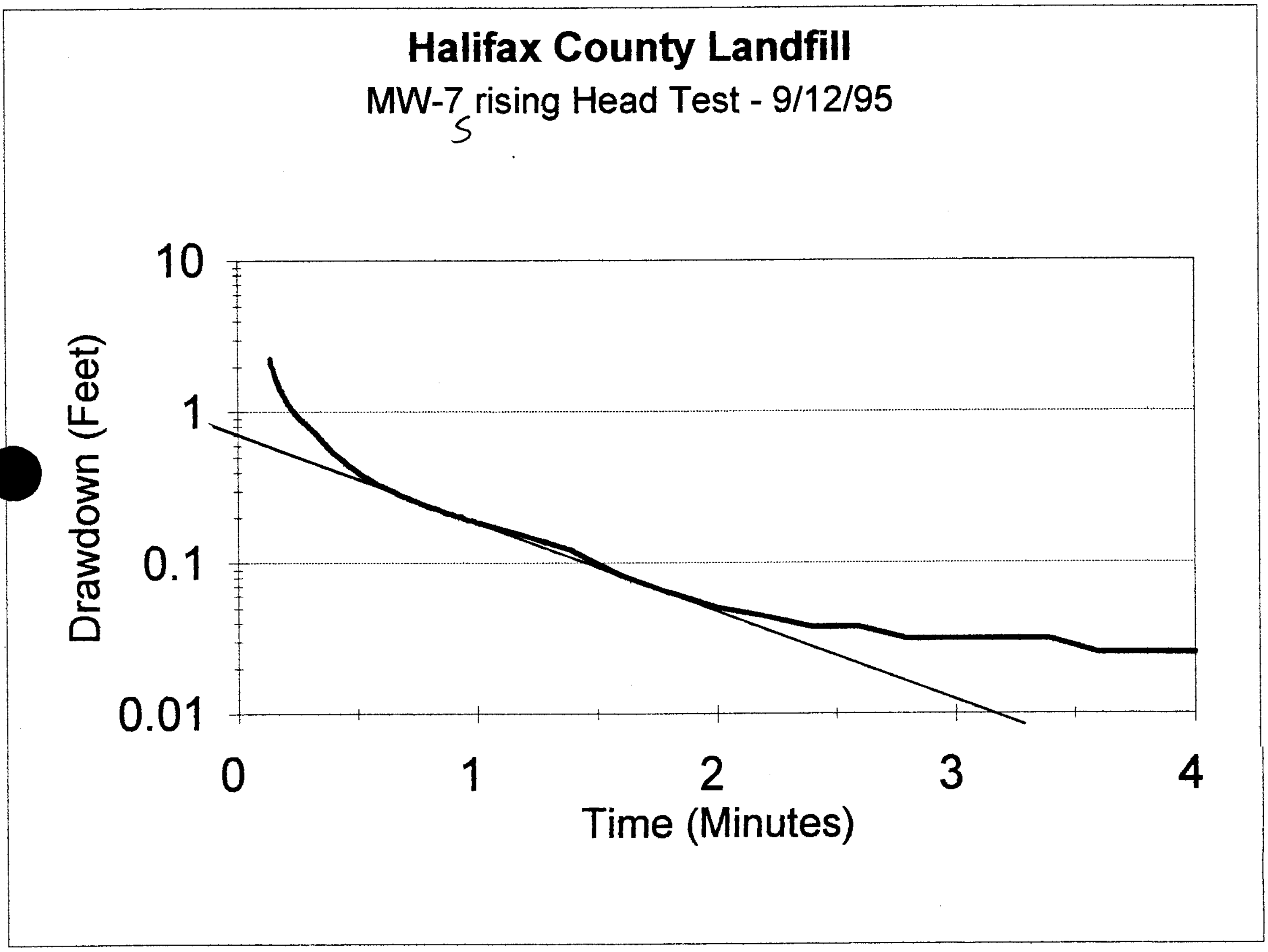
ln Re/Rw= 2.736511 exp-1

**ln Re/Rw=** 0.365429

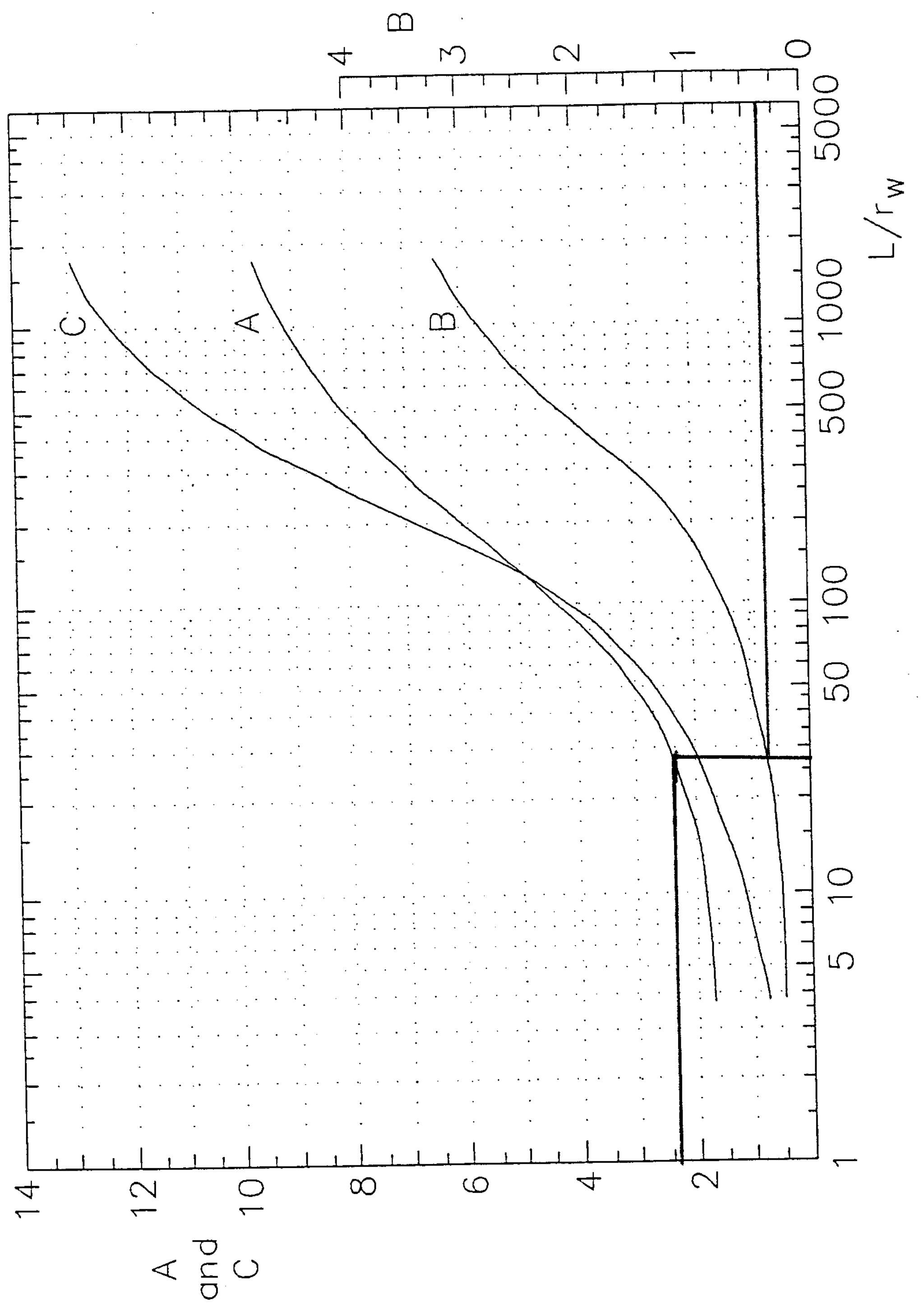
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 5.6E-05 Ft/Min or 2.84E-05 CM/Sec

**K =** 0.080589 Ft/Day



Halifax County Landfill
MW-7 rising Head Test - 9/12/95
S
10
1
0.1
0.01
Drawdown (Feet)
0
1
2
3
4
Time (Minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.


G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Landfill
mw-7s

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-16a |
| | | **Referenc**e | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 16.42 |
| Le = Screened Interval Open to Aquifer = | 16.42 |
| Rw = Radius of Well Including Sand Pack = | 0.43 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 35 |
| Yo = Relative Height of Water at Time Zero | 2.6 |
| Yt = Relative Height of Water at Time t = | 2 |
| n = Porosity = | 0.12 |
| Time Tt (in minutes) = | 3 |
| H - Lw = | 18.58 |
| Yo/Yt = | 1.3 |
| Lw/Rw = | 38.18605 |
| ln(H-Lw)/Rw = | 3.766056 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.029904

**Req =** 0.172927

**Evaluation of A and B:**

Le/Rw = 38.18605

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.7 |
| **B =** | 0.45 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

ln Re/Rw= 3.046374 exp-1

**ln Re/Rw=** 0.328259

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 2.61E-05 Ft/Min or 1.33E-05 CM/Sec

**K =** 0.037643 Ft/Day

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-16a |
| | | **Referenc**e | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 16.42 |
| | Le = Screened Interval Open to Aquifer = | 16.42 |
| | Rw = Radius of Well Including Sand Pack | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zer | 2.6 |
| | Yt = Relative Height of Water at Time t = | 2 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 3 |
| | H - Lw = | 18.58 |
| | Yo/Yt = | 1.3 |
| | Lw/Rw = | 38.18605 |
| | ln(H-Lw)/Rw = | 3.766056 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 38.18605

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.7 |
| **B =** | 0.45 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp**

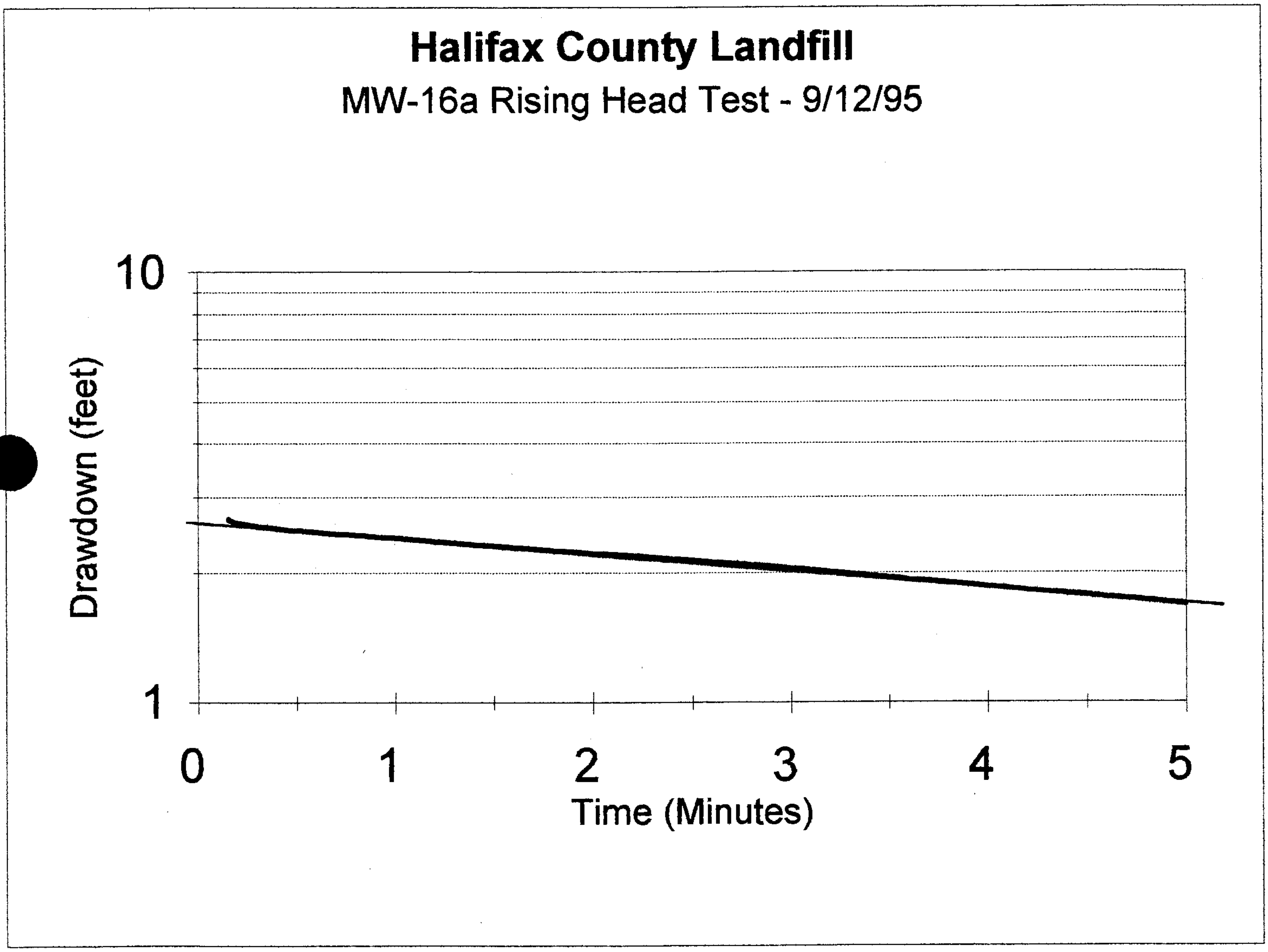
ln Re/Rw= 3.046374 exp-1

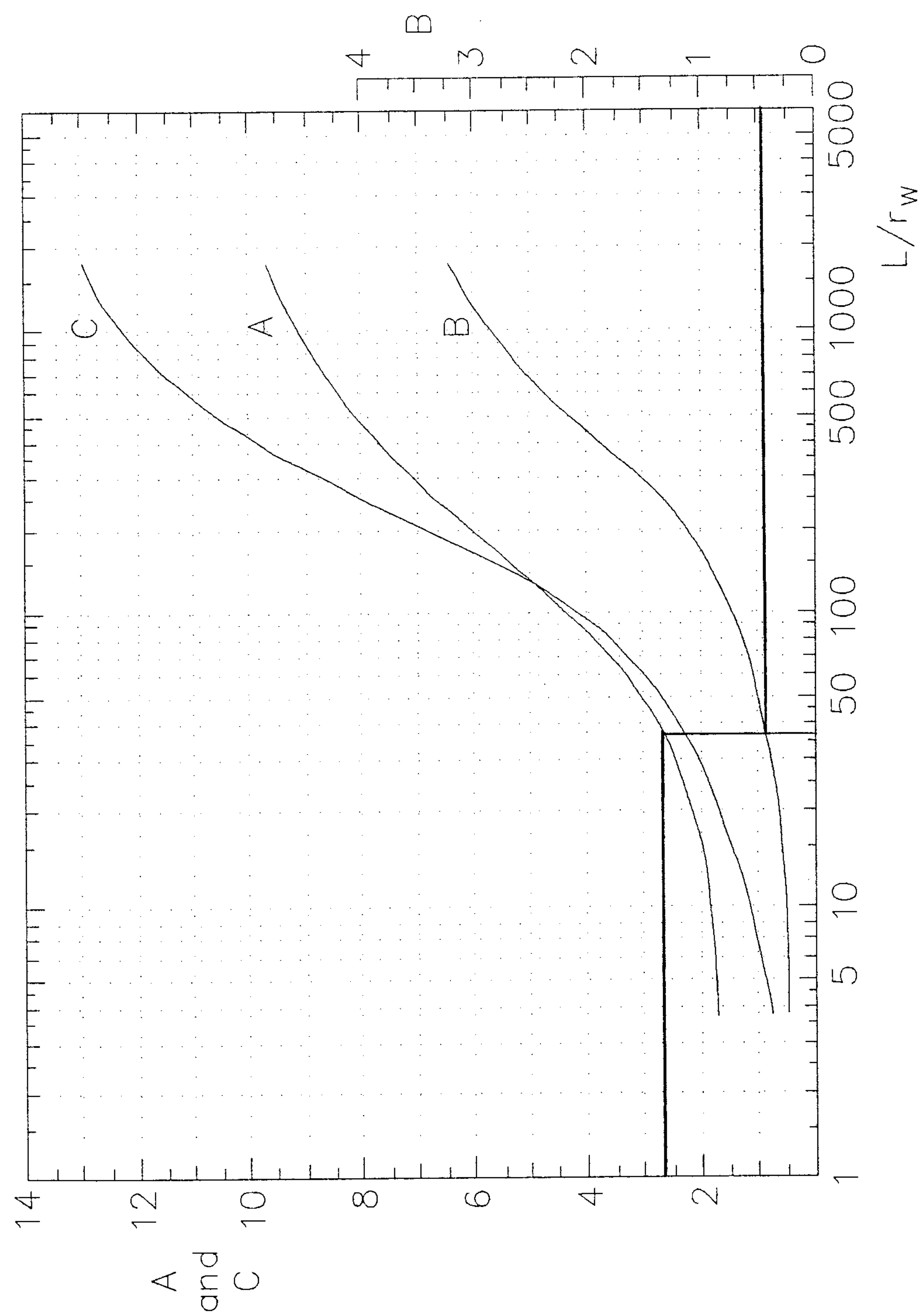
**ln Re/Rw=** 0.328259

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 4E-05 Ft/Min or 2E-05 CM/Sec

**K =** 0.056957 Ft/Day


Halifax County Landfill
MW-16a Rising Head Test - 9/12/95
10
1
Drawdown (feet)
0
1
2
3
4
5
Time (Minutes)




Curves relating coefficients A, B, and C to L/r_w

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Landfill
MW-16a

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-3 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 5.86 |
| Le = Screened Interval Open to Aquifer = | 5.86 |
| Rw = Radius of Well Including Sand Pack = | 0.167 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 22 |
| Yo = Relative Height of Water at Time Zero | 0.34 |
| Yt = Relative Height of Water at Time t = | 0.12 |
| n = Porosity = | 0.17 |
| Time Tt (in minutes) = | 2 |
| H - Lw = | 16.14 |
| Yo/Yt = | 2.833333 |
| Lw/Rw = | 35.08982 |
| ln(H-Lw)/Rw = | 4.571062 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.012801

**Req =** 0.113143

**Evaluation of A and B:**

Le/Rw = 35.08982

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.65 |
| **B =** | 0.4 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

ln Re/Rw= 3.011277 exp-1

**ln Re/Rw=** 0.332085

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.000189 Ft/Min or 9.6E-05 CM/Sec

**K =** 0.271986 Ft/Day

## G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-3 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 5.86 |
| Le = Screened Interval Open to Aquifer = | 5.86 |
| Rw = Radius of Well Including Sand Pack | 0.167 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 22 |
| Yo = Relative Height of Water at Time Zer | 0.34 |
| Yt = Relative Height of Water at Time t = | 0.12 |
| n = Porosity = | 0.2 |
| Time Tt (in minutes) = | 2 |
| H - Lw = | 16.14 |
| Yo/Yt = | 2.833333 |
| Lw/Rw = | 35.08982 |
| ln(H-Lw)/Rw = | 4.571062 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.013845

**Req =** 0.117663

**Evaluation of A and B:**

Le/Rw = 35.08982

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.65 |
| **B =** | 0.4 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

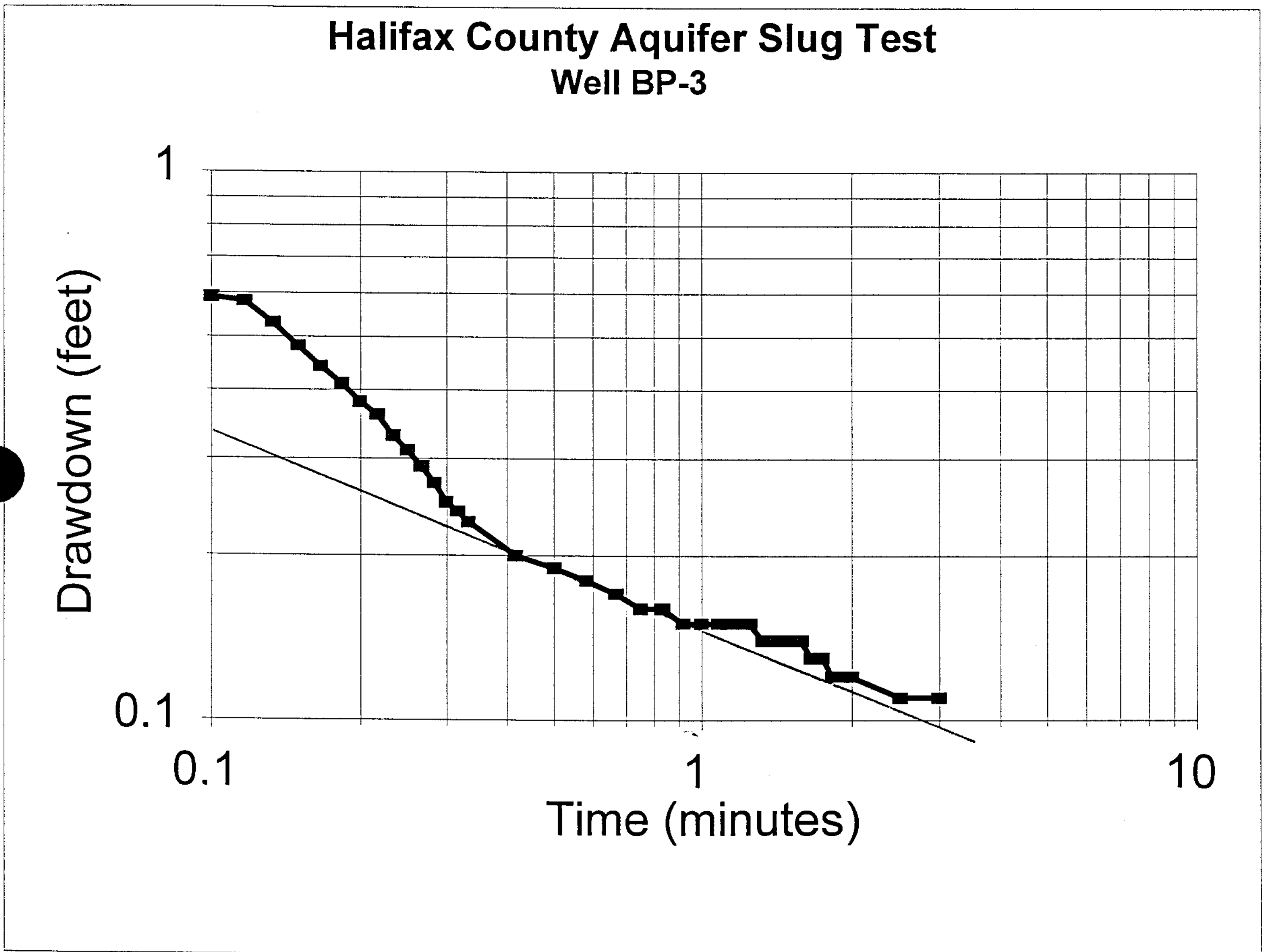
ln Re/Rw= 3.011277 exp-1

**ln Re/Rw=** 0.332085

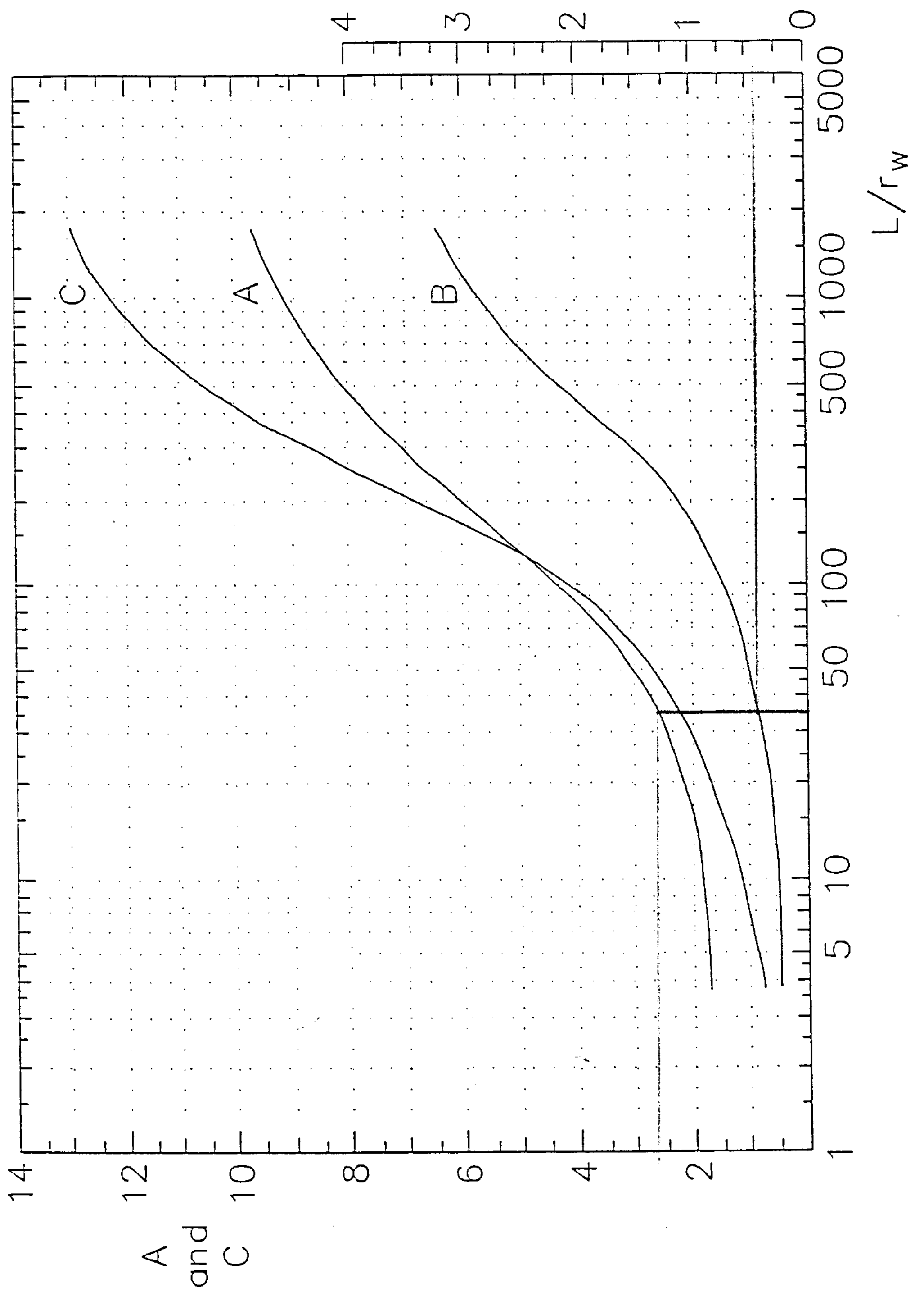
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.000204 Ft/Min or 0.000104 CM/Sec

**K =** 0.294154 Ft/Day



Halifax County Aquifer Slug Test
Well BP-3
1
0.1
Drawdown (feet)
0.1
1
10
Time (minutes)



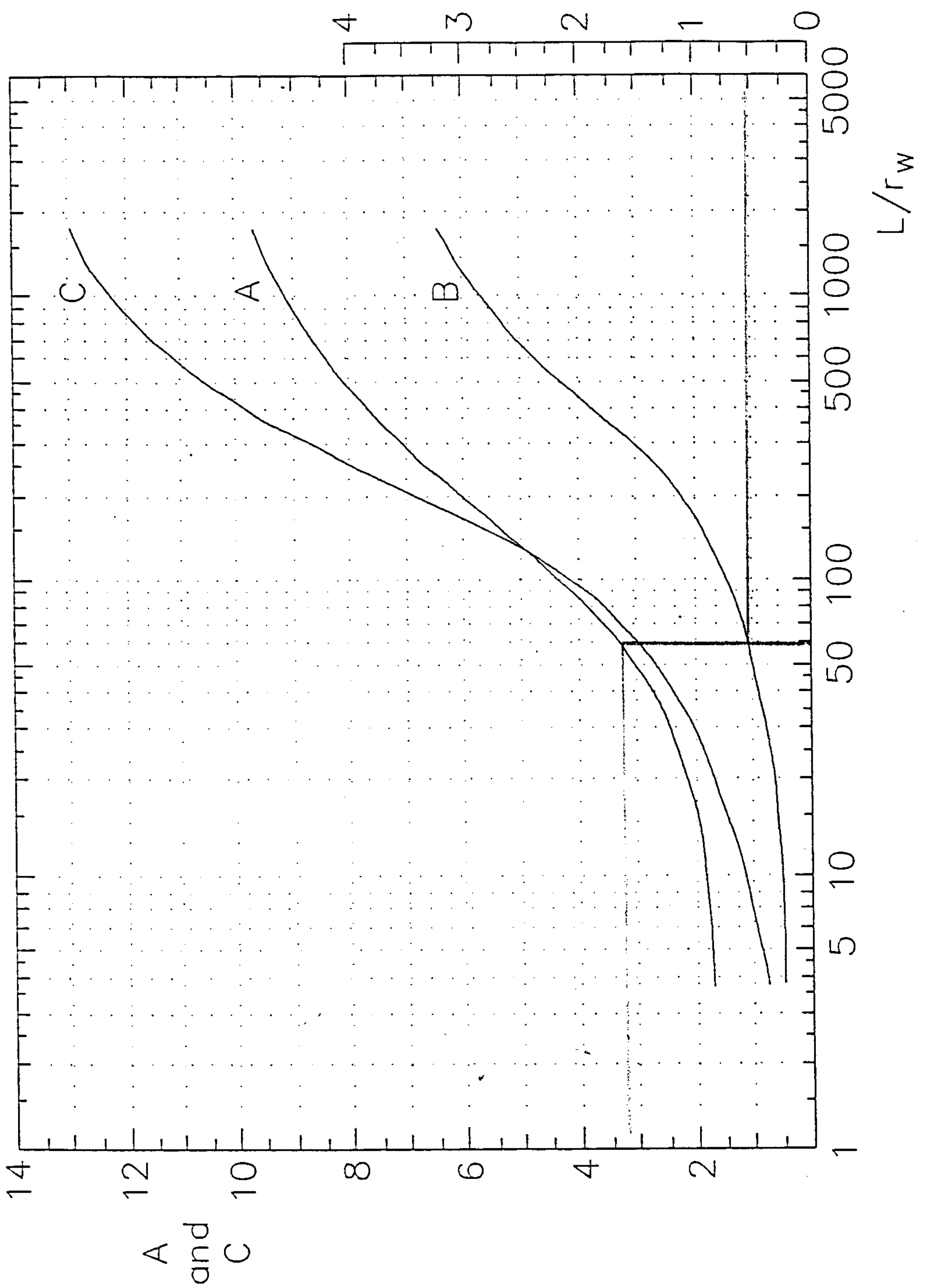

Curves relating coefficients A, B, and C to L/$r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.


G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-3

| | |
|---|---|
| [illegible] | [illegible] |
| 0.2333 | 43.67 |
| 0.2500 | 43.65 |
| 0.2666 | 43.63 |
| 0.2833 | 43.61 |




Curves relating coefficients A, B, and C to L/$r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.


G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-4

Halifax County BP-4 Slug Test

SE1000B
Environmental Logger
05/15 20:51

Unit# 00799 Test# 3

INPUT 1: Level (M) TOC

Reference 35.93
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 13:16

| Elapsed Time | Value |
|---|---|
| 0.0000 | 35.88 |
| 0.0033 | 35.89 |
| 0.0066 | 35.88 |
| 0.0099 | 36.80 |
| 0.0133 | 37.93 |
| 0.0166 | 37.06 |
| 0.0200 | 36.73 |
| 0.0233 | 36.77 |
| 0.0266 | 36.75 |
| 0.0300 | 36.74 |
| 0.0333 | 36.74 |
| 0.0500 | 36.75 |
| 0.0666 | 36.73 |
| 0.0833 | 36.73 |
| 0.1000 | 36.73 |
| 0.1166 | 36.73 |
| 0.1333 | 36.73 |
| 0.1500 | 36.73 |
| 0.1666 | 36.73 |
| 0.1833 | 36.72 |
| 0.2000 | 36.72 |
| 0.2166 | 36.72 |
| 0.2333 | 36.72 |
| 0.2500 | 36.72 |
| 0.2666 | 36.72 |
| 0.2833 | 36.72 |

| | |
|---|---|
| 0.3000 | 36.72 |
| 0.3166 | 36.72 |
| 0.3333 | 36.72 |
| 0.4167 | 36.71 |
| 0.5000 | 36.71 |
| 0.5833 | 36.70 |
| 0.6667 | 36.70 |
| 0.7500 | 36.70 |
| 0.8333 | 36.69 |
| 0.9167 | 36.69 |
| 1.0000 | 36.68 |
| 1.0833 | 36.68 |
| 1.1667 | 36.68 |
| 1.2500 | 36.67 |
| 1.3333 | 36.67 |
| 1.4166 | 36.66 |
| 1.5000 | 36.66 |
| 1.5833 | 36.66 |
| 1.6667 | 36.65 |
| 1.7500 | 36.65 |
| 1.8333 | 36.65 |
| 1.9167 | 36.65 |
| 2.0000 | 36.64 |
| 2.5000 | 36.62 |
| 3.0000 | 36.61 |
| 3.5000 | 36.59 |
| 4.0000 | 36.57 |
| 4.5000 | 36.55 |
| 5.0000 | 36.54 |
| 5.5000 | 36.52 |
| 6.0000 | 36.51 |
| 6.5000 | 36.49 |
| 7.0000 | 36.48 |
| 7.5000 | 36.47 |
| 8.0000 | 36.45 |
| 8.5000 | 36.44 |
| 9.0000 | 36.43 |
| 9.5000 | 36.42 |
| 10.0000 | 36.41 |
| 12.0000 | 36.37 |
| 14.0000 | 36.33 |

| | |
|---|---|
| 16.0000 | 36.30 |
| 18.0000 | 36.26 |
| 20.0000 | 36.24 |
| 22.0000 | 36.22 |
| 24.0000 | 36.19 |
| 26.0000 | 36.18 |
| 28.0000 | 36.16 |
| 30.0000 | 36.15 |
| 32.0000 | 36.13 |
| 34.0000 | 36.12 |
| 36.0000 | 36.11 |
| 38.0000 | 36.11 |
| 40.0000 | 36.10 |
| 42.0000 | 36.09 |
| 44.0000 | 36.08 |
| 46.0000 | 36.08 |
| 48.0000 | 36.07 |
| 50.0000 | 36.07 |
| 52.0000 | 36.06 |
| 54.0000 | 36.05 |
| 56.0000 | 36.05 |
| 58.0000 | 36.04 |
| 60.0000 | 36.04 |
| 62.0000 | 36.04 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-7 5 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| **Where:** | | |
|---|---|---|
| | Lw = Height of Water Column in Well = | 12.19 |
| | Le = Screened Interval Open to Aquifer = | 12.919 |
| | Rw = Radius of Well Including Sand Pack | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zer | 0.7 |
| | Yt = Relative Height of Water at Time t = | 0.05 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 2 |
| | H - Lw = | 22.81 |
| | Yo/Yt = | 14 |
| | Lw/Rw = | 28.34884 |
| | ln(H-Lw)/Rw = | 3.971169 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 28.34884

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.4 |
| **B =** | 0.35 |

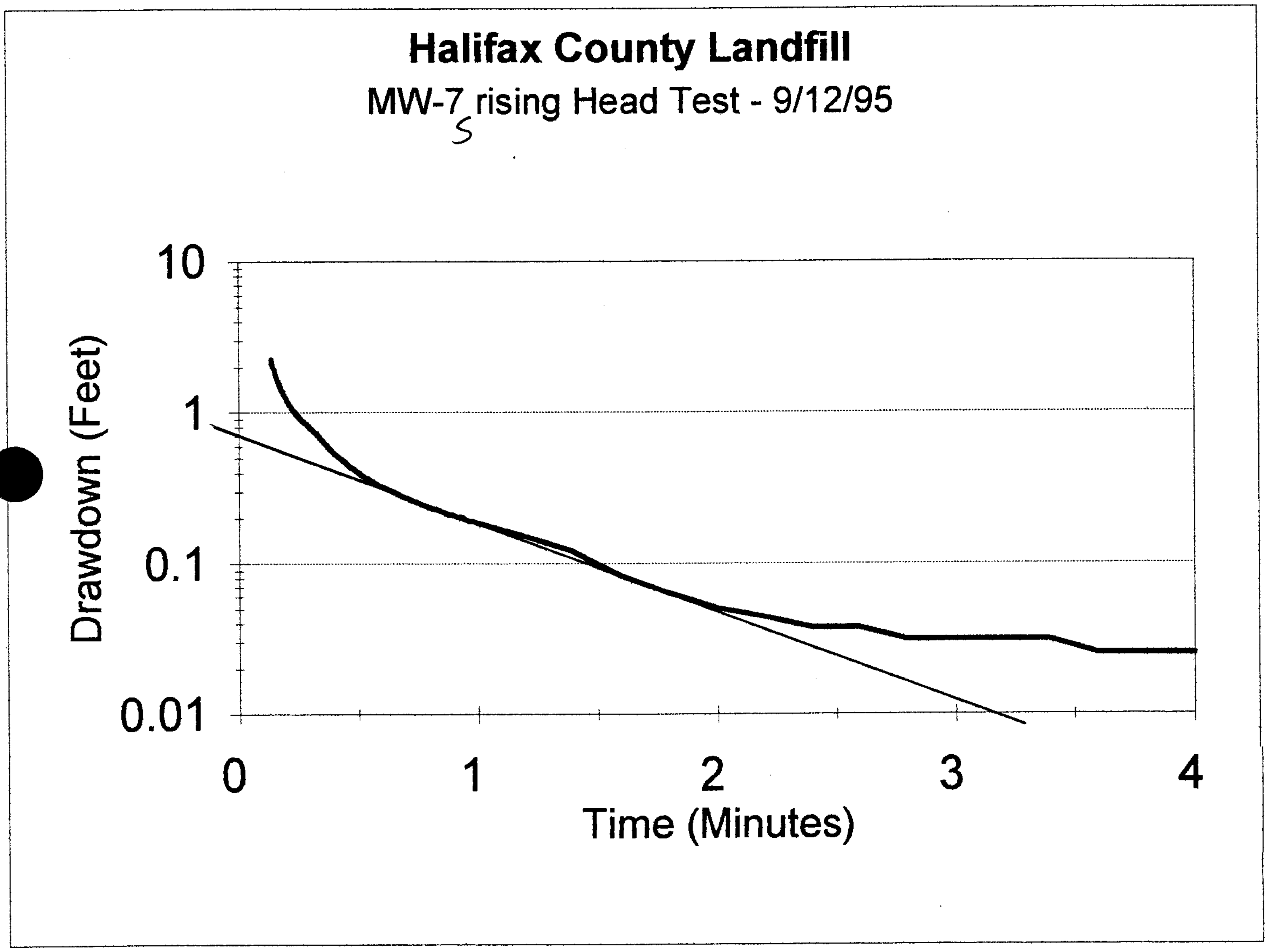
**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

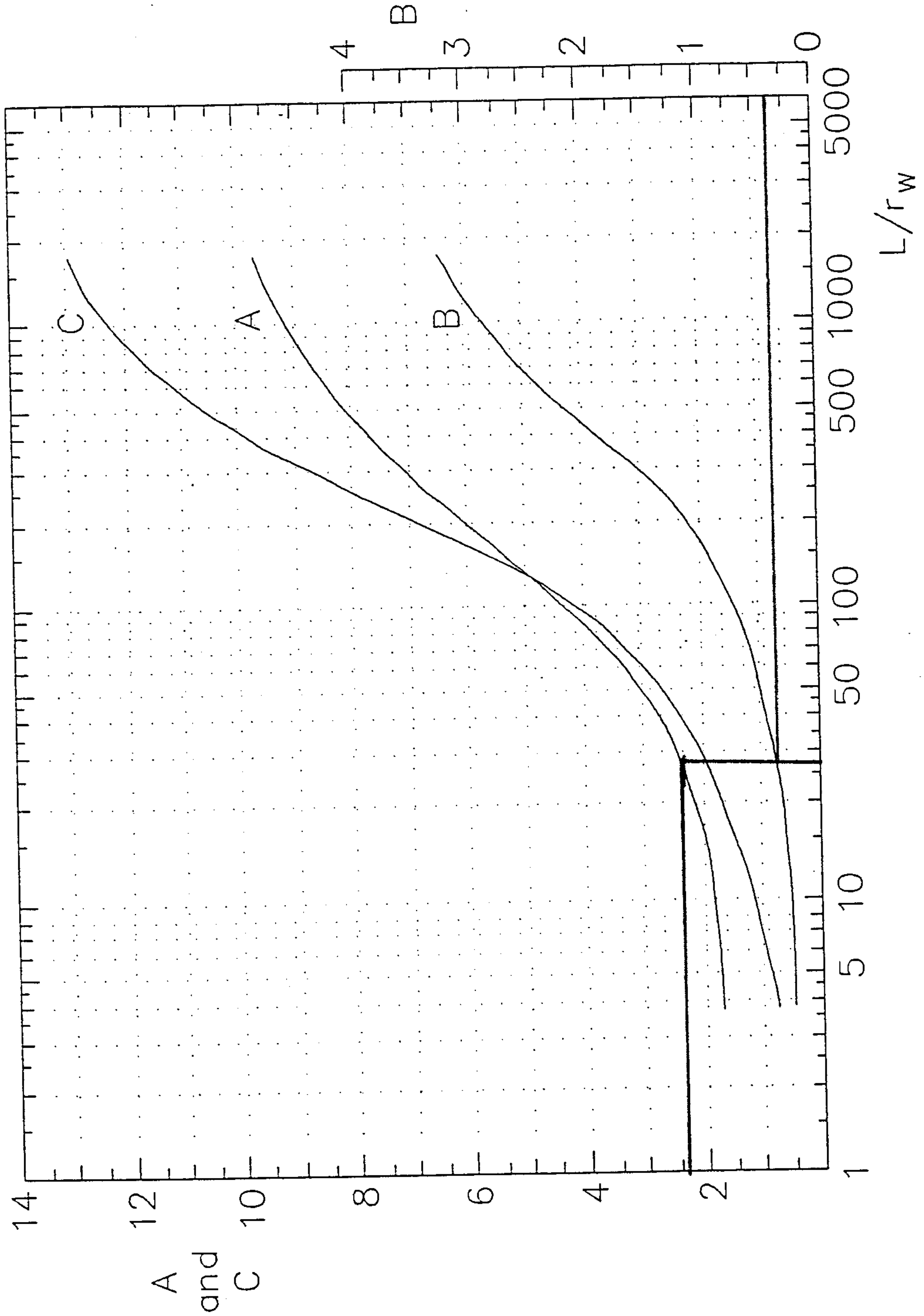
ln Re/Rw= 2.736511 exp-1

**ln Re/Rw=** 0.365429

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

| | | | | | |
|---|---|---|---|---|---|
| **K =** | 5.6E-05 | Ft/Min | or | 2.84E-05 | CM/Sec |
| **K =** | 0.080589 | Ft/Day | | | |


Halifax County Landfill
MW-7 rising Head Test - 9/12/95
S
10
1
0.1
0.01
Drawdown (Feet)
0
1
2
3
4
Time (Minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.


G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST

Halifax County Landfill

MW-7S

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-16a |
| | | **Reference** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 16.42 |
| | Le = Screened Interval Open to Aquifer = | 16.42 |
| | Rw = Radius of Well Including Sand Pack = | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 35 |
| | Yo = Relative Height of Water at Time Zero | 2.6 |
| | Yt = Relative Height of Water at Time t = | 2 |
| | n = Porosity = | 0.12 |
| | Time Tt (in minutes) = | 3 |
| | H - Lw = | 18.58 |
| | Yo/Yt = | 1.3 |
| | Lw/Rw = | 38.18605 |
| | ln(H-Lw)/Rw = | 3.766056 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.029904

**Req = 0.172927**

**Evaluation of A and B:**

Le/Rw = 38.18605

**From Attached Graph of A and B:**

**A =** 2.7

**B =** 0.45

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

ln Re/Rw= 3.046374 exp-1

**ln Re/Rw=** 0.328259

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 2.61E-05 Ft/Min or 1.33E-05 CM/Sec

**K =** 0.037643 Ft/Day

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 9/12/95 |
| | | **Well:** | MW-16a |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 16.42 |
| Le = Screened Interval Open to Aquifer = | 16.42 |
| Rw = Radius of Well Including Sand Pack | 0.43 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 35 |
| Yo = Relative Height of Water at Time Zer | 2.6 |
| Yt = Relative Height of Water at Time t = | 2 |
| n = Porosity = | 0.2 |
| Time Tt (in minutes) = | 3 |
| H - Lw = | 18.58 |
| Yo/Yt = | 1.3 |
| Lw/Rw = | 38.18605 |
| ln(H-Lw)/Rw = | 3.766056 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.045247

**Req =** 0.212713

**Evaluation of A and B:**

Le/Rw = 38.18605

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.7 |
| **B =** | 0.45 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp**

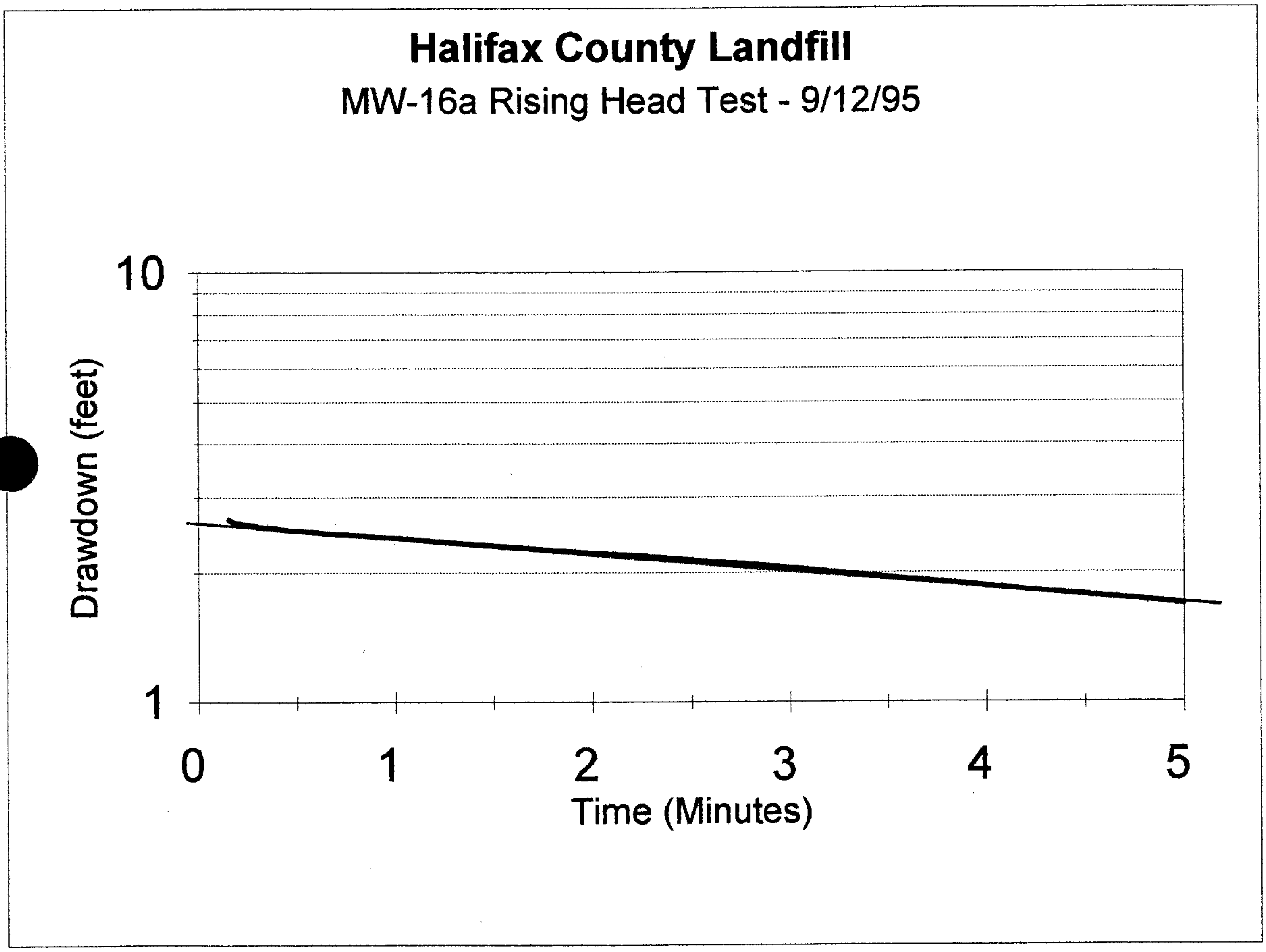
ln Re/Rw= 3.046374 exp-1

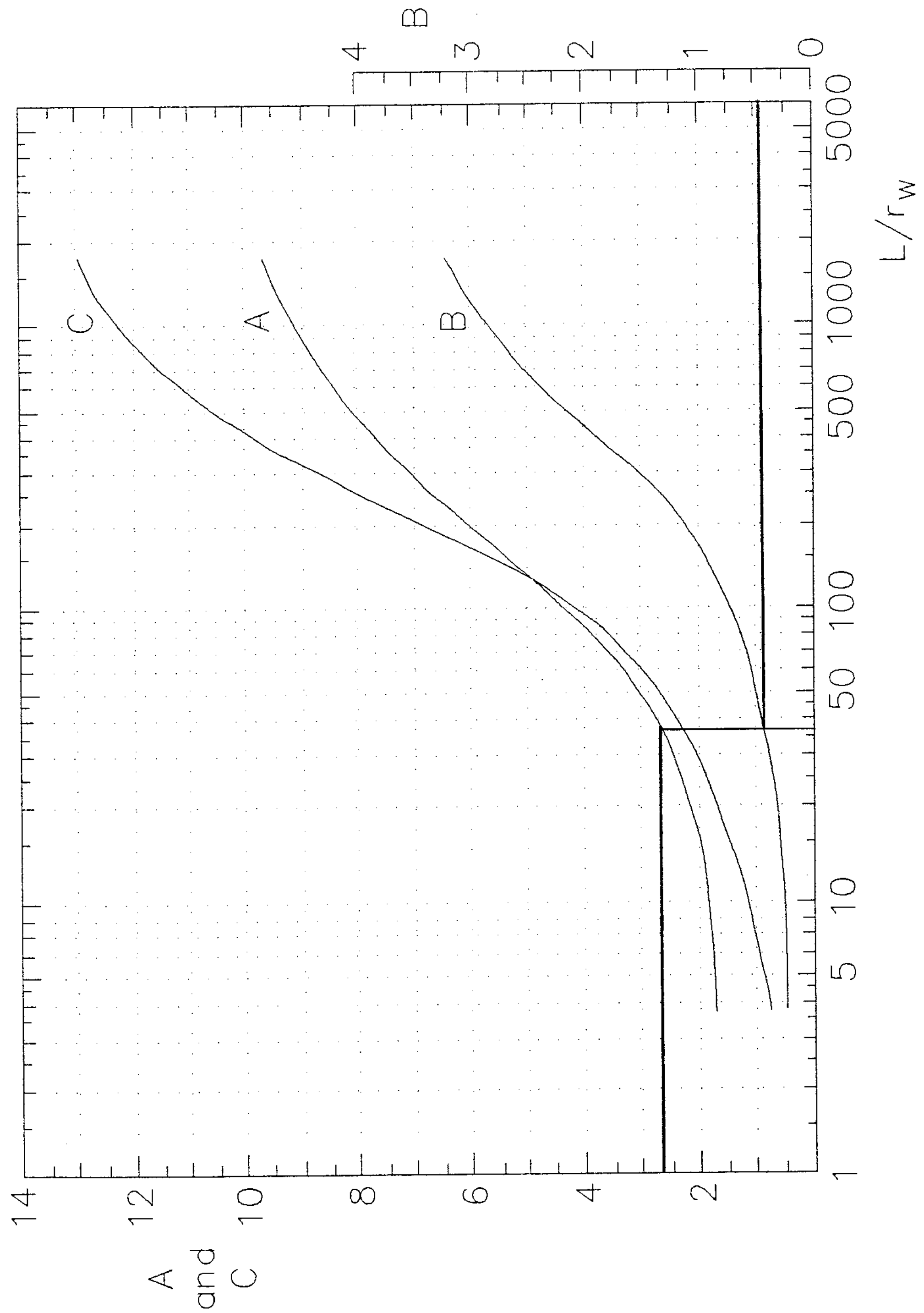
**ln Re/Rw=** 0.328259

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 4E-05 Ft/Min or 2E-05 CM/Sec

**K =** 0.056957 Ft/Day


Halifax County Landfill
MW-16a Rising Head Test - 9/12/95
10
1
Drawdown (feet)
0
1
2
3
4
5
Time (Minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.


G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST

Halifax County Landfill

MW-16a

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-3 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 5.86 |
| Le = Screened Interval Open to Aquifer = | 5.86 |
| Rw = Radius of Well Including Sand Pack = | 0.167 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 22 |
| Yo = Relative Height of Water at Time Zero | 0.34 |
| Yt = Relative Height of Water at Time t = | 0.12 |
| n = Porosity = | 0.17 |
| Time Tt (in minutes) = | 2 |
| H - Lw = | 16.14 |
| Yo/Yt = | 2.833333 |
| Lw/Rw = | 35.08982 |
| ln(H-Lw)/Rw = | 4.571062 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.012801

**Req =** 0.113143

**Evaluation of A and B:**

Le/Rw = 35.08982

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.65 |
| **B =** | 0.4 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

ln Re/Rw= 3.011277 exp-1

**ln Re/Rw=** 0.332085

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

| | | | |
|---|---|---|---|
| **K =** | 0.000189 Ft/Min | or | 9.6E-05 CM/Sec |
| **K =** | 0.271986 Ft/Day | | |

## G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-3 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 5.86 |
| Le = Screened Interval Open to Aquifer = | 5.86 |
| Rw = Radius of Well Including Sand Pack | 0.167 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 22 |
| Yo = Relative Height of Water at Time Zer | 0.34 |
| Yt = Relative Height of Water at Time t = | 0.12 |
| n = Porosity = | 0.2 |
| Time Tt (in minutes) = | 2 |
| H - Lw = | 16.14 |
| Yo/Yt = | 2.833333 |
| Lw/Rw = | 35.08982 |
| ln(H-Lw)/Rw = | 4.571062 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.013845

**Req =** 0.117663

**Evaluation of A and B:**

Le/Rw = 35.08982

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.65 |
| **B =** | 0.4 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

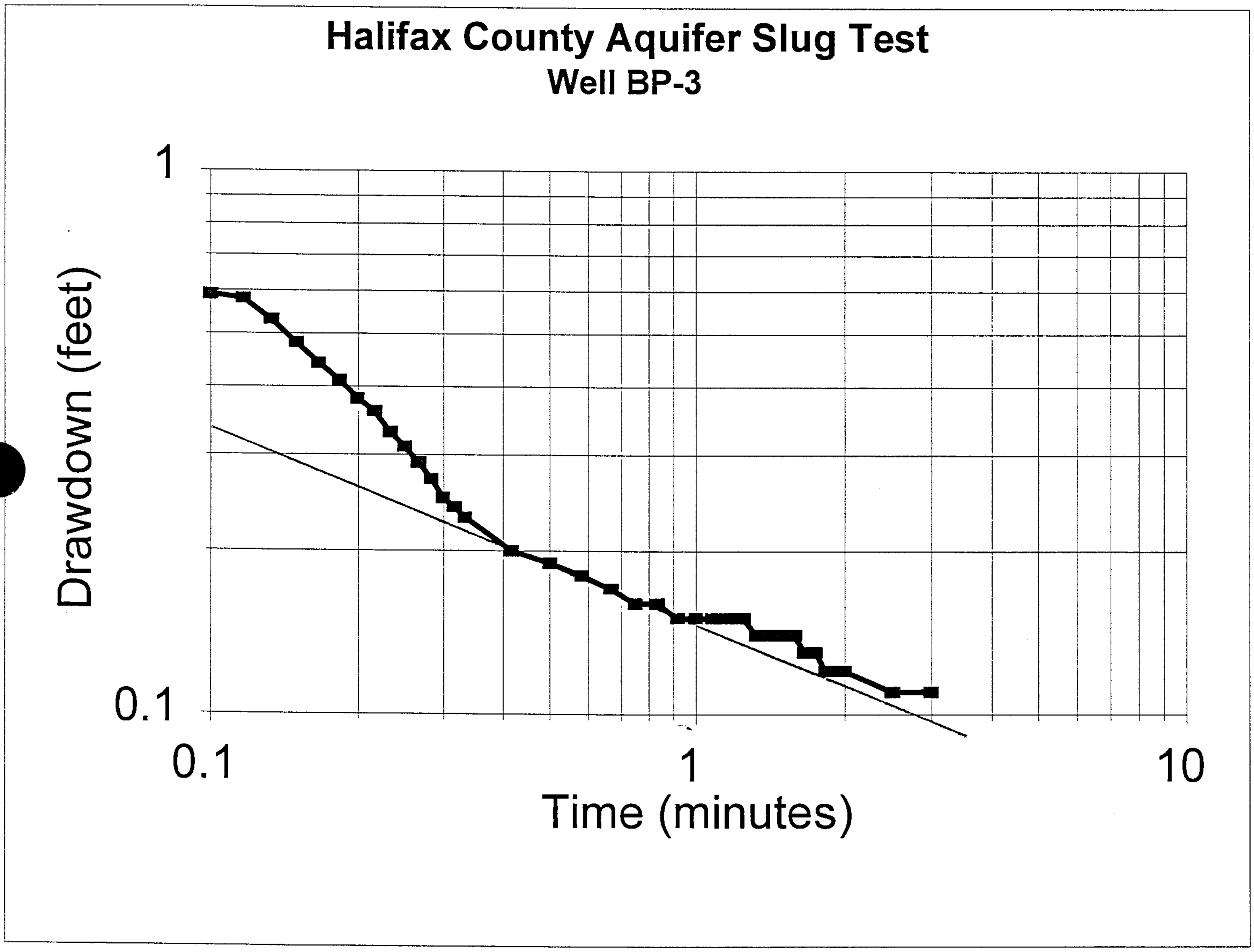
ln Re/Rw= 3.011277 exp-1

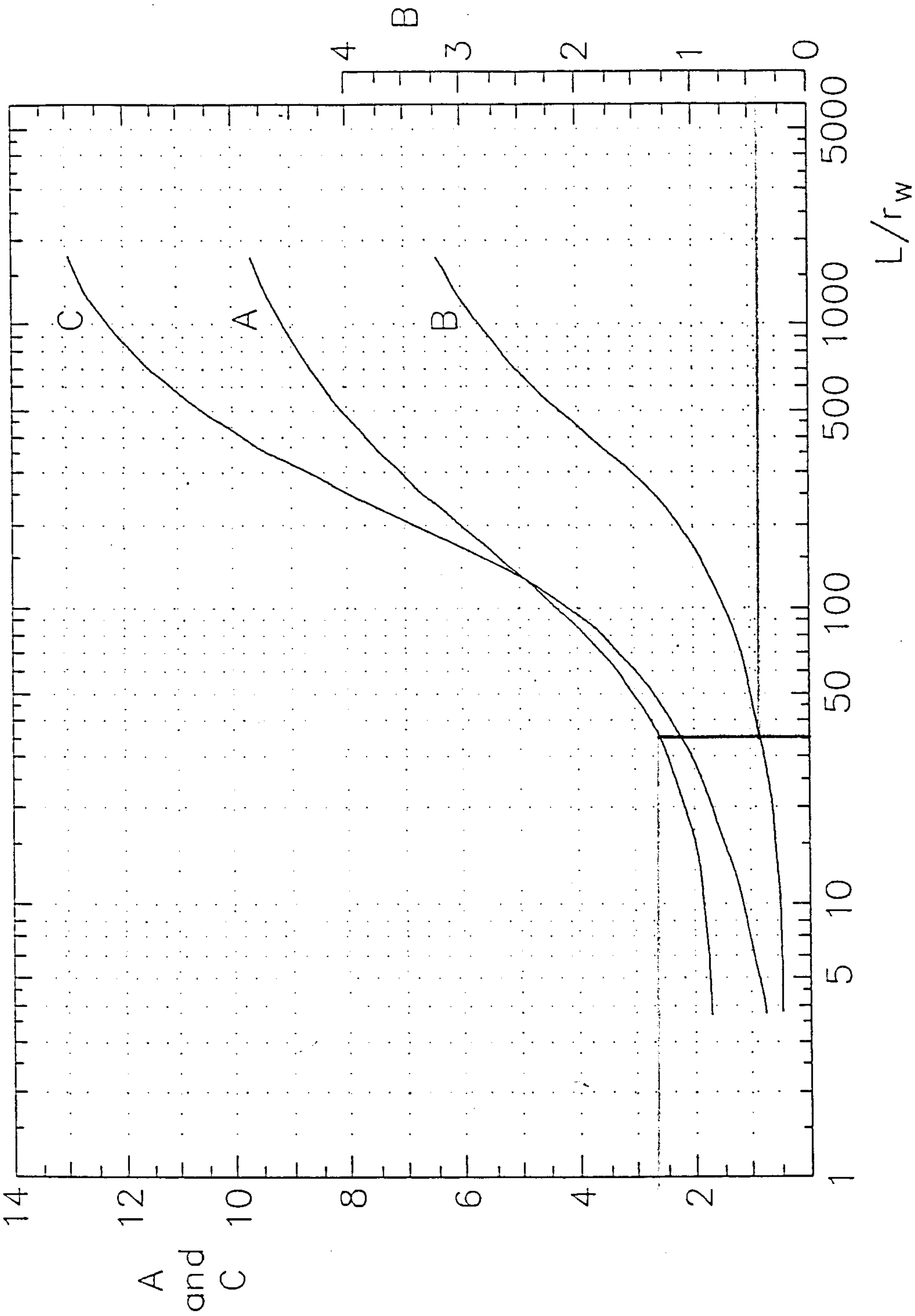
**ln Re/Rw=** 0.332085

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.000204 Ft/Min or 0.000104 CM/Sec

**K =** 0.294154 Ft/Day


Halifax County Aquifer Slug Test
Well BP-3
1
0.1
Drawdown (feet)
0.1
1
10
Time (minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-3

Halifax County BP-3 Slug Test

SE1000B
Environmental Logger
05/16 14:09

Unit# 00799 Test# 0

INPUT 1: Level (M) TOC

Reference 43.34
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 07:40

| Elapsed Time | Value |
|---|---|
| 0.0000 | 43.30 |
| 0.0033 | 43.30 |
| 0.0066 | 43.30 |
| 0.0099 | 43.35 |
| 0.0133 | 43.75 |
| 0.0166 | 44.32 |
| 0.0200 | 44.21 |
| 0.0233 | 44.06 |
| 0.0266 | 43.78 |
| 0.0300 | 44.14 |
| 0.0333 | 44.16 |
| 0.0500 | 44.10 |
| 0.0666 | 44.02 |
| 0.0833 | 43.98 |
| 0.1000 | 43.93 |
| 0.1166 | 43.92 |
| 0.1333 | 43.87 |
| 0.1500 | 43.82 |
| 0.1666 | 43.78 |
| 0.1833 | 43.75 |
| 0.2000 | 43.72 |
| 0.2166 | 43.70 |
| 0.2333 | 43.67 |
| 0.2500 | 43.65 |
| 0.2666 | 43.63 |
| 0.2833 | 43.61 |

| | |
|---|---|
| 0.3000 | 43.59 |
| 0.3166 | 43.58 |
| 0.3333 | 43.57 |
| 0.4167 | 43.54 |
| 0.5000 | 43.53 |
| 0.5833 | 43.52 |
| 0.6667 | 43.51 |
| 0.7500 | 43.50 |
| 0.8333 | 43.50 |
| 0.9167 | 43.49 |
| 1.0000 | 43.49 |
| 1.0833 | 43.49 |
| 1.1667 | 43.49 |
| 1.2500 | 43.49 |
| 1.3333 | 43.48 |
| 1.4166 | 43.48 |
| 1.5000 | 43.48 |
| 1.5833 | 43.48 |
| 1.6667 | 43.47 |
| 1.7500 | 43.47 |
| 1.8333 | 43.46 |
| 1.9167 | 43.46 |
| 2.0000 | 43.46 |
| 2.5000 | 43.45 |
| 3.0000 | 43.45 |
| 3.5000 | 43.44 |
| 4.0000 | 43.44 |
| 4.5000 | 43.43 |
| 5.0000 | 43.43 |
| 5.5000 | 43.43 |
| 6.0000 | 43.42 |
| 6.5000 | 43.42 |
| 7.0000 | 43.41 |
| 7.5000 | 43.41 |
| 8.0000 | 43.41 |
| 8.5000 | 43.41 |
| 9.0000 | 43.40 |
| 9.5000 | 43.40 |
| 10.0000 | 43.40 |
| 12.0000 | 43.39 |
| 14.0000 | 43.38 |

| | |
|---|---|
| 16.0000 | 43.38 |
| 18.0000 | 43.37 |
| 20.0000 | 43.37 |
| 22.0000 | 43.36 |
| 24.0000 | 43.35 |
| 26.0000 | 43.35 |
| 28.0000 | 43.35 |
| 30.0000 | 43.35 |
| 32.0000 | 43.34 |
| 34.0000 | 43.34 |
| 36.0000 | 43.34 |
| 38.0000 | 43.33 |
| 40.0000 | 43.32 |
| 42.0000 | 43.32 |
| 44.0000 | 43.32 |
| 46.0000 | 43.32 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-4 |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 14.03 |
| | Le = Screened Interval Open to Aquifer = | 10 |
| | Rw = Radius of Well Including Sand Pack = | 0.167 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 40 |
| | Yo = Relative Height of Water at Time Zero | 0.81 |
| | Yt = Relative Height of Water at Time t = | 0.62 |
| | n = Porosity = | 0.17 |
| | Time Tt (in minutes) = | 2.5 |
| | H - Lw = | 25.97 |
| | Yo/Yt = | 1.306452 |
| | Lw/Rw = | 84.01198 |
| | ln(H-Lw)/Rw = | 5.046703 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 59.88024

**From Attached Graph of A and B:**

**A =** 3.2

**B =** 0.5

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

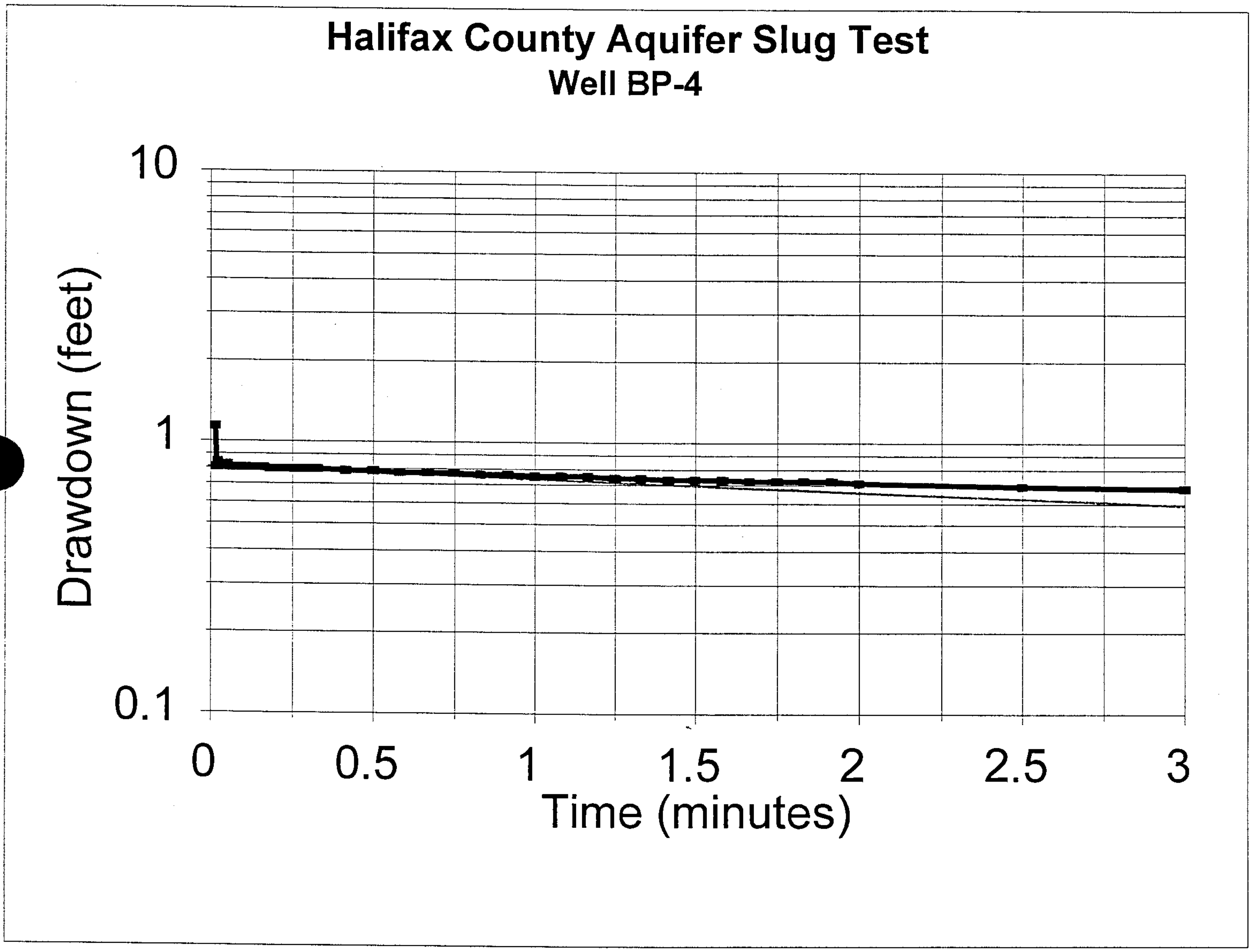
ln Re/Rw= 3.490393 exp-1

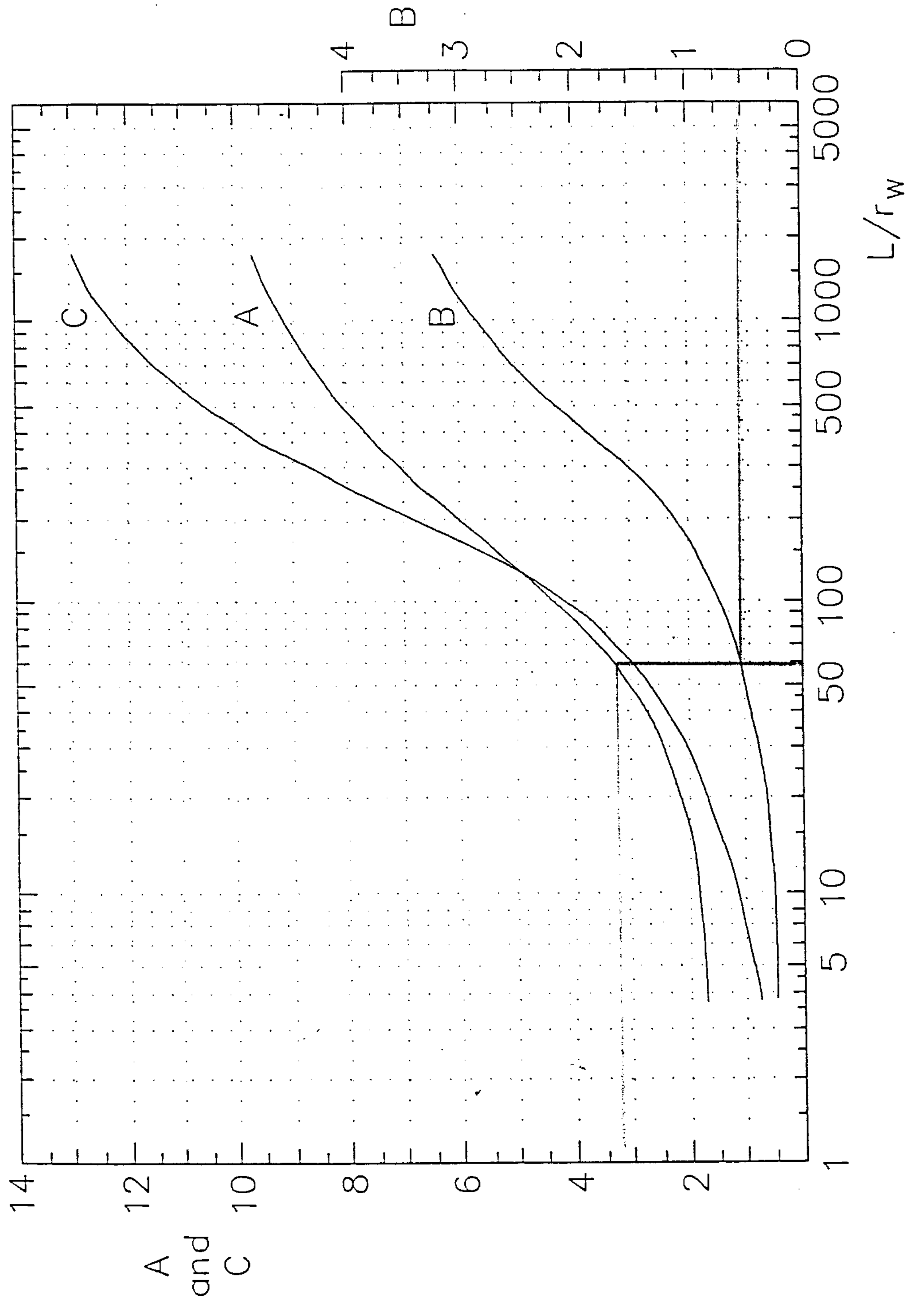
**ln Re/Rw=** 0.286501

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.001532 Ft/Min or 0.000778 CM/Sec

**K =** 2.205673 Ft/Day


Halifax County Aquifer Slug Test
Well BP-4
Drawdown (feet)
10
1
0.1
0
0.5
1
1.5
2
2.5
3
Time (minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-4

Halifax County BP-4 Slug Test

SE1000B
Environmental Logger
05/15 20:51

Unit# 00799 Test# 3

INPUT 1: Level (M) TOC

Reference 35.93
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 13:16

| Elapsed Time | Value |
|---|---|
| 0.0000 | 35.88 |
| 0.0033 | 35.89 |
| 0.0066 | 35.88 |
| 0.0099 | 36.80 |
| 0.0133 | 37.93 |
| 0.0166 | 37.06 |
| 0.0200 | 36.73 |
| 0.0233 | 36.77 |
| 0.0266 | 36.75 |
| 0.0300 | 36.74 |
| 0.0333 | 36.74 |
| 0.0500 | 36.75 |
| 0.0666 | 36.73 |
| 0.0833 | 36.73 |
| 0.1000 | 36.73 |
| 0.1166 | 36.73 |
| 0.1333 | 36.73 |
| 0.1500 | 36.73 |
| 0.1666 | 36.73 |
| 0.1833 | 36.72 |
| 0.2000 | 36.72 |
| 0.2166 | 36.72 |
| 0.2333 | 36.72 |
| 0.2500 | 36.72 |
| 0.2666 | 36.72 |
| 0.2833 | 36.72 |

| | |
|---|---|
| 0.3000 | 36.72 |
| 0.3166 | 36.72 |
| 0.3333 | 36.72 |
| 0.4167 | 36.71 |
| 0.5000 | 36.71 |
| 0.5833 | 36.70 |
| 0.6667 | 36.70 |
| 0.7500 | 36.70 |
| 0.8333 | 36.69 |
| 0.9167 | 36.69 |
| 1.0000 | 36.68 |
| 1.0833 | 36.68 |
| 1.1667 | 36.68 |
| 1.2500 | 36.67 |
| 1.3333 | 36.67 |
| 1.4166 | 36.66 |
| 1.5000 | 36.66 |
| 1.5833 | 36.66 |
| 1.6667 | 36.65 |
| 1.7500 | 36.65 |
| 1.8333 | 36.65 |
| 1.9167 | 36.65 |
| 2.0000 | 36.64 |
| 2.5000 | 36.62 |
| 3.0000 | 36.61 |
| 3.5000 | 36.59 |
| 4.0000 | 36.57 |
| 4.5000 | 36.55 |
| 5.0000 | 36.54 |
| 5.5000 | 36.52 |
| 6.0000 | 36.51 |
| 6.5000 | 36.49 |
| 7.0000 | 36.48 |
| 7.5000 | 36.47 |
| 8.0000 | 36.45 |
| 8.5000 | 36.44 |
| 9.0000 | 36.43 |
| 9.5000 | 36.42 |
| 10.0000 | 36.41 |
| 12.0000 | 36.37 |
| 14.0000 | 36.33 |

| | |
|---|---|
| 16.0000 | 36.30 |
| 18.0000 | 36.26 |
| 20.0000 | 36.24 |
| 22.0000 | 36.22 |
| 24.0000 | 36.19 |
| 26.0000 | 36.18 |
| 28.0000 | 36.16 |
| 30.0000 | 36.15 |
| 32.0000 | 36.13 |
| 34.0000 | 36.12 |
| 36.0000 | 36.11 |
| 38.0000 | 36.11 |
| 40.0000 | 36.10 |
| 42.0000 | 36.09 |
| 44.0000 | 36.08 |
| 46.0000 | 36.08 |
| 48.0000 | 36.07 |
| 50.0000 | 36.07 |
| 52.0000 | 36.06 |
| 54.0000 | 36.05 |
| 56.0000 | 36.05 |
| 58.0000 | 36.04 |
| 60.0000 | 36.04 |
| 62.0000 | 36.04 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-6 |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 13.6 |
| | Le = Screened Interval Open to Aquifer = | 10 |
| | Rw = Radius of Well Including Sand Pack = | 0.167 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 40 |
| | Yo = Relative Height of Water at Time Zero | 1 |
| | Yt = Relative Height of Water at Time t = | 0.2 |
| | n = Porosity = | 0.17 |
| | Time Tt (in minutes) = | 2.75 |
| | H - Lw = | 26.4 |
| | Yo/Yt = | 5 |
| | Lw/Rw = | 81.43713 |
| | ln(H-Lw)/Rw = | 5.063125 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 59.88024

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 3.6 |
| **B =** | 0.6 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

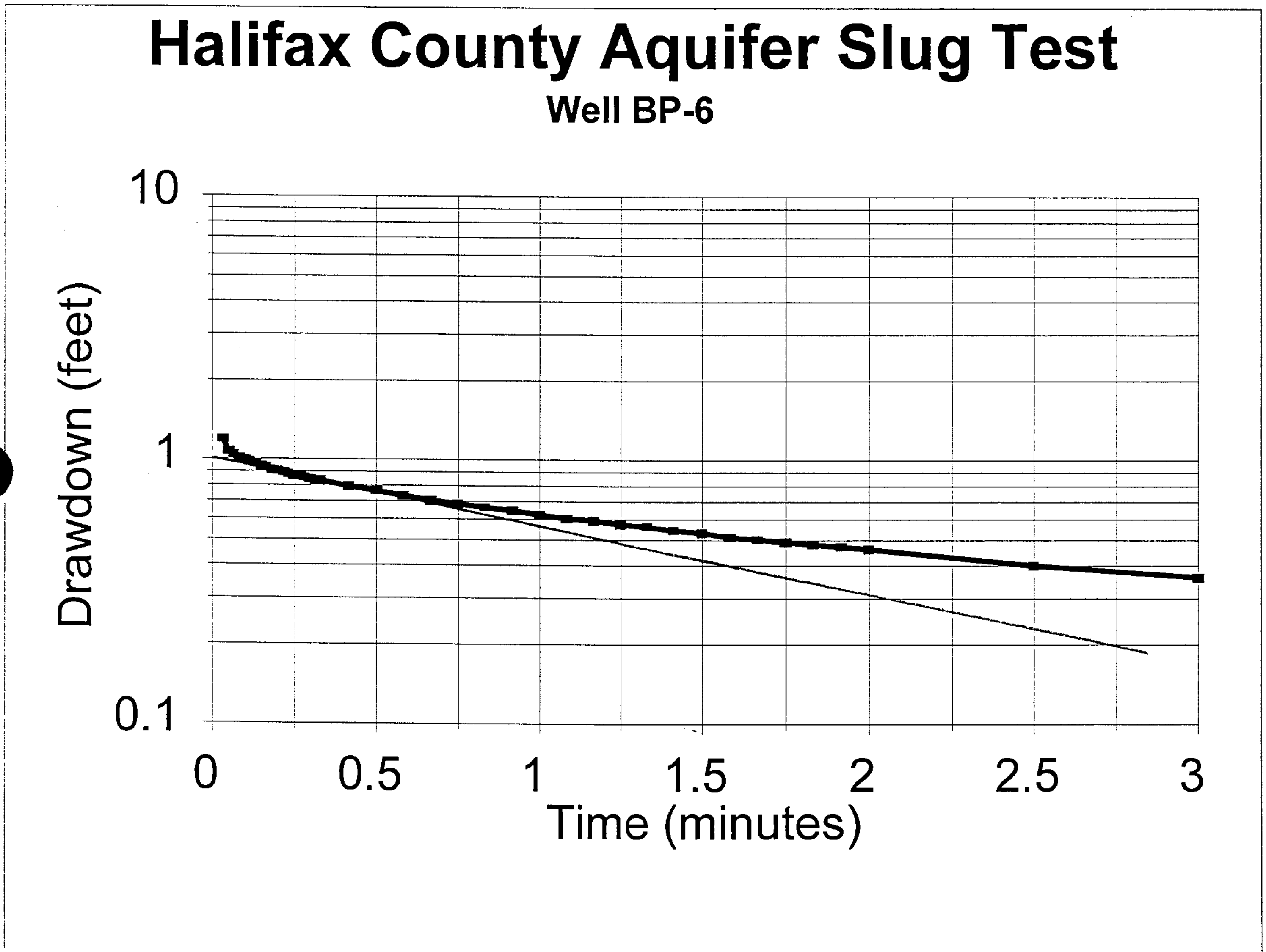
ln Re/Rw= 3.900742 exp-1

**ln Re/Rw=** 0.256361

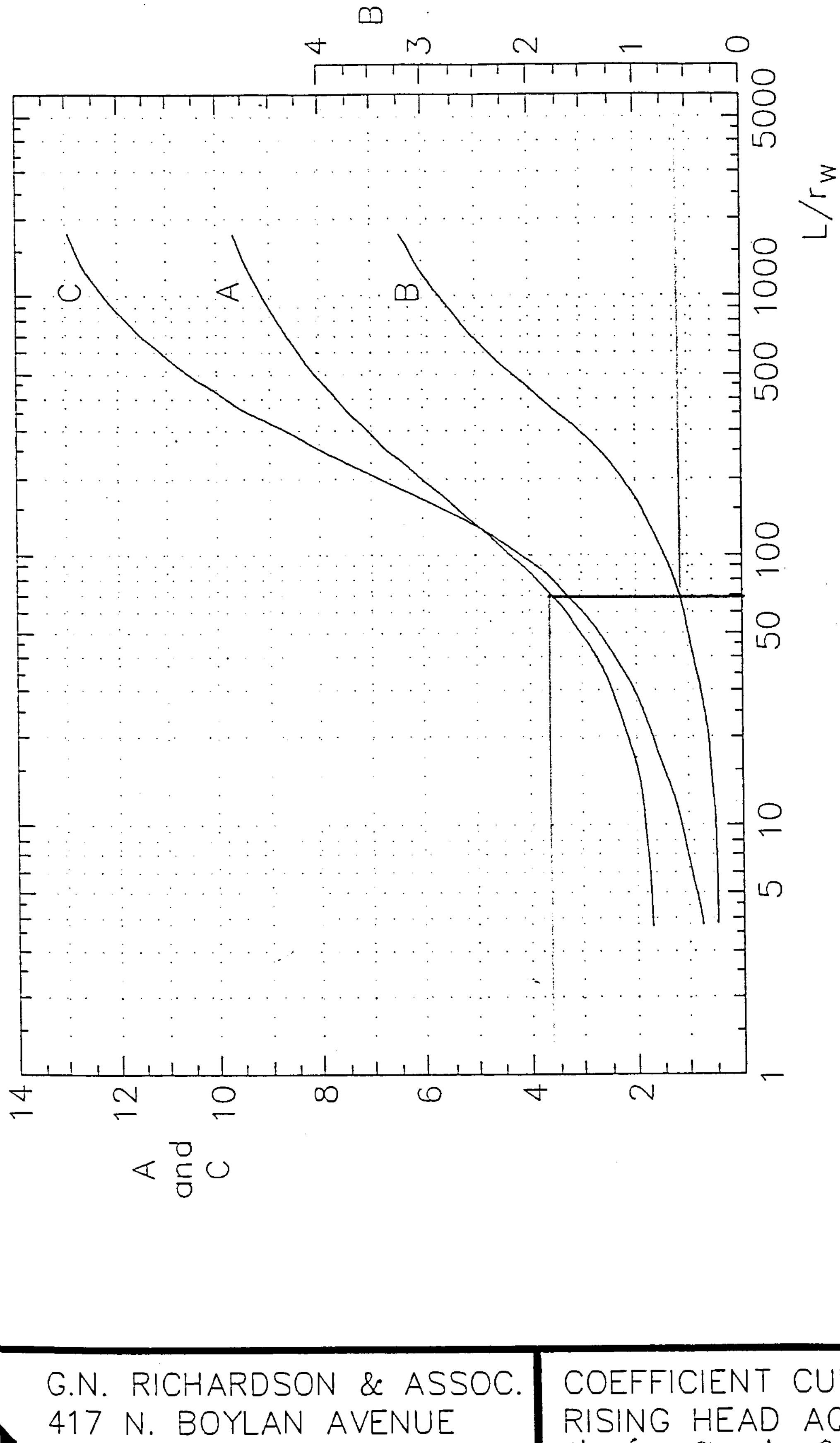
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.007502 Ft/Min or 0.003811 CM/Sec

**K =** 10.80256 Ft/Day



Halifax County Aquifer Slug Test
Well BP-6
Drawdown (feet)
10
1
0.1
0
0.5
1
1.5
2
2.5
3
Time (minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.


G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-7o

Halifax County BP-6 Slug Test

SE1000B
Environmental Logger
05/16 14:11

Unit# 00799 Test# 1

INPUT 1: Level (M) TOC

Reference 14.47
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 08:35

| Elapsed Time | Value |
|---|---|
| 0.0000 | 14.37 |
| 0.0033 | 14.61 |
| 0.0066 | 16.52 |
| 0.0099 | 16.46 |
| 0.0133 | 16.18 |
| 0.0166 | 15.75 |
| 0.0200 | 15.59 |
| 0.0233 | 16.38 |
| 0.0266 | 15.43 |
| 0.0300 | 15.62 |
| 0.0333 | 15.66 |
| 0.0500 | 15.54 |
| 0.0666 | 15.51 |
| 0.0833 | 15.48 |
| 0.1000 | 15.46 |
| 0.1166 | 15.45 |
| 0.1333 | 15.43 |
| 0.1500 | 15.41 |
| 0.1666 | 15.40 |
| 0.1833 | 15.38 |
| 0.2000 | 15.37 |
| 0.2166 | 15.36 |
| 0.2333 | 15.35 |
| 0.2500 | 15.34 |
| 0.2666 | 15.33 |

Halifax County BP-6 Slug Test

| | |
|---|---|
| 0.2833 | 15.32 |
| 0.3000 | 15.31 |
| 0.3166 | 15.30 |
| 0.3333 | 15.30 |
| 0.4167 | 15.26 |
| 0.5000 | 15.23 |
| 0.5833 | 15.20 |
| 0.6667 | 15.17 |
| 0.7500 | 15.15 |
| 0.8333 | 15.13 |
| 0.9167 | 15.11 |
| 1.0000 | 15.09 |
| 1.0833 | 15.07 |
| 1.1667 | 15.06 |
| 1.2500 | 15.04 |
| 1.3333 | 15.03 |
| 1.4166 | 15.01 |
| 1.5000 | 15.00 |
| 1.5833 | 14.98 |
| 1.6667 | 14.97 |
| 1.7500 | 14.96 |
| 1.8333 | 14.95 |
| 1.9167 | 14.94 |
| 2.0000 | 14.93 |
| 2.5000 | 14.87 |
| 3.0000 | 14.83 |
| 3.5000 | 14.79 |
| 4.0000 | 14.76 |
| 4.5000 | 14.73 |
| 5.0000 | 14.71 |
| 5.5000 | 14.69 |
| 6.0000 | 14.67 |
| 6.5000 | 14.65 |
| 7.0000 | 14.64 |
| 7.5000 | 14.63 |
| 8.0000 | 14.62 |
| 8.5000 | 14.61 |
| 9.0000 | 14.60 |
| 9.5000 | 14.59 |
| 10.0000 | 14.58 |
| 12.0000 | 14.56 |
| 14.0000 | 14.55 |
| 16.0000 | 14.53 |

| | |
|---|---|
| 18.0000 | 14.52 |
| 20.0000 | 14.52 |
| 22.0000 | 14.51 |
| 24.0000 | 14.52 |
| 26.0000 | 14.52 |
| 28.0000 | 14.52 |
| 30.0000 | 14.52 |
| 32.0000 | 14.51 |
| 34.0000 | 14.51 |
| 36.0000 | 14.51 |

G. N. Richardson and Associates

**Client:** Halifax County

**Project:** Halifax County Landfill

**Proj. No.** Halifax-4
**Sheet:** 1/1
**Date:** 5/97
**Well:** BP-7
**Reference:** Bouwer, 1989

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 19.67 |
| Le = Screened Interval Open to Aquifer = | 5 |
| Rw = Radius of Well Including Sand Pack = | 0.167 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 40 |
| Yo = Relative Height of Water at Time Zero | 1.51 |
| Yt = Relative Height of Water at Time t = | 0.5 |
| n = Porosity = | 0.17 |
| Time Tt (in minutes) = | 2.5 |
| H - Lw = | 20.33 |
| Yo/Yt = | 3.02 |
| Lw/Rw = | 117.784431 |
| ln(H-Lw)/Rw = | 4.80185909 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 29.94012

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.5 |
| **B =** | 0.35 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-1**

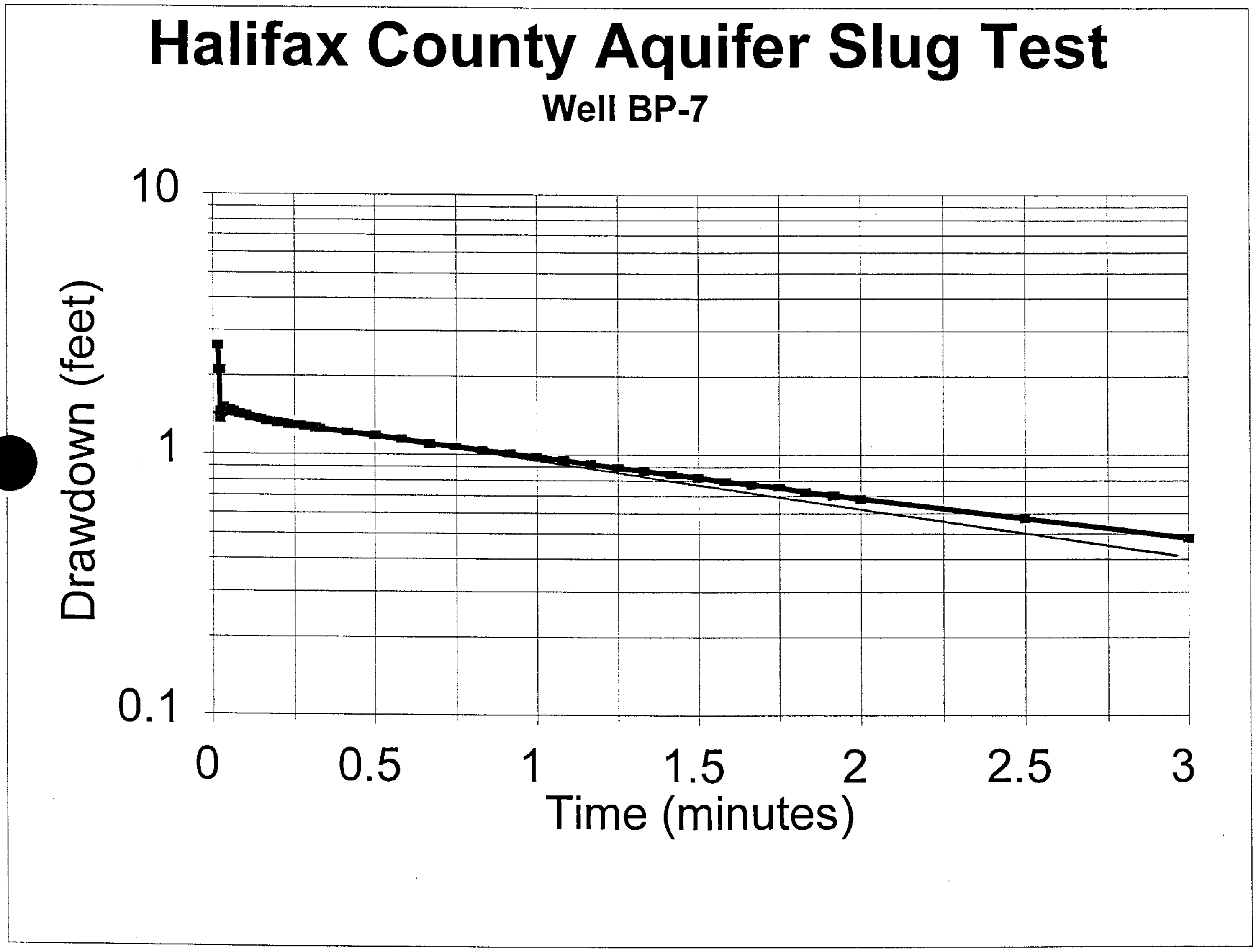
ln Re/Rw= 2.786797 exp-1

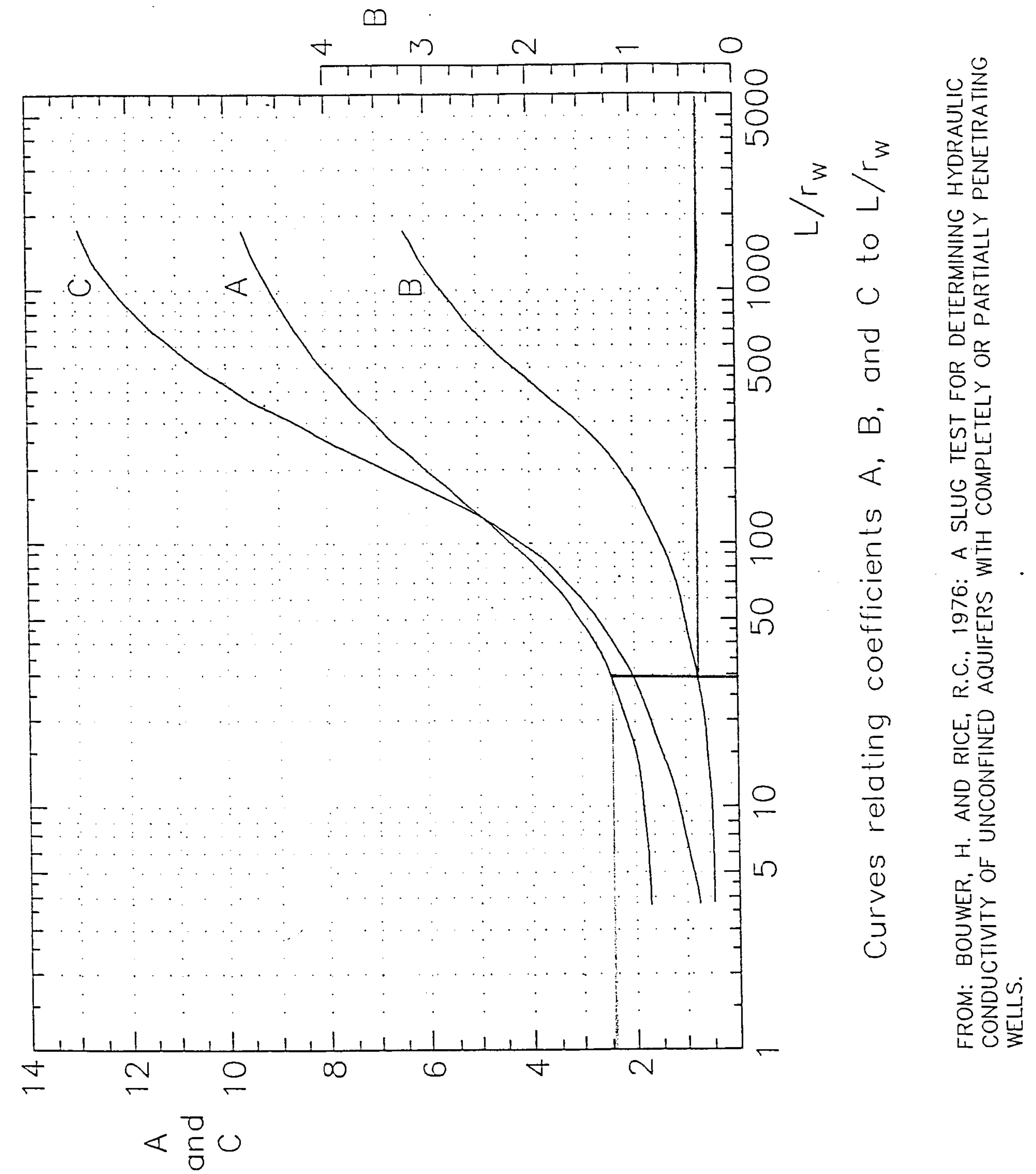
**ln Re/Rw=** 0.358835

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.015864 Ft/Min or 0.008059 CM/Sec

**K =** 22.84443 Ft/Day


Halifax County Aquifer Slug Test
Well BP-7
10
1
0.1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)





G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577


COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-7

Halifax County BP-7 Slug Test

SE1000B
Environmental Logger
05/16 14:12

Unit# 00799 Test# 2

INPUT 1: Level (M) TOC

Reference 5.64
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 09:22

| Elapsed Time | Value |
|---|---|
| 0.0000 | 5.61 |
| 0.0033 | 5.63 |
| 0.0066 | 6.28 |
| 0.0099 | 7.86 |
| 0.0133 | 8.03 |
| 0.0166 | 7.26 |
| 0.0200 | 7.74 |
| 0.0233 | 7.00 |
| 0.0266 | 7.10 |
| 0.0300 | 7.16 |
| 0.0333 | 7.15 |
| 0.0500 | 7.12 |
| 0.0666 | 7.10 |
| 0.0833 | 7.07 |
| 0.1000 | 7.05 |
| 0.1166 | 7.03 |
| 0.1333 | 7.01 |
| 0.1500 | 7.00 |
| 0.1666 | 6.98 |
| 0.1833 | 6.97 |
| 0.2000 | 6.96 |
| 0.2166 | 6.95 |
| 0.2333 | 6.94 |
| 0.2500 | 6.93 |
| 0.2666 | 6.93 |

| | |
|---|---|
| 0.2833 | 6.92 |
| 0.3000 | 6.91 |
| 0.3166 | 6.90 |
| 0.3333 | 6.89 |
| 0.4167 | 6.85 |
| 0.5000 | 6.82 |
| 0.5833 | 6.78 |
| 0.6667 | 6.74 |
| 0.7500 | 6.71 |
| 0.8333 | 6.68 |
| 0.9167 | 6.65 |
| 1.0000 | 6.62 |
| 1.0833 | 6.59 |
| 1.1667 | 6.56 |
| 1.2500 | 6.53 |
| 1.3333 | 6.51 |
| 1.4166 | 6.48 |
| 1.5000 | 6.46 |
| 1.5833 | 6.43 |
| 1.6667 | 6.41 |
| 1.7500 | 6.39 |
| 1.8333 | 6.36 |
| 1.9167 | 6.34 |
| 2.0000 | 6.32 |
| 2.5000 | 6.21 |
| 3.0000 | 6.12 |
| 3.5000 | 6.04 |
| 4.0000 | 5.98 |
| 4.5000 | 5.92 |
| 5.0000 | 5.88 |
| 5.5000 | 5.84 |
| 6.0000 | 5.81 |
| 6.5000 | 5.78 |
| 7.0000 | 5.76 |
| 7.5000 | 5.74 |
| 8.0000 | 5.73 |
| 8.5000 | 5.71 |
| 9.0000 | 5.70 |
| 9.5000 | 5.69 |
| 10.0000 | 5.69 |
| 12.0000 | 5.67 |
| 14.0000 | 5.66 |

| | |
|---|---|
| 16.0000 | 5.65 |
| 18.0000 | 5.65 |
| 20.0000 | 5.65 |
| 22.0000 | 5.65 |
| 24.0000 | 5.65 |
| 26.0000 | 5.65 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-8 |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| **Where:** | | |
|---|---|---|
| | Lw = Height of Water Column in Well = | 17.53 |
| | Le = Screened Interval Open to Aquifer = | 5 |
| | Rw = Radius of Well Including Sand Pack = | 0.167 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 40 |
| | Yo = Relative Height of Water at Time Zero | 1 |
| | Yt = Relative Height of Water at Time t = | 0.83 |
| | n = Porosity = | 0.17 |
| | Time Tt (in minutes) = | 3 |
| | H - Lw = | 22.47 |
| | Yo/Yt = | 1.204819 |
| | Lw/Rw = | 104.9701 |
| | ln(H-Lw)/Rw = | 4.901943 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 29.94012

**From Attached Graph of A and B:**

**A =** 2.5

**B =** 0.35

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-1**

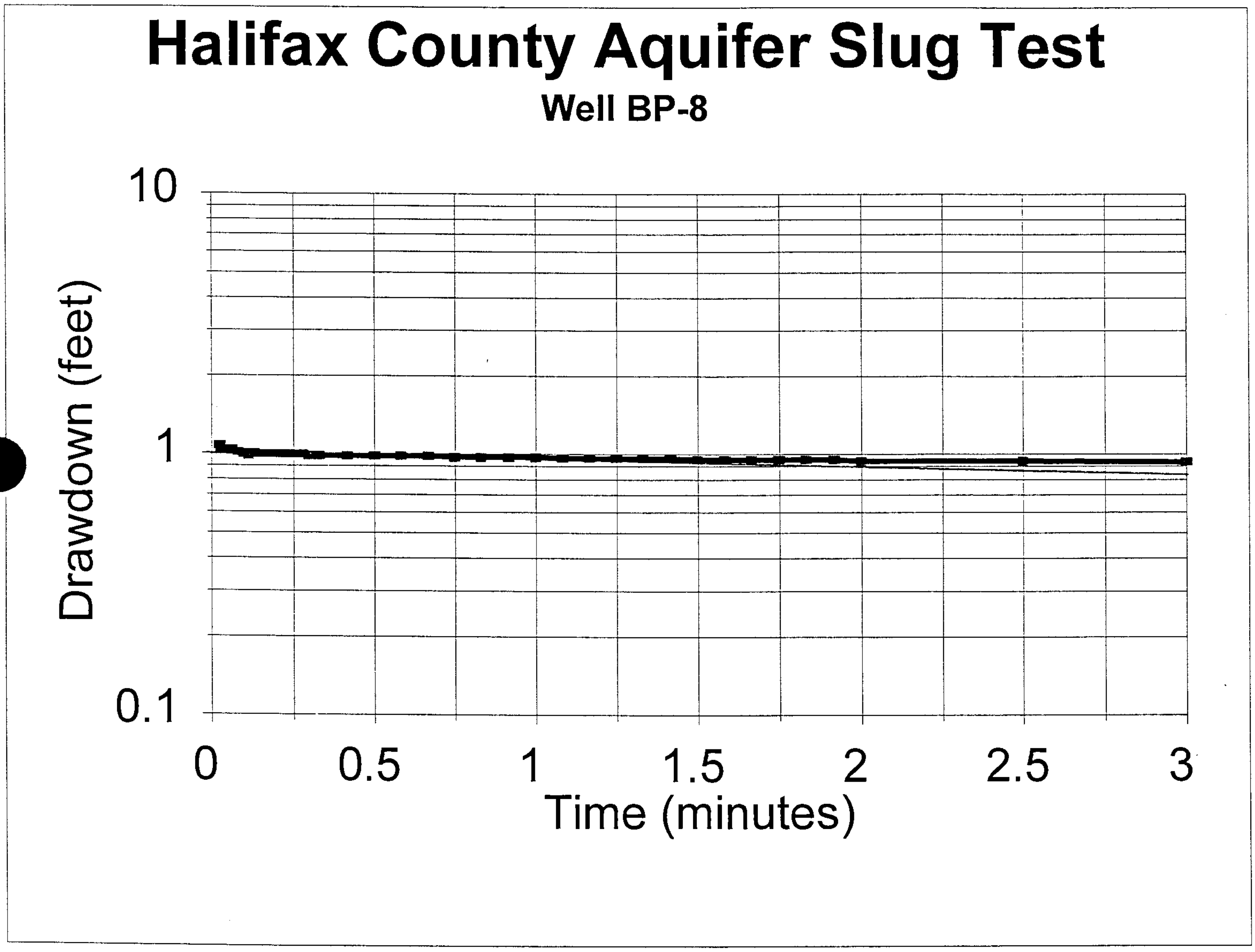
ln Re/Rw= 2.793676 exp-1

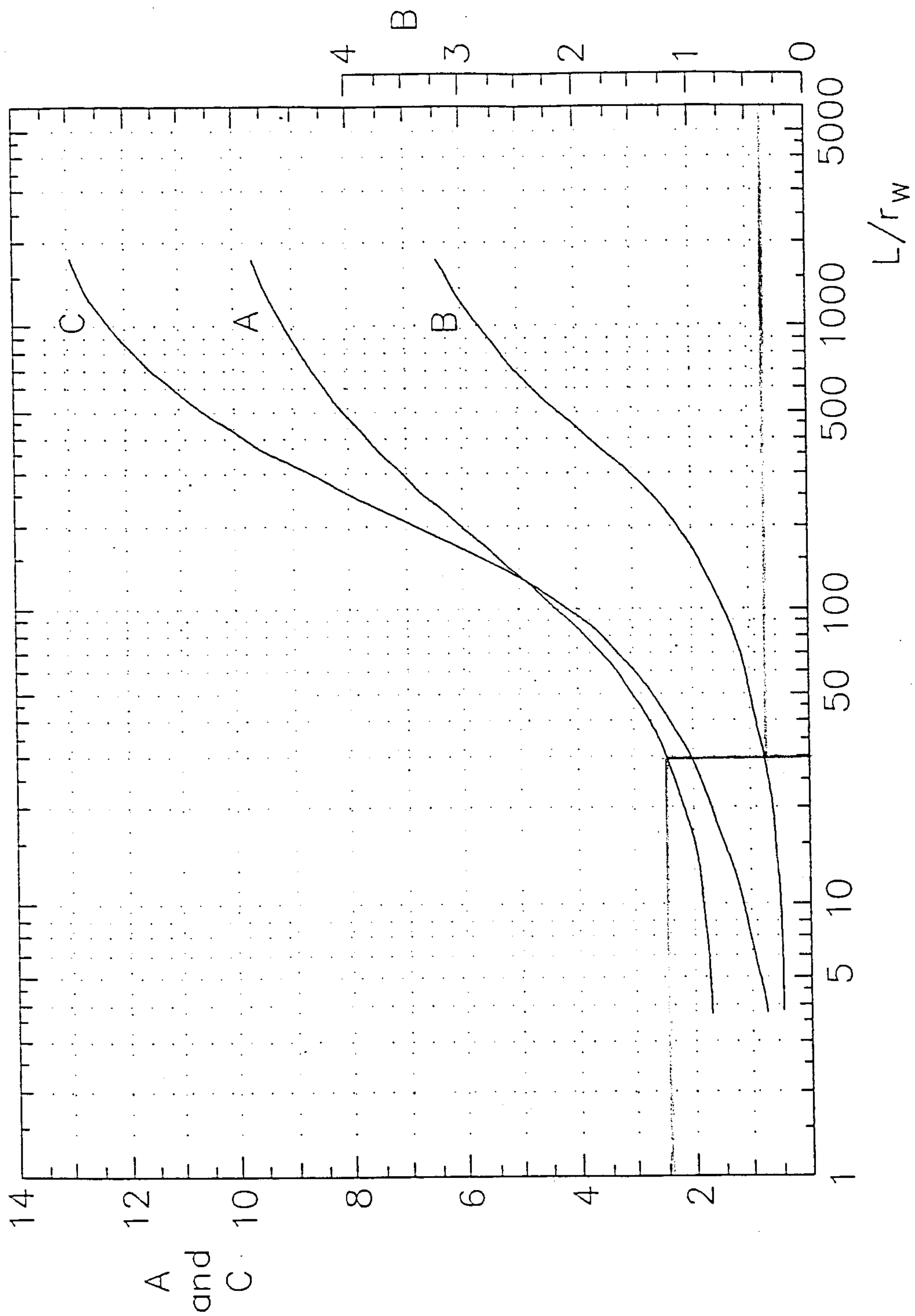
**ln Re/Rw=** 0.357951

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.002223 Ft/Min or 0.001129 CM/Sec

**K =** 3.201452 Ft/Day


Halifax County Aquifer Slug Test
Well BP-8
10
1
0.1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)




Curves relating coefficients A, B, and C to L/$r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-8

Halifax County BP-8 Slug Test

SE1000B
Environmental Logger
05/16 14:17

Unit# 00799 Test# 4

INPUT 1: Level (M) TOC

Reference 16.68
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 12:06

| Elapsed Time | Value |
|---|---|
| 0.0000 | 16.96 |
| 0.0033 | 17.54 |
| 0.0066 | 17.94 |
| 0.0099 | 17.94 |
| 0.0133 | 17.37 |
| 0.0166 | 17.24 |
| 0.0200 | 17.86 |
| 0.0233 | 17.45 |
| 0.0266 | 17.75 |
| 0.0300 | 17.71 |
| 0.0333 | 17.71 |
| 0.0500 | 17.71 |
| 0.0666 | 17.71 |
| 0.0833 | 17.69 |
| 0.1000 | 17.68 |
| 0.1166 | 17.66 |
| 0.1333 | 17.68 |
| 0.1500 | 17.67 |
| 0.1666 | 17.67 |
| 0.1833 | 17.67 |
| 0.2000 | 17.67 |
| 0.2166 | 17.67 |
| 0.2333 | 17.67 |
| 0.2500 | 17.67 |
| 0.2666 | 17.67 |

| | |
|---|---|
| 0.2833 | 17.67 |
| 0.3000 | 17.66 |
| 0.3166 | 17.66 |
| 0.3333 | 17.66 |
| 0.4167 | 17.66 |
| 0.5000 | 17.66 |
| 0.5833 | 17.66 |
| 0.6667 | 17.66 |
| 0.7500 | 17.65 |
| 0.8333 | 17.65 |
| 0.9167 | 17.65 |
| 1.0000 | 17.65 |
| 1.0833 | 17.64 |
| 1.1667 | 17.64 |
| 1.2500 | 17.64 |
| 1.3333 | 17.64 |
| 1.4166 | 17.64 |
| 1.5000 | 17.63 |
| 1.5833 | 17.63 |
| 1.6667 | 17.63 |
| 1.7500 | 17.63 |
| 1.8333 | 17.63 |
| 1.9167 | 17.63 |
| 2.0000 | 17.62 |
| 2.5000 | 17.62 |
| 3.0000 | 17.61 |
| 3.5000 | 17.60 |
| 4.0000 | 17.59 |
| 4.5000 | 17.58 |
| 5.0000 | 17.57 |
| 5.5000 | 17.56 |
| 6.0000 | 17.55 |
| 6.5000 | 17.55 |
| 7.0000 | 17.54 |
| 7.5000 | 17.53 |
| 8.0000 | 17.52 |
| 8.5000 | 17.51 |
| 9.0000 | 17.50 |
| 9.5000 | 17.49 |
| 10.0000 | 17.48 |
| 12.0000 | 17.45 |
| 14.0000 | 17.42 |

| | |
|---|---|
| 16.0000 | 17.39 |
| 18.0000 | 17.36 |
| 20.0000 | 17.33 |
| 22.0000 | 17.30 |
| 24.0000 | 17.27 |
| 26.0000 | 17.25 |
| 28.0000 | 17.22 |
| 30.0000 | 17.20 |
| 32.0000 | 17.17 |
| 34.0000 | 17.14 |
| 36.0000 | 17.12 |
| 38.0000 | 17.10 |
| 40.0000 | 17.08 |
| 42.0000 | 17.06 |
| 44.0000 | 17.03 |
| 46.0000 | 17.01 |
| 48.0000 | 16.99 |
| 50.0000 | 16.96 |
| 52.0000 | 16.94 |
| 54.0000 | 16.93 |
| 56.0000 | 16.90 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-9 |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 19.77 |
| | Le = Screened Interval Open to Aquifer = | 10 |
| | Rw = Radius of Well Including Sand Pack = | 0.167 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 40 |
| | Yo = Relative Height of Water at Time Zero | 1.55 |
| | Yt = Relative Height of Water at Time t = | 1.09 |
| | n = Porosity = | 0.17 |
| | Time Tt (in minutes) = | 2 |
| | H - Lw = | 20.23 |
| | Yo/Yt = | 1.422018 |
| | Lw/Rw = | 118.3832 |
| | ln(H-Lw)/Rw = | 4.796928 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 59.88024

**From Attached Graph of A and B:**

**A =** 3.4

**B =** 0.5

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

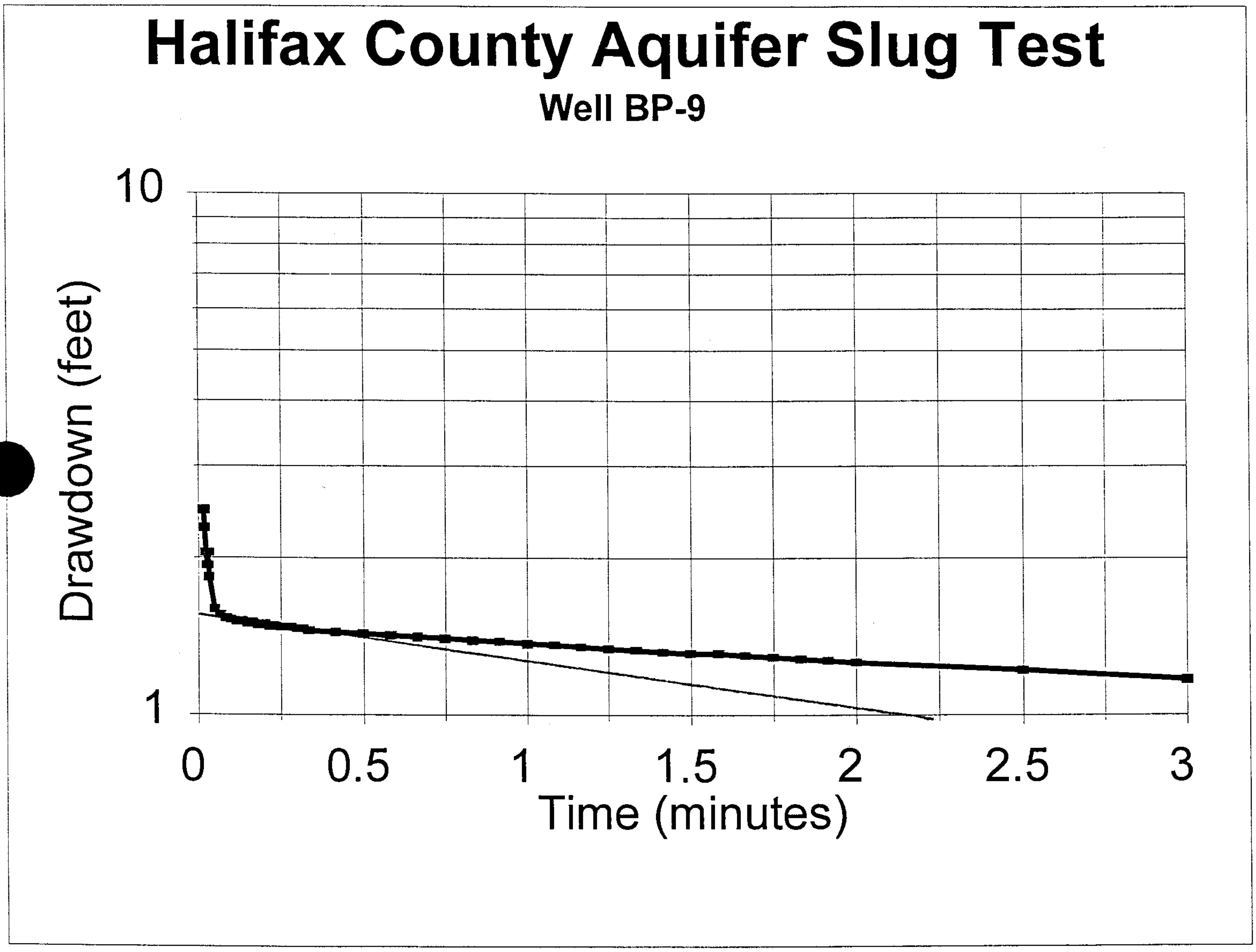
ln Re/Rw= 3.670473 exp-1

**ln Re/Rw=** 0.272444

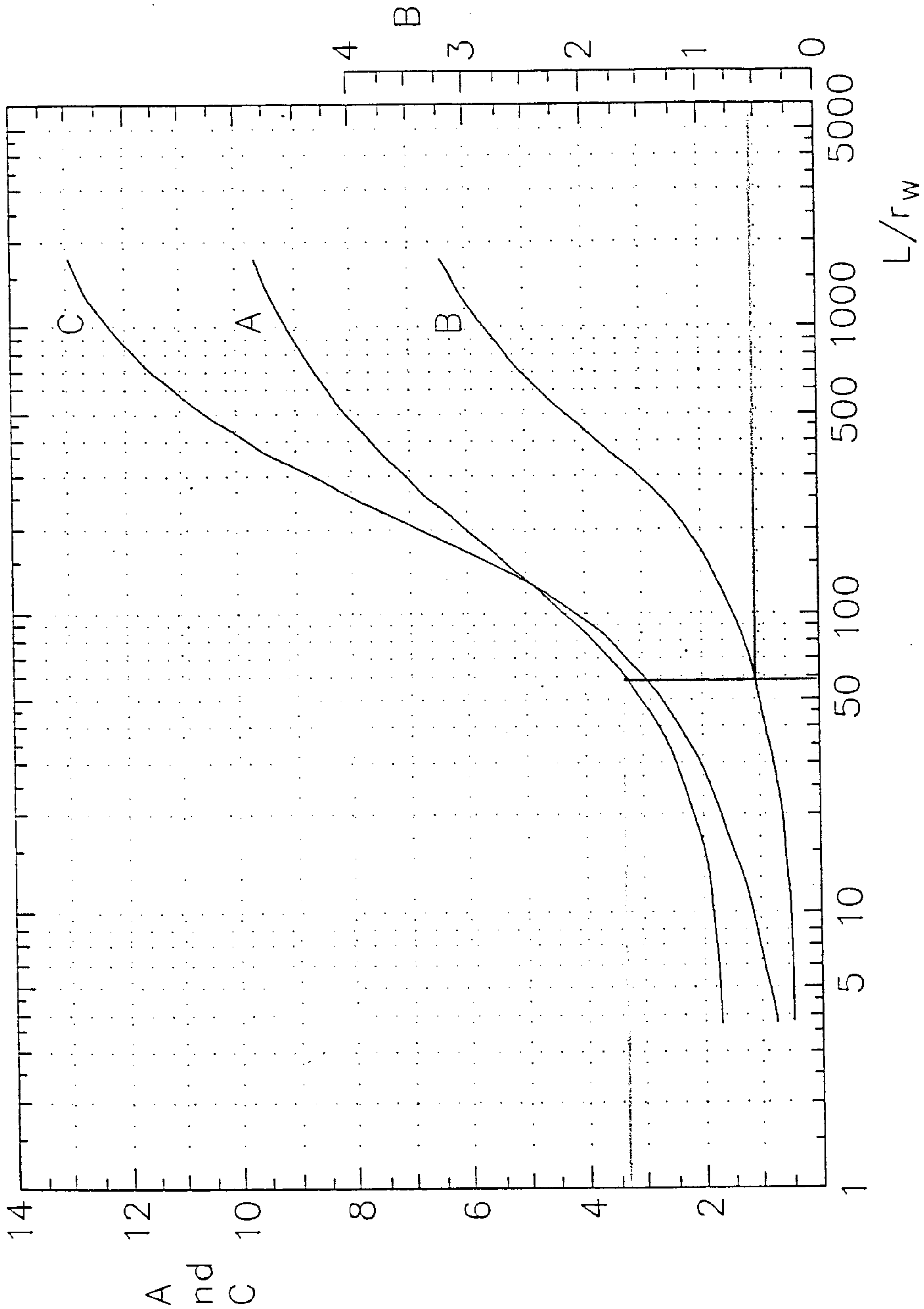
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.002398 Ft/Min or 0.001218 CM/Sec

**K =** 3.453174 Ft/Day



Halifax County Aquifer Slug Test
Well BP-9
10
1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-9

Halifax County BP-9 Slug Test

SE1000B
Environmental Logger
05/15 20:47

Unit# 00799 Test# 1

INPUT 1: Level (M) TOC

Reference 18.98
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 11:23

| Elapsed Time | Value |
|---|---|
| 0.0000 | 18.87 |
| 0.0033 | 18.87 |
| 0.0066 | 19.06 |
| 0.0099 | 20.64 |
| 0.0133 | 21.10 |
| 0.0166 | 21.45 |
| 0.0200 | 21.26 |
| 0.0233 | 21.02 |
| 0.0266 | 20.91 |
| 0.0300 | 21.02 |
| 0.0333 | 20.81 |
| 0.0500 | 20.57 |
| 0.0666 | 20.53 |
| 0.0833 | 20.51 |
| 0.1000 | 20.50 |
| 0.1166 | 20.49 |
| 0.1333 | 20.49 |
| 0.1500 | 20.48 |
| 0.1666 | 20.48 |
| 0.1833 | 20.47 |
| 0.2000 | 20.47 |
| 0.2166 | 20.46 |
| 0.2333 | 20.46 |
| 0.2500 | 20.45 |
| 0.2666 | 20.45 |

| | |
|---|---|
| 0.2833 | 20.45 |
| 0.3000 | 20.44 |
| 0.3166 | 20.44 |
| 0.3333 | 20.43 |
| 0.4167 | 20.42 |
| 0.5000 | 20.41 |
| 0.5833 | 20.40 |
| 0.6667 | 20.39 |
| 0.7500 | 20.38 |
| 0.8333 | 20.37 |
| 0.9167 | 20.36 |
| 1.0000 | 20.35 |
| 1.0833 | 20.34 |
| 1.1667 | 20.33 |
| 1.2500 | 20.32 |
| 1.3333 | 20.31 |
| 1.4166 | 20.30 |
| 1.5000 | 20.29 |
| 1.5833 | 20.29 |
| 1.6667 | 20.28 |
| 1.7500 | 20.27 |
| 1.8333 | 20.26 |
| 1.9167 | 20.25 |
| 2.0000 | 20.24 |
| 2.5000 | 20.20 |
| 3.0000 | 20.15 |
| 3.5000 | 20.11 |
| 4.0000 | 20.07 |
| 4.5000 | 20.03 |
| 5.0000 | 20.00 |
| 5.5000 | 19.96 |
| 6.0000 | 19.93 |
| 6.5000 | 19.90 |
| 7.0000 | 19.87 |
| 7.5000 | 19.84 |
| 8.0000 | 19.81 |
| 8.5000 | 19.78 |
| 9.0000 | 19.75 |
| 9.5000 | 19.73 |
| 10.0000 | 19.70 |
| 12.0000 | 19.61 |
| 14.0000 | 19.53 |

| | |
|---|---|
| 16.0000 | 19.47 |
| 18.0000 | 19.41 |
| 20.0000 | 19.36 |
| 22.0000 | 19.31 |
| 24.0000 | 19.27 |
| 26.0000 | 19.24 |
| 28.0000 | 19.21 |
| 30.0000 | 19.18 |
| 32.0000 | 19.16 |
| 34.0000 | 19.14 |
| 36.0000 | 19.12 |
| 38.0000 | 19.10 |
| 40.0000 | 19.08 |
| 42.0000 | 19.06 |
| 44.0000 | 19.05 |
| 46.0000 | 19.03 |
| 48.0000 | 19.02 |
| 50.0000 | 19.02 |
| 52.0000 | 19.02 |
| 54.0000 | 19.01 |
| 56.0000 | 19.01 |
| 58.0000 | 19.02 |
| 60.0000 | 19.01 |
| 62.0000 | 19.01 |
| 64.0000 | 19.02 |
| 66.0000 | 19.01 |
| 68.0000 | 19.01 |
| 70.0000 | 19.01 |
| 72.0000 | 19.01 |
| 74.0000 | 19.01 |
| 76.0000 | 19.01 |
| 78.0000 | 19.00 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 5/97 |
| | | **Well:** | BP-10 |
| | | **Referenc€** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 11.19 |
| | Le = Screened Interval Open to Aquifer = | 5 |
| | Rw = Radius of Well Including Sand Pack = | 0.167 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 40 |
| | Yo = Relative Height of Water at Time Zero | 1 |
| | Yt = Relative Height of Water at Time t = | 0.7 |
| | n = Porosity = | 0.17 |
| | Time Tt (in minutes) = | 0.65 |
| | H - Lw = | 28.81 |
| | Yo/Yt = | 1.428571 |
| | Lw/Rw = | 67.00599 |
| | ln(H-Lw)/Rw = | 5.150484 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 29.94012

**From Attached Graph of A and B:**

| | |
|---|---|
| **A =** | 2.5 |
| **B =** | 0.4 |

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-**

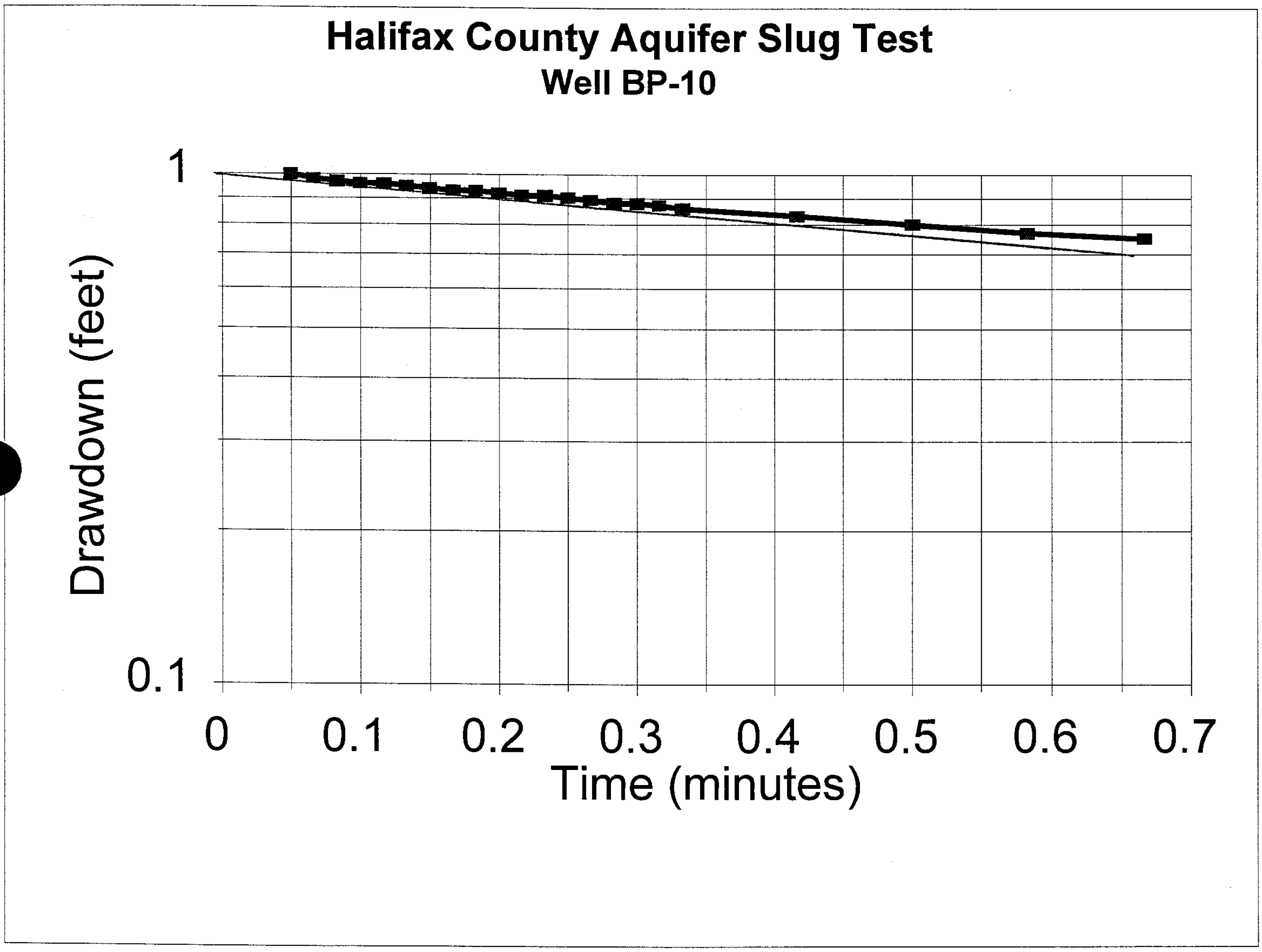
ln Re/Rw= 2.830417 exp-1

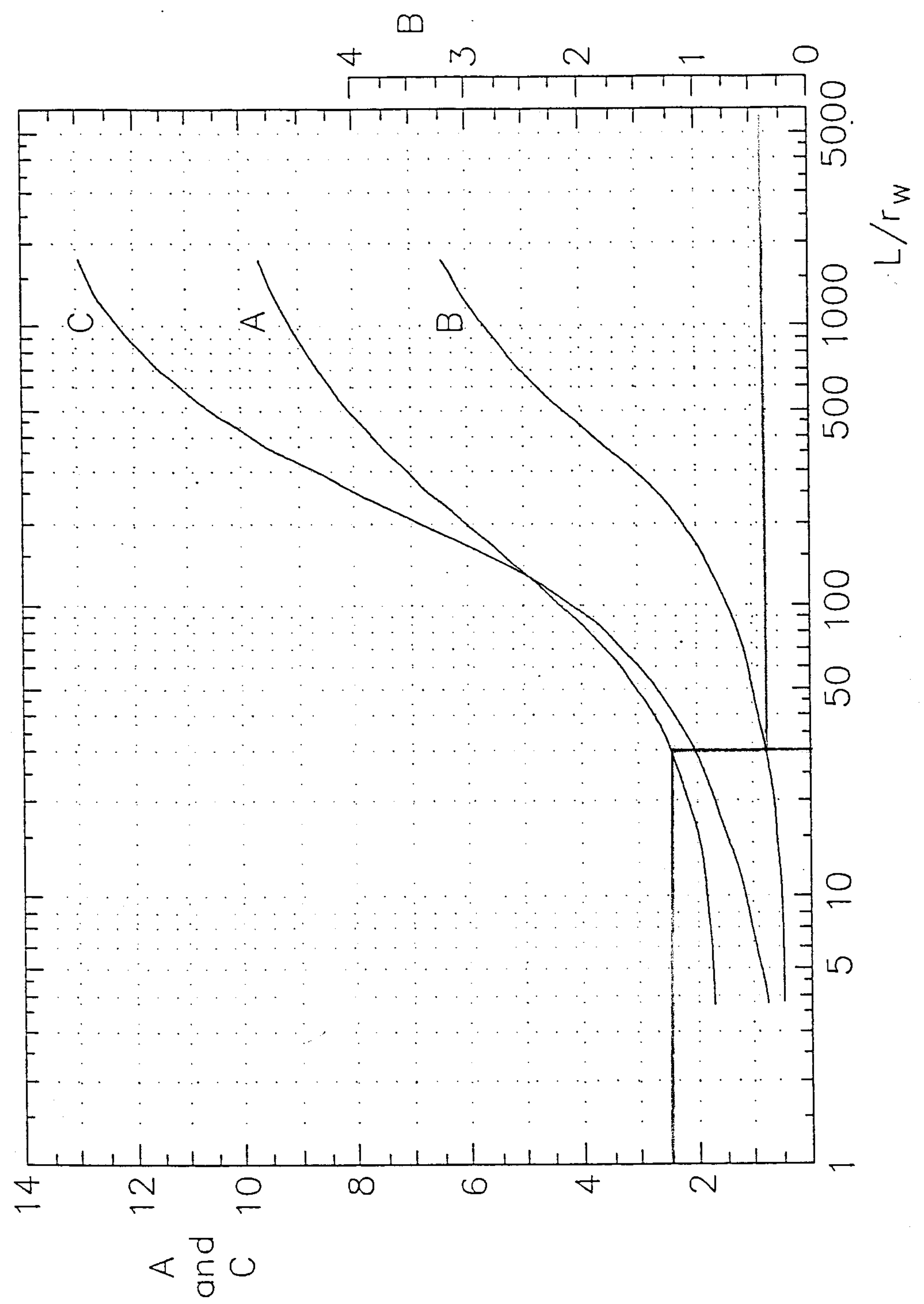
**ln Re/Rw=** 0.353305

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 0.019387 Ft/Min or 0.009849 CM/Sec

**K =** 27.91716 Ft/Day


Halifax County Aquifer Slug Test
Well BP-10
Drawdown (feet)
1
0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Time (minutes)




Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-10

Halifax County BP-10 Slug Test

SE1000B
Environmental Logger
05/15 20:50

Unit# 00799 Test# 2

INPUT 1: Level (M) TOC

Reference 8.10
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 12:49

| Elapsed Time | Value |
|---|---|
| 0.0000 | 8.04 |
| 0.0033 | 8.04 |
| 0.0066 | 8.06 |
| 0.0099 | 8.77 |
| 0.0133 | 9.75 |
| 0.0166 | 9.63 |
| 0.0200 | 9.76 |
| 0.0233 | 9.38 |
| 0.0266 | 9.53 |
| 0.0300 | 9.15 |
| 0.0333 | 9.08 |
| 0.0500 | 9.10 |
| 0.0666 | 9.08 |
| 0.0833 | 9.07 |
| 0.1000 | 9.06 |
| 0.1166 | 9.06 |
| 0.1333 | 9.05 |
| 0.1500 | 9.04 |
| 0.1666 | 9.03 |
| 0.1833 | 9.03 |
| 0.2000 | 9.02 |
| 0.2166 | 9.01 |
| 0.2333 | 9.01 |
| 0.2500 | 9.00 |
| 0.2666 | 8.99 |

| | |
|---|---|
| 0.2833 | 8.98 |
| 0.3000 | 8.98 |
| 0.3166 | 8.97 |
| 0.3333 | 8.96 |
| 0.4167 | 8.93 |
| 0.5000 | 8.90 |
| 0.5833 | 8.87 |
| 0.6667 | 8.85 |
| 0.7500 | 8.82 |
| 0.8333 | 8.79 |
| 0.9167 | 8.77 |
| 1.0000 | 8.75 |
| 1.0833 | 8.72 |
| 1.1667 | 8.70 |
| 1.2500 | 8.68 |
| 1.3333 | 8.66 |
| 1.4166 | 8.64 |
| 1.5000 | 8.62 |
| 1.5833 | 8.60 |
| 1.6667 | 8.58 |
| 1.7500 | 8.56 |
| 1.8333 | 8.55 |
| 1.9167 | 8.53 |
| 2.0000 | 8.51 |
| 2.5000 | 8.43 |
| 3.0000 | 8.36 |
| 3.5000 | 8.31 |
| 4.0000 | 8.26 |
| 4.5000 | 8.23 |
| 5.0000 | 8.20 |
| 5.5000 | 8.18 |
| 6.0000 | 8.17 |
| 6.5000 | 8.16 |
| 7.0000 | 8.15 |
| 7.5000 | 8.14 |
| 8.0000 | 8.14 |
| 8.5000 | 8.13 |
| 9.0000 | 8.13 |
| 9.5000 | 8.13 |
| 10.0000 | 8.13 |
| 12.0000 | 8.13 |
| 14.0000 | 8.13 |
| 16.0000 | 8.13 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 1/96 |
| | | **Well:** | B-4s |
| | | **Reference:** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 9.78 |
| | Le = Screened Interval Open to Aquifer = | 5 |
| | Rw = Radius of Well Including Sand Pack = | 0.43 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 10 |
| | Yo = Relative Height of Water at Time Zero | 1.5 |
| | Yt = Relative Height of Water at Time t = | 1 |
| | n = Porosity = | 0.15 |
| | Time Tt (in minutes) = | 7 |
| | H - Lw = | 0.22 |
| | Yo/Yt = | 1.5 |
| | Lw/Rw = | 22.744186 |
| | ln(H-Lw)/Rw = | -0.6701577 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 11.62791

**From Attached Graph of A and B:**

**A =** 1.95

**B =** 0.25

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-1**

ln Re/Rw= 2.2876694 exp-1

**ln Re/Rw=** 0.4371261

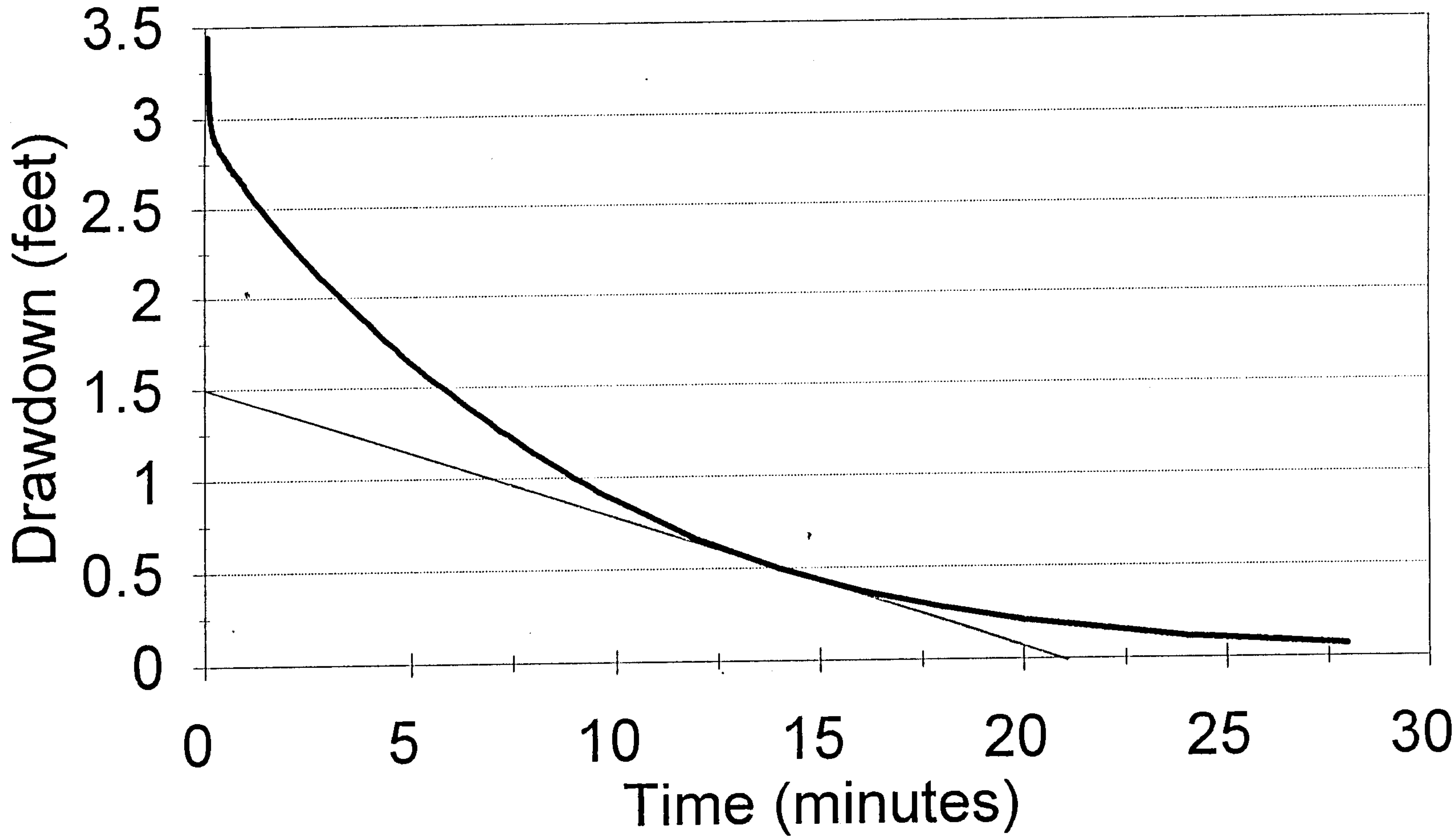
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

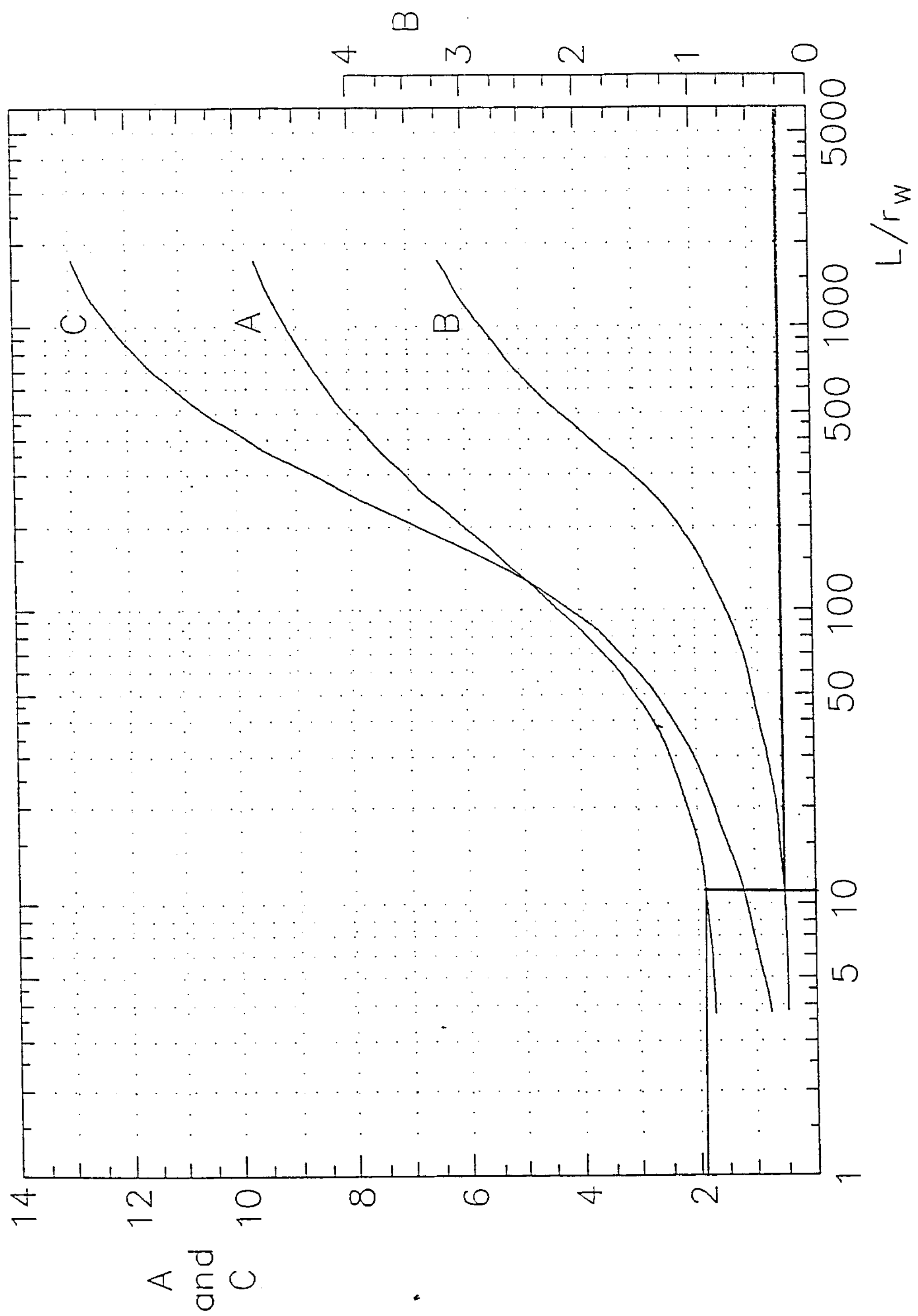
**K =** 0.002532 Ft/Min or 0.001286 CM/Sec

**K =** 3.646067 Ft/Day

## Halifax Landfill Slug Test Data

Piezometer B-4s - January, 1996






Curves relating coefficients A, B, and C to $L/r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax Landfill
B-4s

**Haliifax B-4s Data - slug test 1/24/96**

SE1000C

Environmental Logger

01/24 20:47

Unit# 00069 Test 2

Setups: INPUT 1

| | |
|---|---|
| Type | Level (F) |
| Mode | TOC |
| I.D. | 00001 |

| | |
|---|---|
| Reference | 0.000 |
| Linearity | 0.120 |
| Scale factor | 20.020 |
| Offset | -0.020 |
| Delay mSEC | 50.000 |

Step 0 01/24 11:59:03

| Elapsed Time | INPUT 1 |
|---|---|
| 0.0000 | 0.031 |
| 0.0033 | 0.025 |
| 0.0066 | 0.025 |
| 0.0100 | 0.025 |
| 0.0133 | 0.012 |
| 0.0166 | 0.195 |
| 0.0200 | -0.056 |
| 0.0233 | -0.069 |
| 0.0266 | -0.025 |
| 0.0300 | 0.613 |
| 0.0333 | -0.145 |
| 0.0366 | 0.233 |
| 0.0400 | 0.524 |
| 0.0433 | -0.107 |
| 0.0466 | 0.347 |
| 0.0500 | 1.446 |
| 0.0533 | 2.861 |
| 0.0566 | 3.474 |
| 0.0600 | 2.697 |
| 0.0633 | 1.889 |
| 0.0666 | 1.478 |
| 0.0700 | 3.613 |
| 0.0733 | 1.946 |
| 0.0766 | 2.899 |
| 0.0800 | 3.209 |
| 0.0833 | 3.442 |
| 0.0866 | 3.322 |
| 0.0900 | 3.284 |

**Halifax B-4s Slug Test Data Page 2**

| Elapsed Time | INPUT 1 |
|---|---|
| 0.0933 | 3.259 |
| 0.0966 | 3.209 |
| 0.1000 | 3.183 |
| 0.1033 | 3.165 |
| 0.1066 | 3.139 |
| 0.1100 | 3.127 |
| 0.1133 | 3.095 |
| 0.1166 | 3.089 |
| 0.1200 | 3.070 |
| 0.1233 | 3.051 |
| 0.1266 | 3.044 |
| 0.1300 | 3.032 |
| 0.1333 | 3.019 |
| 0.1366 | 3.013 |
| 0.1400 | 3.000 |
| 0.1433 | 2.988 |
| 0.1466 | 2.988 |
| 0.1500 | 2.988 |
| 0.1533 | 2.975 |
| 0.1566 | 2.969 |
| 0.1600 | 2.962 |
| 0.1633 | 2.956 |
| 0.1666 | 2.956 |
| 0.1700 | 2.950 |
| 0.1733 | 2.950 |
| 0.1766 | 2.943 |
| 0.1800 | 2.937 |
| 0.1833 | 2.937 |
| 0.1866 | 2.931 |
| 0.1900 | 2.931 |
| 0.1933 | 2.918 |
| 0.1966 | 2.925 |
| 0.2000 | 2.912 |
| 0.2033 | 2.918 |
| 0.2066 | 2.912 |
| 0.2100 | 2.906 |
| 0.2133 | 2.906 |
| 0.2166 | 2.906 |
| 0.2200 | 2.906 |
| 0.2233 | 2.899 |
| 0.2266 | 2.899 |
| 0.2300 | 2.893 |
| 0.2333 | 2.893 |
| 0.2366 | 2.893 |
| 0.2400 | 2.893 |
| 0.2433 | 2.887 |
| 0.2466 | 2.887 |
| 0.2500 | 2.887 |

**Halifax B-4s Slug Test Data Page 3**

| Elapsed Time | INPUT 1 |
|---|---|
| 0.2533 | 2.887 |
| 0.2566 | 2.880 |
| 0.2600 | 2.880 |
| 0.2633 | 2.880 |
| 0.2666 | 2.874 |
| 0.2700 | 2.874 |
| 0.2733 | 2.874 |
| 0.2766 | 2.874 |
| 0.2800 | 2.874 |
| 0.2833 | 2.868 |
| 0.2866 | 2.868 |
| 0.2900 | 2.868 |
| 0.2933 | 2.868 |
| 0.2966 | 2.861 |
| 0.3000 | 2.861 |
| 0.3033 | 2.861 |
| 0.3066 | 2.861 |
| 0.3100 | 2.861 |
| 0.3133 | 2.855 |
| 0.3166 | 2.855 |
| 0.3200 | 2.855 |
| 0.3233 | 2.855 |
| 0.3266 | 2.855 |
| 0.3300 | 2.849 |
| 0.3333 | 2.849 |
| 0.3500 | 2.842 |
| 0.3666 | 2.836 |
| 0.3833 | 2.823 |
| 0.4000 | 2.817 |
| 0.4166 | 2.811 |
| 0.4333 | 2.805 |
| 0.4500 | 2.798 |
| 0.4666 | 2.792 |
| 0.4833 | 2.792 |
| 0.5000 | 2.779 |
| 0.5166 | 2.779 |
| 0.5333 | 2.773 |
| 0.5500 | 2.767 |
| 0.5666 | 2.760 |
| 0.5833 | 2.754 |
| 0.6000 | 2.748 |
| 0.6166 | 2.741 |
| 0.6333 | 2.741 |
| 0.6500 | 2.729 |
| 0.6666 | 2.729 |
| 0.6833 | 2.722 |
| 0.7000 | 2.716 |
| 0.7166 | 2.710 |
| 0.7333 | 2.703 |
| 0.7500 | 2.697 |
| 0.7666 | 2.697 |
| 0.7833 | 2.691 |

**Halifax B-4s Slug Test Data Page 4**

| Elapsed Time | INPUT 1 |
|---|---|
| 0.8000 | 2.685 |
| 0.8166 | 2.678 |
| 0.8333 | 2.672 |
| 0.8500 | 2.672 |
| 0.8666 | 2.666 |
| 0.8833 | 2.659 |
| 0.9000 | 2.653 |
| 0.9166 | 2.647 |
| 0.9333 | 2.647 |
| 0.9500 | 2.640 |
| 0.9666 | 2.634 |
| 0.9833 | 2.628 |
| 1.0000 | 2.621 |
| 1.2000 | 2.552 |
| 1.4000 | 2.495 |
| 1.6000 | 2.438 |
| 1.8000 | 2.381 |
| 2.0000 | 2.331 |
| 2.2000 | 2.274 |
| 2.4000 | 2.224 |
| 2.6000 | 2.173 |
| 2.8000 | 2.122 |
| 3.0000 | 2.078 |
| 3.2000 | 2.034 |
| 3.4000 | 1.983 |
| 3.6000 | 1.939 |
| 3.8000 | 1.895 |
| 4.0000 | 1.851 |
| 4.2000 | 1.807 |
| 4.4000 | 1.762 |
| 4.6000 | 1.724 |
| 4.8000 | 1.680 |
| 5.0000 | 1.642 |
| 5.2000 | 1.604 |
| 5.4000 | 1.567 |
| 5.6000 | 1.529 |
| 5.8000 | 1.497 |

## Halifax B-4s Slug Test Data Page 5

| Elapsed Time | INPUT 1 |
|---|---|
| 6.0000 | 1.465 |
| 6.2000 | 1.428 |
| 6.4000 | 1.390 |
| 6.6000 | 1.358 |
| 6.8000 | 1.326 |
| 7.0000 | 1.295 |
| 7.2000 | 1.257 |
| 7.4000 | 1.232 |
| 7.6000 | 1.200 |
| 7.8000 | 1.169 |
| 8.0000 | 1.137 |
| 8.2000 | 1.112 |
| 8.4000 | 1.080 |
| 8.6000 | 1.055 |
| 8.8000 | 1.029 |
| 9.0000 | 0.998 |
| 9.2000 | 0.973 |
| 9.4000 | 0.947 |
| 9.6000 | 0.922 |
| 9.8000 | 0.897 |
| 10.0000 | 0.878 |
| 12.0000 | 0.663 |
| 14.0000 | 0.499 |
| 16.0000 | 0.372 |
| 18.0000 | 0.278 |
| 20.0000 | 0.208 |
| 22.0000 | 0.157 |
| 24.0000 | 0.113 |
| 26.0000 | 0.088 |
| 28.0000 | 0.063 |
| 30.0000 | 0.044 |
| 32.0000 | 0.025 |
| 34.0000 | 0.012 |
| 36.0000 | 0.006 |
| 38.0000 | -0.006 |
| 40.0000 | -0.018 |
| 42.0000 | -0.031 |
| 44.0000 | -0.044 |
| 46.0000 | -0.044 |
| 48.0000 | -0.050 |
| 50.0000 | -0.056 |
| 52.0000 | -0.063 |
| 54.0000 | -0.069 |
| 56.0000 | -0.069 |
| 58.0000 | -0.069 |
| 60.0000 | -0.069 |
| 62.0000 | -0.069 |
| 64.0000 | -0.069 |

**G. N. Richardson and Associates**

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 1/96 |
| | | **Well:** | B-4d |
| | | **Reference:** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

**Where:**

| | |
|---|---|
| Lw = Height of Water Column in Well = | 17.29 |
| Le = Screened Interval Open to Aquifer = | 10 |
| Rw = Radius of Well Including Sand Pack = | 0.43 |
| Rc = Radius of Well Casing = | 0.083 |
| H = Aquifer Thickness to First Aquitard = | 25 |
| Yo = Relative Height of Water at Time Zero | 1.5 |
| Yt = Relative Height of Water at Time t = | 0.75 |
| n = Porosity = | 0.1 |
| Time Tt (in minutes) = | 10 |
| H - Lw = | 7.71 |
| Yo/Yt = | 2 |
| Lw/Rw = | 40.2093023 |
| ln(H-Lw)/Rw = | 2.88648826 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 1

**Req =** 1

**Evaluation of A and B:**

Le/Rw = 23.25581

**From Attached Graph of A and B:**

**A =** 2.4

**B =** 0.4

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-1**

ln Re/Rw= 2.7474199 exp-1

**ln Re/Rw=** 0.3639779

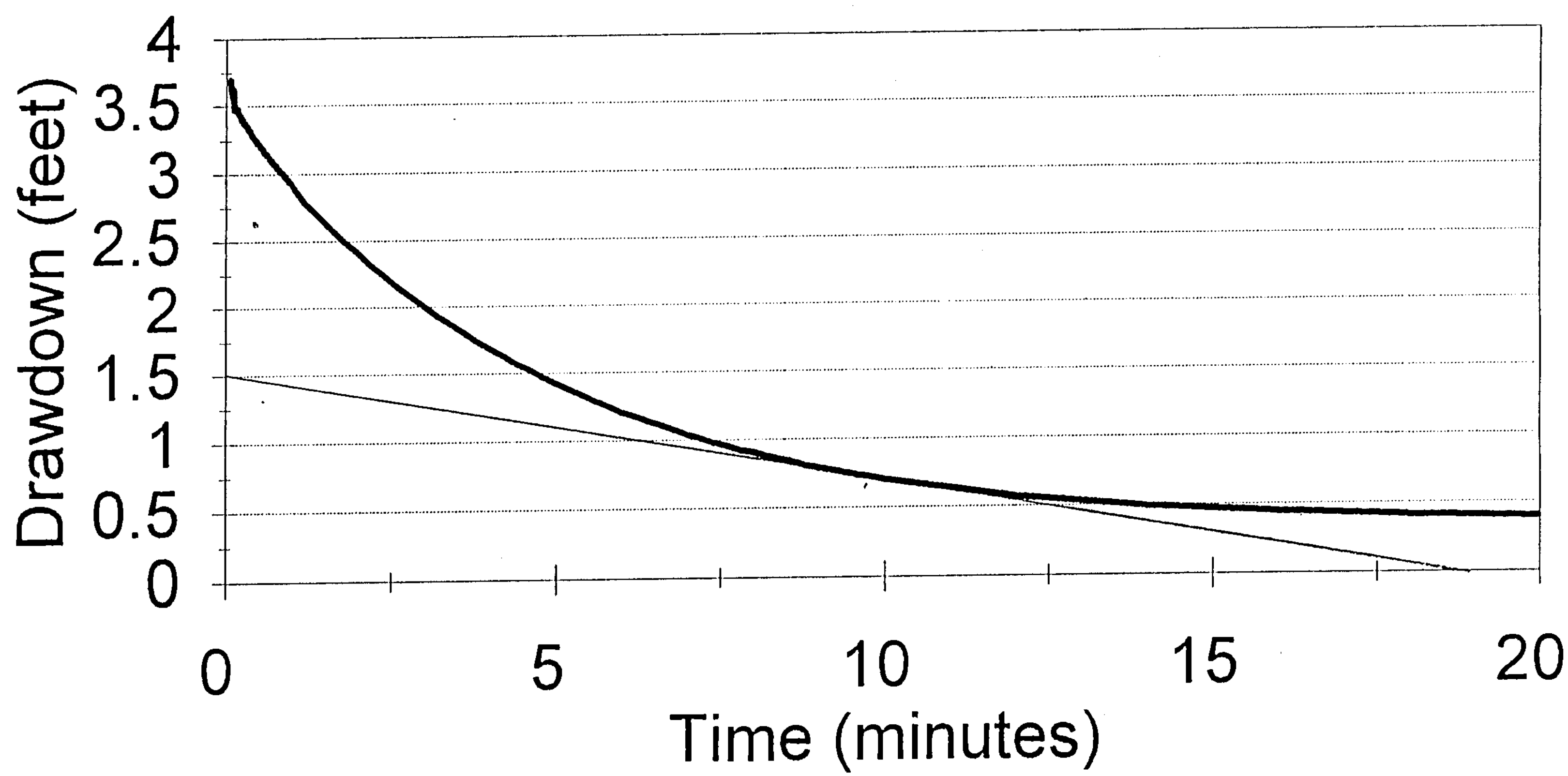
**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

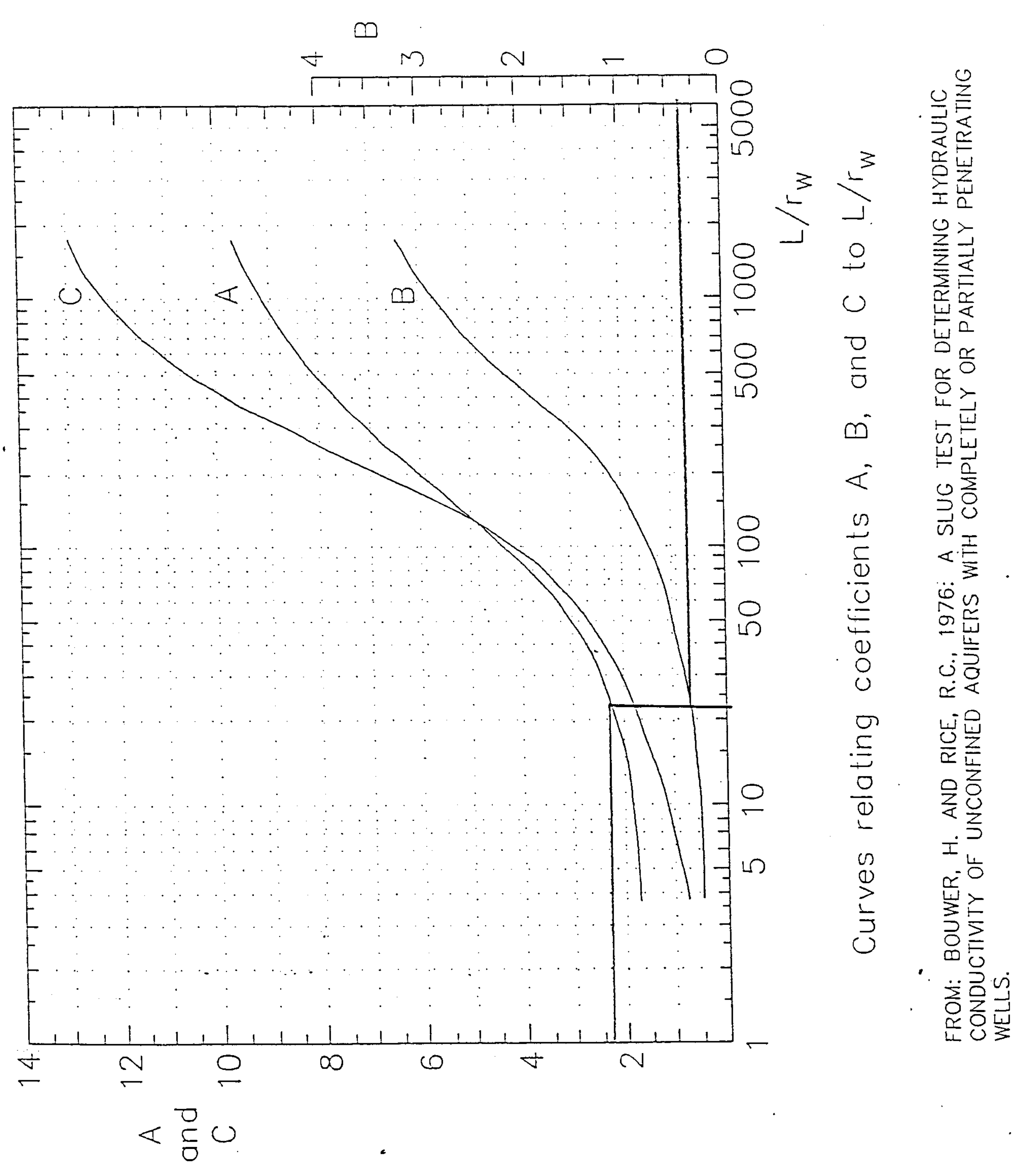
**K =** 0.001261 Ft/Min or 0.000641 CM/Sec

**K =** 1.81649 Ft/Day

## Halifax Landfill Slug Test Data

Piezometer B-4 - January, 1996






G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax landfill
B-4

**Halifax B-4 data - Slug Test 1/24/96**

SE1000C

Environmental Logger

01/24 20:50

Unit# 00069 Test 1

| Setups: | INPUT 1 |
| --- | --- |
| Type | Level (F) |
| Mode | TOC |
| I.D. | 00001 |

| | |
| --- | --- |
| Reference | 0.000 |
| Linearity | 0.120 |
| Scale factor | 20.020 |
| Offset | -0.020 |
| Delay mSEC | 50.000 |

Step 0 01/24 10:41:55

| Elapsed Time | INPUT 1 |
| --- | --- |
| 0.0000 | 0.012 |
| 0.0033 | 0.012 |
| 0.0066 | 0.012 |
| 0.0100 | 0.012 |
| 0.0133 | 0.012 |
| 0.0166 | 0.012 |
| 0.0200 | 0.019 |
| 0.0233 | 0.436 |
| 0.0266 | 1.328 |
| 0.0300 | 2.486 |
| 0.0333 | 3.112 |
| 0.0366 | 3.903 |
| 0.0400 | 3.915 |
| 0.0433 | 4.592 |
| 0.0466 | 4.958 |
| 0.0500 | 5.363 |
| 0.0533 | 3.106 |
| 0.0566 | 2.429 |
| 0.0600 | 3.100 |
| 0.0633 | 2.429 |
| 0.0666 | 3.277 |
| 0.0700 | 3.694 |
| 0.0733 | 3.694 |
| 0.0766 | 3.675 |
| 0.0800 | 3.656 |
| 0.0833 | 3.637 |
| 0.0866 | 3.631 |
| 0.0900 | 3.612 |
| 0.0933 | 3.593 |

Halifax B-4 Slug Test Data Page 2

| Elapsed Time | INPUT 1 |
|---|---|
| 0.0966 | 3.587 |
| 0.1000 | 3.580 |
| 0.1033 | 3.580 |
| 0.1066 | 3.599 |
| 0.1100 | 3.555 |
| 0.1133 | 3.555 |
| 0.1166 | 3.549 |
| 0.1200 | 3.542 |
| 0.1233 | 3.536 |
| 0.1266 | 3.624 |
| 0.1300 | 3.593 |
| 0.1333 | 3.587 |
| 0.1366 | 3.473 |
| 0.1400 | 3.498 |
| 0.1433 | 3.504 |
| 0.1466 | 3.498 |
| 0.1500 | 3.498 |
| 0.1533 | 3.492 |
| 0.1566 | 3.492 |
| 0.1600 | 3.485 |
| 0.1633 | 3.485 |
| 0.1666 | 3.485 |
| 0.1700 | 3.485 |
| 0.1733 | 3.473 |
| 0.1766 | 3.454 |
| 0.1800 | 3.466 |
| 0.1833 | 3.466 |
| 0.1866 | 3.460 |
| 0.1900 | 3.454 |
| 0.1933 | 3.454 |
| 0.1966 | 3.447 |
| 0.2000 | 3.447 |
| 0.2033 | 3.441 |
| 0.2066 | 3.441 |
| 0.2100 | 3.435 |
| 0.2133 | 3.435 |
| 0.2166 | 3.428 |
| 0.2200 | 3.428 |
| 0.2233 | 3.428 |
| 0.2266 | 3.422 |
| 0.2300 | 3.416 |
| 0.2333 | 3.416 |
| 0.2366 | 3.416 |
| 0.2400 | 3.409 |
| 0.2433 | 3.409 |
| 0.2466 | 3.403 |
| 0.2500 | 3.409 |
| 0.2533 | 3.403 |
| 0.2566 | 3.397 |
| 0.2600 | 3.397 |

**Halifax B-4 Slug Test Data Page 3**

| Elapsed Time | INPUT 1 |
|---|---|
| 0.2633 | 3.390 |
| 0.2666 | 3.390 |
| 0.2700 | 3.390 |
| 0.2733 | 3.384 |
| 0.2766 | 3.384 |
| 0.2800 | 3.378 |
| 0.2833 | 3.378 |
| 0.2866 | 3.372 |
| 0.2900 | 3.372 |
| 0.2933 | 3.372 |
| 0.2966 | 3.372 |
| 0.3000 | 3.365 |
| 0.3033 | 3.365 |
| 0.3066 | 3.359 |
| 0.3100 | 3.359 |
| 0.3133 | 3.359 |
| 0.3166 | 3.353 |
| 0.3200 | 3.353 |
| 0.3233 | 3.346 |
| 0.3266 | 3.346 |
| 0.3300 | 3.340 |
| 0.3333 | 3.340 |
| 0.3500 | 3.327 |
| 0.3666 | 3.315 |
| 0.3833 | 3.302 |
| 0.4000 | 3.289 |
| 0.4166 | 3.277 |
| 0.4333 | 3.264 |
| 0.4500 | 3.251 |
| 0.4666 | 3.245 |
| 0.4833 | 3.232 |
| 0.5000 | 3.220 |
| 0.5166 | 3.213 |
| 0.5333 | 3.201 |
| 0.5500 | 3.188 |
| 0.5666 | 3.182 |
| 0.5833 | 3.169 |
| 0.6000 | 3.157 |
| 0.6166 | 3.150 |
| 0.6333 | 3.138 |
| 0.6500 | 3.125 |
| 0.6666 | 3.112 |
| 0.6833 | 3.106 |
| 0.7000 | 3.093 |
| 0.7166 | 3.087 |

Halifax B-4 Slug Test Data Page 4

| Elapsed Time | INPUT 1 |
|---|---|
| 0.7333 | 3.074 |
| 0.7500 | 3.068 |
| 0.7666 | 3.055 |
| 0.7833 | 3.043 |
| 0.8000 | 3.036 |
| 0.8166 | 3.024 |
| 0.8333 | 3.017 |
| 0.8500 | 3.005 |
| 0.8666 | 2.998 |
| 0.8833 | 2.986 |
| 0.9000 | 2.979 |
| 0.9166 | 2.967 |
| 0.9333 | 2.960 |
| 0.9500 | 2.948 |
| 0.9666 | 2.941 |
| 0.9833 | 2.935 |
| 1.0000 | 2.922 |
| 1.2000 | 2.790 |
| 1.4000 | 2.689 |
| 1.6000 | 2.594 |
| 1.8000 | 2.499 |
| 2.0000 | 2.410 |
| 2.2000 | 2.322 |
| 2.4000 | 2.239 |
| 2.6000 | 2.157 |
| 2.8000 | 2.081 |
| 3.0000 | 2.012 |
| 3.2000 | 1.942 |
| 3.4000 | 1.872 |
| 3.6000 | 1.809 |
| 3.8000 | 1.746 |
| 4.0000 | 1.683 |
| 4.2000 | 1.632 |
| 4.4000 | 1.575 |
| 4.6000 | 1.525 |
| 4.8000 | 1.468 |
| 5.0000 | 1.423 |
| 5.2000 | 1.379 |
| 5.4000 | 1.335 |
| 5.6000 | 1.290 |
| 5.8000 | 1.252 |
| 6.0000 | 1.208 |
| 6.2000 | 1.177 |
| 6.4000 | 1.139 |
| 6.6000 | 1.107 |

Halifax B-4 Slug Test Data Page 5

| Elapsed Time | INPUT 1 |
|---|---|
| 6.8000 | 1.075 |
| 7.0000 | 1.037 |
| 7.2000 | 1.012 |
| 7.4000 | 0.980 |
| 7.6000 | 0.955 |
| 7.8000 | 0.923 |
| 8.0000 | 0.905 |
| 8.2000 | 0.879 |
| 8.4000 | 0.854 |
| 8.6000 | 0.835 |
| 8.8000 | 0.810 |
| 9.0000 | 0.791 |
| 9.2000 | 0.772 |
| 9.4000 | 0.753 |
| 9.6000 | 0.734 |
| 9.8000 | 0.721 |
| 10.0000 | 0.702 |
| 12.0000 | 0.575 |
| 14.0000 | 0.493 |
| 16.0000 | 0.449 |
| 18.0000 | 0.417 |
| 20.0000 | 0.398 |
| 22.0000 | 0.386 |
| 24.0000 | 0.379 |
| 26.0000 | 0.373 |
| 28.0000 | 0.367 |
| 30.0000 | 0.367 |
| 32.0000 | 0.367 |
| 34.0000 | 0.367 |
| 36.0000 | 0.379 |
| 38.0000 | 0.367 |
| 40.0000 | 0.367 |
| 42.0000 | 0.373 |
| 44.0000 | 0.373 |
| 46.0000 | 0.367 |
| 48.0000 | 0.367 |
| 50.0000 | 0.367 |
| 52.0000 | 0.367 |
| 54.0000 | 0.367 |
| 56.0000 | 0.367 |
| 58.0000 | 0.367 |
| 60.0000 | 0.373 |

G. N. Richardson and Associates

| | | | |
|---|---|---|---|
| **Client:** | Halifax County | **Proj. No.** | Halifax-4 |
| | | **Sheet:** | 1/1 |
| **Project:** | Halifax County Landfill | **Date:** | 1/96 |
| | | **Well:** | G-13 S |
| | | **Referenc** | Bouwer, 1989 |

**ln[Re/Rw] = [1.1/ln(Lw/Rw) + A + Bln[(H-Lw)/Rw]/Le/Rw] exp -1**

| | | |
|---|---|---|
| **Where:** | Lw = Height of Water Column in Well = | 9.02 |
| | Le = Screened Interval Open to Aquifer = | 9.02 |
| | Rw = Radius of Well Including Sand Pack | 0.167 |
| | Rc = Radius of Well Casing = | 0.083 |
| | H = Aquifer Thickness to First Aquitard = | 27 |
| | Yo = Relative Height of Water at Time Zer | 9 |
| | Yt = Relative Height of Water at Time t = | 6.5 |
| | n = Porosity = | 0.2 |
| | Time Tt (in minutes) = | 3.8 |
| | H - Lw = | 17.98 |
| | Yo/Yt = | 1.384615 |
| | Lw/Rw = | 54.01198 |
| | ln(H-Lw)/Rw = | 4.679021 |

**Correction for Sandpack:**

**Req = [Rc exp2 + n(Rw exp2 + Rc exp2)] exp1/2**

Req = 0.013845

**Req =** 0.117663

**Evaluation of A and B:**

Le/Rw = 54.01198

**From Attached Graph of A and B:**

**A =** 3.2

**B =** 0.6

**ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-1**

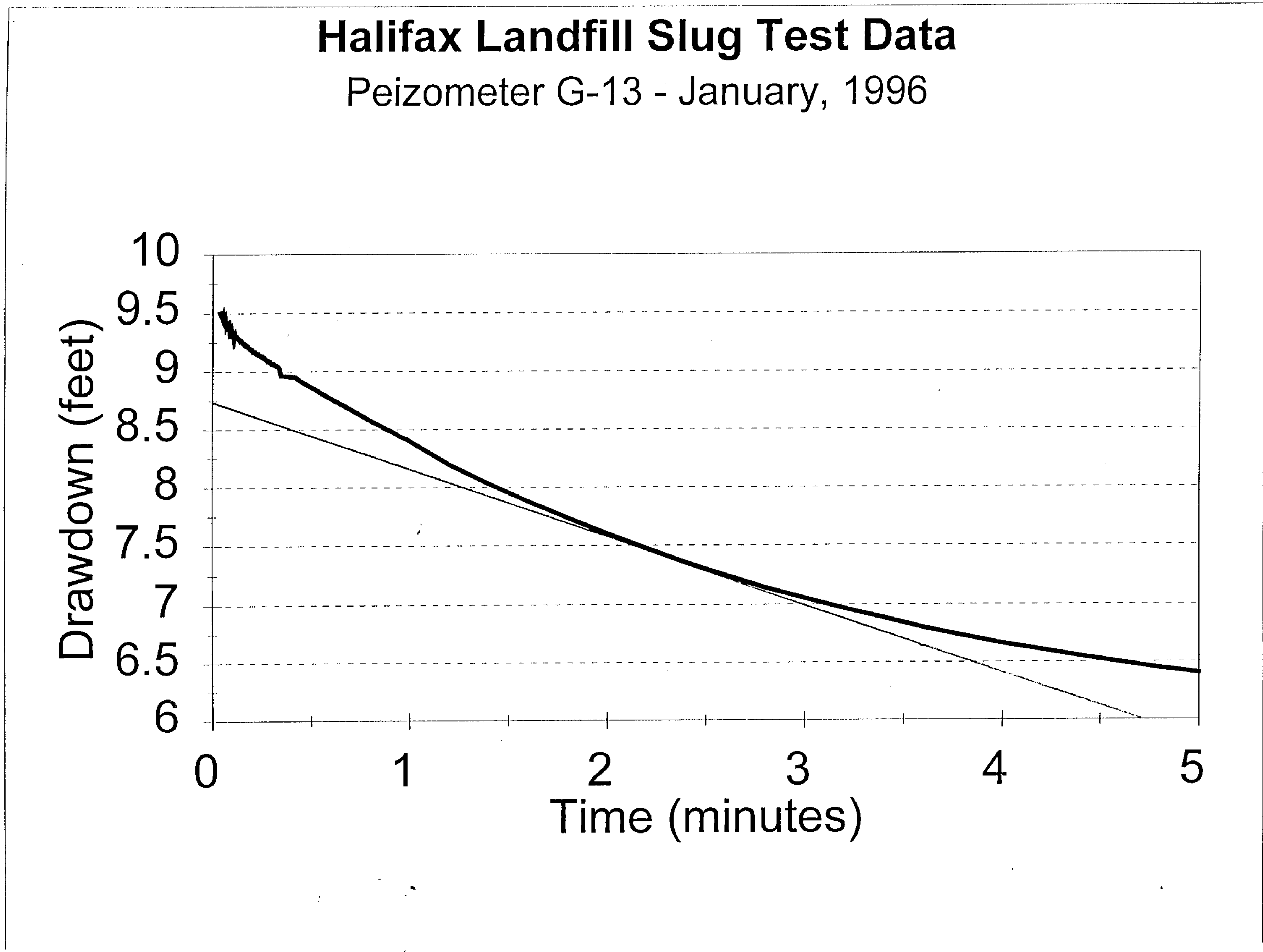
ln Re/Rw= 3.527722 exp-1

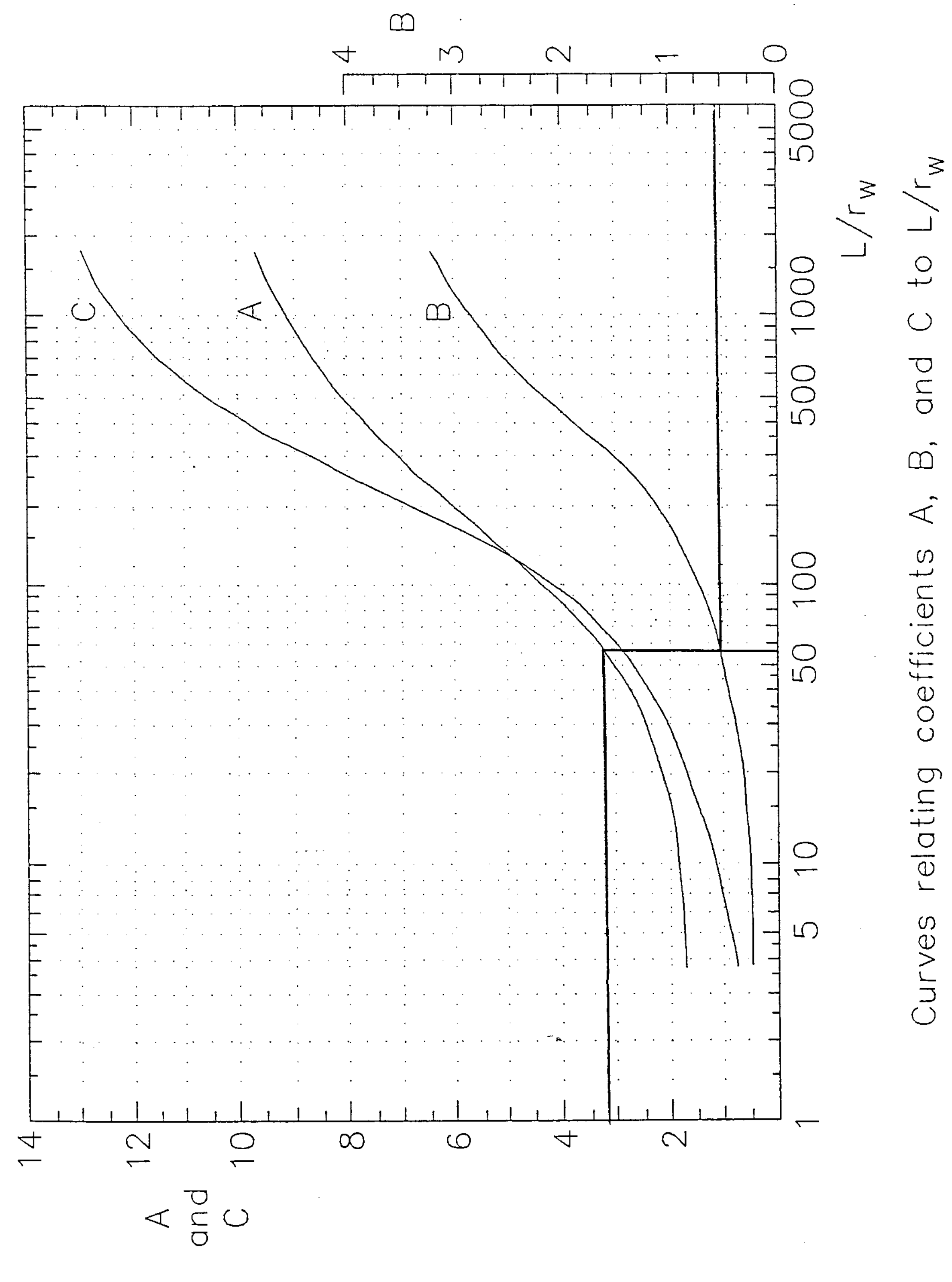
**ln Re/Rw=** 0.283469

**K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le**

**K =** 1.86E-05 Ft/Min or 9.46E-06 CM/Sec

**K =** 0.026827 Ft/Day


Halifax Landfill Slug Test Data
Peizometer G-13 - January, 1996
Drawdown (feet)
10
9.5
9
8.5
8
7.5
7
6.5
6
0
1
2
3
4
5
Time (minutes)




Curves relating coefficients A, B, and C to L/$r_w$

FROM: BOUWER, H. AND RICE, R.C., 1976: A SLUG TEST FOR DETERMINING HYDRAULIC CONDUCTIVITY OF UNCONFINED AQUIFERS WITH COMPLETELY OR PARTIALLY PENETRATING WELLS.

G.N. RICHARDSON & ASSOC.
417 N. BOYLAN AVENUE
RALEIGH N.C. 27603
919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
G-13
Halifax County Landfill

**Halifax G-13 Slug Test Data**
SE1000C
Environmental Logger
01/23 21:59

Unit# 00069 Test 2

Setups: INPUT 1

| Setups: | INPUT 1 |
|---|---|
| Type | Level (F) |
| Mode | TOC |
| I.D. | 00001 |

| | |
|---|---|
| Reference | 0.000 |
| Linearity | 0.120 |
| Scale factor | 20.020 |
| Offset | -0.020 |
| Delay mSEC | 50.000 |

Step 0 01/23 12:17:51

| Elapsed Time | INPUT 1 |
|---|---|
| 0 | |
| 0.0033 | |
| 0.0066 | |
| 0.01 | |
| 0.0133 | |
| 0.0166 | |
| 0.02 | |
| 0.0233 | |
| 0.0266 | |
| 0.03 | |
| 0.0333 | |
| 0.0366 | |
| 0.04 | 9.503 |
| 0.0433 | 9.477 |
| 0.0466 | 9.471 |
| 0.05 | 9.458 |
| 0.0533 | 9.471 |
| 0.0566 | 9.427 |
| 0.06 | 9.414 |
| 0.0633 | 9.42 |
| 0.0666 | 9.439 |
| 0.07 | 9.389 |
| 0.0733 | 9.402 |
| 0.0766 | 9.402 |
| 0.08 | 9.383 |
| 0.0833 | 9.345 |
| 0.0866 | 9.376 |
| 0.09 | 9.345 |
| 0.0933 | 9.332 |

**Halifax G-13 Slug Test Data**
**Page 2**

| Elapsed Time | INPUT 1 |
|---|---|
| 0.0966 | 9.351 |
| 0.1 | 9.332 |
| 0.1033 | 9.32 |
| 0.1066 | 9.282 |
| 0.11 | 9.313 |
| 0.1133 | 9.32 |
| 0.1166 | 9.301 |
| 0.12 | 9.301 |
| 0.1233 | 9.301 |
| 0.1266 | 9.288 |
| 0.13 | 9.282 |
| 0.1333 | 9.282 |
| 0.1366 | 9.275 |
| 0.14 | 9.263 |
| 0.1433 | 9.269 |
| 0.1466 | 9.263 |
| 0.15 | 9.25 |
| 0.1533 | 9.244 |
| 0.1566 | 9.244 |
| 0.16 | 9.237 |
| 0.1633 | 9.237 |
| 0.1666 | 9.231 |
| 0.17 | 9.225 |
| 0.1733 | 9.225 |
| 0.1766 | 9.219 |
| 0.18 | 9.212 |
| 0.1833 | 9.206 |
| 0.1866 | 9.2 |
| 0.19 | 9.2 |
| 0.1933 | 9.193 |
| 0.1966 | 9.187 |
| 0.2 | 9.187 |
| 0.2033 | 9.181 |
| 0.2066 | 9.174 |
| 0.21 | 9.174 |
| 0.2133 | 9.168 |
| 0.2166 | 9.168 |
| 0.22 | 9.162 |
| 0.2233 | 9.155 |
| 0.2266 | 9.155 |
| 0.23 | 9.149 |
| 0.2333 | 9.149 |
| 0.2366 | 9.143 |
| 0.24 | 9.137 |
| 0.2433 | 9.137 |
| 0.2466 | 9.13 |
| 0.25 | 9.13 |
| 0.2533 | 9.124 |
| 0.2566 | 9.118 |

**Halifax G-13 Slug Test Data**
**Page 3**

| Elapsed Time | INPUT 1 |
|---|---|
| 0.26 | 9.118 |
| 0.2633 | 9.111 |
| 0.2666 | 9.111 |
| 0.27 | 9.105 |
| 0.2733 | 9.099 |
| 0.2766 | 9.099 |
| 0.28 | 9.092 |
| 0.2833 | 9.092 |
| 0.2866 | 9.086 |
| 0.29 | 9.086 |
| 0.2933 | 9.08 |
| 0.2966 | 9.073 |
| 0.3 | 9.073 |
| 0.3033 | 9.067 |
| 0.3066 | 9.067 |
| 0.31 | 9.061 |
| 0.3133 | 9.061 |
| 0.3166 | 9.054 |
| 0.32 | 9.054 |
| 0.3233 | 9.048 |
| 0.3266 | 9.048 |
| 0.33 | 9.042 |
| 0.3333 | 9.036 |
| 0.3366 | 9.023 |
| 0.34 | 9.004 |
| 0.3433 | 8.985 |
| 0.3466 | 8.966 |
| 0.4166 | 8.953 |
| 0.4333 | 8.935 |
| 0.45 | 8.916 |
| 0.4666 | 8.897 |
| 0.4833 | 8.884 |
| 0.5 | 8.865 |
| 0.5166 | 8.852 |
| 0.5333 | 8.834 |
| 0.55 | 8.815 |
| 0.5666 | 8.802 |
| 0.5833 | 8.783 |
| 0.6 | 8.77 |
| 0.6166 | 8.751 |
| 0.6333 | 8.739 |
| 0.65 | 8.72 |
| 0.6666 | 8.707 |
| 0.6833 | 8.688 |
| 0.7 | 8.676 |
| 0.7166 | 8.657 |
| 0.7333 | 8.644 |
| 0.75 | 8.625 |
| 0.7666 | 8.613 |
| 0.7833 | 8.594 |

**Halifax G-13 Slug Test Data**
**Page 5**

| Elapsed Time | INPUT 1 |
| --- | --- |
| 7.6 | 6.081 |
| 7.8 | 6.068 |
| 8 | 6.055 |
| 8.2 | 6.049 |
| 8.4 | 6.036 |
| 8.6 | 6.03 |
| 8.8 | 6.024 |
| 9 | 6.017 |
| 9.2 | 6.011 |
| 9.4 | 6.005 |
| 9.6 | 5.998 |
| 9.8 | 5.998 |
| 10 | 5.992 |
| 12 | 5.973 |
| 14 | 5.967 |
| 16 | 5.961 |
| 18 | 5.961 |
| 20 | 5.954 |
| 22 | 5.954 |
| 24 | 5.954 |
| 26 | 5.954 |
| 28 | 5.954 |
| 30 | 5.954 |
| 32 | 5.954 |
| 34 | 5.954 |
| 36 | 5.954 |
| 38 | 5.954 |
| 40 | 5.961 |
| 42 | 5.954 |
| 44 | 5.954 |
| 46 | 5.954 |
| 48 | 5.954 |
| 50 | 5.961 |
| 52 | 5.961 |
| 54 | 5.954 |
| 56 | 5.954 |
| 58 | 5.954 |
| 60 | 5.954 |

# Appendix G

# Sampling and Analysis Plan
# Halifax County Unlined Landfill

## Halifax, North Carolina

Prepared for:

**Halifax County**
**Department of Public Works**
**Halifax, North Carolina**

The water quality monitoring plan for this facility has been prepared by a qualified geologist who is licensed to practice in the state of North Carolina. The plan has been prepared based on knowledge of site conditions and familiarity with North Carolina solid waste rules and industry standard protocol. The water quality monitoring plan described herein should provide reasonably effective early detection of a chronic release of hazardous constituents into the ground or surface waters of the state, due to or caused by activities at the landfill. No other warranties, expressed or implied, are made.

Peter U. Schaer FOR

Joan A. Finkbeiner, P.G.
Project Hydrogeologist

G. David Garrett

G. David Garrett, P.G.
Principal, Senior Geologist

NORTH CAROLINA LICENSED GEOLOGIST SEAL 983 G. DAVID GARRETT

**October, 1996**


**G.N. Richardson & Associates**
Engineering and Geological Services
417 N. Boylan Avenue
Raleigh, North Carolina 27603

# SAMPLING AND ANALYSIS PLAN
# HALIFAX COUNTY LANDFILL
# HALIFAX COUNTY, NORTH CAROLINA

**PERMIT 42-02**

Prepared For:

**Halifax County Solid Waste Dept.**
Halifax, North Carolina

Prepared By:


**G. N. Richardson and Associates**

417 North Boylan Avenue

Raleigh, North Carolina 27603

Phone: (919) 828-0577


August 1997

## TABLE OF CONTENTS

# 1.0 Introduction

## 1.1 Plan Description

This site is a MSW landfill (scheduled closure date is January 1, 1998) and a new C&D landfill located east of the closed MSW landfill. Both landfills are located within the permitted facility boundary at the Halifax County Landfill (Permit 42-04). The ground water monitoring network includes nine monitoring wells (MW-1, MW-2a, MW-3ad, MW-6s, MW-6d, MW-7s, MW-7d, MW-15, MW-16a) and three surface water sampling locations (SW-1, SW-2 and SW-3), located about the MSW landfill as shown in Figure 1. These sampling locations have been in service for several years. Monitoring of the closed landfill will continue without modification.

The ground water monitoring program will be modified upon completion of the planned C&D landfill with two new monitoring wells (MW-17 and MW-18) and one new surface water sampling location (SW-4). This revised Sampling and Analysis Plan (SAP) is submitted due to planned modifications to the site monitoring program required for the planned C&D landfill. This plan is based in part on ground water studies for both landfill sites. Ground water flow directions based on these studies are shown in Figure 2. This plan does not pertain to or modify the ground water monitoring program for the nearby ash monofill.

## 1.2 Regulatory Requirements

North Carolina Solid Waste Management rules, 15A NCAC 13B, Section .1630 through .1637, and Section .0504 (1) (g) (iv) specify that the owner/operator must provide a monitoring program for a ground water and surface water sampling. This Sampling and Analysis Plan (SAP) has been designed to provide accurate results of ground and surface water quality at the upgradient and downgradient sampling locations. The SAP will address the following subjects:

- Ground water sample collection
- Sample preservation and shipment
- Analytical procedures
- Chain-of-custody
- Quality assurance/quality control (QA/QC)
- Sampling locations and frequency.

The methods and procedures described in the following sections are intended to gather true and representative samples and test data. Field procedures are presented in their general order of implementation. Equipment requirements are presented in each section, and quality assurance and record keeping requirements are presented in the latter sections.

## 2.0 Ground and Surface Water Sample Collection

Table 1 presents a summary description of ground water monitoring wells and surface water sampling points. Figure 1 shows the monitoring well locations and surface sampling points. Ground water samples will be collected from each of the monitor wells and from the surface water sampling locations on a semi-annual schedule. An exception is made for monitoring wells MW-6d and MW-7d, which will be monitored on a bi-annual schedule due to their historical lack of contaminants.

### 2.1 Static Water Level Measurements

Static water level elevations will be measured prior to any purging or sampling activities. These data will be used to monitor changes in site hydrogeologic conditions. The following measurements will be recorded in a dedicated field book prior to sample collection:

- Elevation of water level (to the nearest 0.01 foot)
- Total depth of well
- Height of water column in the riser
- Changes in condition of well and surroundings.

An electronic water level indicator shall be used to accurately measure water elevations to within 0.01 foot. Each well shall have a permanent, easily identified reference point from which all water level measurements will be taken. The reference point shall be marked and the elevation surveyed by a Registered Land Surveyor. The static water level and total depth shall be used to calculate the volume of water in the well. The static water measuring device shall be constructed of inert materials, such as stainless steel and Teflon®. Between well measurements the device shall be thoroughly decontaminated by washing with non-phosphate soap and triple rinsing with deionized water to prevent cross contamination.

### 2.2 Detection of Immiscible Layers

The monitoring wells are designed such that the screened interval intersects the water table to allow detection of light nonaqueous phase liquids (LNAPLS) prior to purging and sampling. The following procedures shall be used to detect immiscible layers at all monitoring wells with known ground water impact. The appropriate procedure will be repeated until the immiscible phase liquid is removed from the well prior to sample collection.

A clear Teflon® bailer shall be lowered into the well until it intersects the water table and allowed to penetrate the water table about 6 inches. The bailer shall be retrieved and the sample will be observed to identify the presence of a light phase immiscible layer. If an immiscible layer is present, the bailer shall again be lowered into the well and allowed to penetrate the water table for the full depth of the bailer. The thickness of the light phase immiscible layer, if present, shall then be recorded in a dedicated field logbook. Should the thickness of the light phase immiscible layer be greater than the length of the bailer, an interface probe shall be used to determine the thickness of the layer. The depth of the water table shall be recorded.

Dense phase immiscible layer shall be detected by lowering the bailer (or interface probe, if used) to the bottom of the well and retrieving it. Any dense phase immiscible compounds observed in the sample will be observed and recorded. A sample of any detected immiscible layers shall be collected in an appropriate sampling bottle for analysis. All immiscible phase liquids shall be removed prior to sampling the well.

The procedure for collecting and/or removing light phase immiscible layer will depend on the thickness the floating layer. If the thickness of the light phase is two (2) feet or greater, a bottom valve bailer shall be lowered slowly until contact is made with the immiscible/water interface depth, determined by previous measurements. If the thickness of the light phase is less than two (2) feet, a bottom valve bailer must be modified to allow the sample to enter from the top. The bottom check valve shall be disassembled and a piece of 2-inch diameter Teflon® disk shall be inserted above the ball seat to seal off the bottom valve.

The ball from the top check valve shall be removed. The additional buoyancy shall be overcome with a length of stainless steel pipe placed on the retrieval line above the bailer. The bailer will be lowered until the top is level with the surface of the light immiscible phase, The bailer will be lowered one-half the thickness of the light immiscible phase, then retrieved.

The procedure to collect dense phase immiscibles will be to use a double check valve bailer. The bailer will be lowered in a controlled manner, then slowly retrieved to retain the dense phase immiscible liquid. Based on past experience with ground water monitoring programs for landfills, it is unlikely that immiscible layers will be detected. Should collection of immiscible phase fluids become necessary on a regular basis, the ground water monitoring protocol shall be re-evaluated and modified as appropriate.

## 2.3 Monitoring Well Evacuation

Following measurement of the static water elevation in all of the wells, individual wells will be purged of all stagnant water. The stagnant water, which is not representative of true aquifer conditions, must be removed to insure that fresh formation water can be sampled. A minimum of three well volumes will be removed prior to sampling the well.

The well volume for 2-inch diameter wells will be calculated using the following equation:

$$V = (TD - SWL) \times C$$

Where:

| | | |
|---|---|---|
| V | = | One well volume |
| TD | = | Total depth of the well (in feet) |
| SWL | = | Static water level (in feet) |
| C | = | Volume constant for given well diameter (gallons/foot) |
| | | C = 0.163 gal/ft for two-inch diameter wells. |

Well completion depth data are included in Table 2. Determining the well volume in gallons will allow the sampler to determine the amount of ground water to purge in order to remove a minimum of three to five well volumes (or until the well is purged dry). Wells will be purged at a rate which will not cause recharge water to be excessively agitated. Dry and low recharge rates, and the total purged volume will be noted in field observations. Should impacted ground water be detected, purge water will be managed to prevent possible soil contamination (either through containment, or treatment on-site).

Prior to purging, new latex or nitrile surgical gloves will be donned. Each well will be purged in such a way that water is removed from the bottom of the screened interval. During the well purging process, field measurements (i.e., pH, temperature, and specific conductance) will be collected at regular intervals, and reported in a tabular format. The well will be purged until field measurements stabilize (to within 10% of each other) or until the well is dry. Stabilization of these measurements will indicate that fresh formation water is present in the well. Field measurements of pH, temperature, and conductivity will be obtained by using a combination water quality meter. Data collected will be recorded in a field log book.

A new, disposable fluorocarbon resin (Teflon®) or inert plastic bailer with bottom check valve will be used to evacuate each well. A new Teflon®-coated stainless steel, inert monofilament line or new nylon rope will be used to retrieve the bailer. Clean, disposable latex or nitrile surgical gloves will be used at each well, and appropriate measures will be taken to prevent surface soils and other contaminant sources from contacting the purging equipment. Non-dedicated field equipment (field measuring devices) will be thoroughly decontaminated between wells by disassembling and washing with (non-phosphate) soapy, de-ionized water and triple rinsed using de-ionized water.

Should dedicated pumps be used, a minimum of three to five well volumes (or until the well is purged dry) will be purged from the well utilizing a dedicated pump. If the Micro-Purge® and/or Purge Saver® systems or similar purging systems are used, less water may be purged based upon the field parameters analyzed by these systems. Pumping shall be completed at a flowrate the aquifer can maintain, and so as to not agitate sediments. Only stainless steel and Teflon® pumps shall be used.

## 2.4 Ground Water Sample Collection

After purging activities are complete, ground water samples will be collected for laboratory analysis. Samples will only be collected after new latex or nitrile surgical gloves have been donned. The wells will be sampled using either disposable Teflon® bailers with bottom check valve, bottom emptying devices and Teflon® coated wire, inert monofilament line or new nylon rope, or by the use of dedicated pumps. Sampling will occur as soon after well recovery as possible. Wells which fail to produce an adequate sample volume within 24 hours of purging will not be sampled.

Temperature, pH, and specific conductance will be taken at the start and ending of sampling as a measure of purging efficiency and as a check on the stability of the water samples over time. Measurements of temperature, pH, and specific conductivity will be recorded for all water samples. The calibration of the pH, temperature, and conductivity meter will be completed at the beginning of each sampling event, according to the manufacturers' specifications and consistent with Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846).

Ground water samples will be collected and contained in the order of volatilization sensitivity of the parameters as follows:

- Initial measurements of pH, temperature and conductivity
- Volatile Organics
- Total Metals
- Turbidity
- Final measurements of pH, temperature, and conductivity

All samples will be collected unfiltered. Samples for dissolved metal analysis, if subsequently required, will be prepared by field filtration using a decontaminated Nalgene® hand-operated filtering pump (or equivalent) or peristaltic pump and a disposable 0.45 micron filter cartridge specifically manufactured for this purpose.

All reusable sampling equipment including meter probes, and filtering pump (if used), which might contact aquifer water or samples, will be thoroughly decontaminated between wells by washing with non-phosphate soapy, de-ionized water and triple rinsing with deionized water.

Samples will be transferred directly from the Teflon® bailer into a container that has been specifically prepared for the preservation and storage of compatible parameters. A bottom emptying device provided with the bailer will be used to transfer samples from bailer to sample container to assure minimum agitation.

Blanks and duplicate samples will be taken and analyzed for the same parameters as ground water samples to insure cross-contamination has not occurred. One set of trip blanks, as described later in this document, will be collected before leaving the laboratory to insure that the sample containers or handling processes have not affected the quality of the samples. One set of field (equipment) blanks will be collected in the field at the time of sampling to insure that the field conditions, equipment used, and handling during sampling collection have not affected the quality of the samples.

A duplicate ground water sample may be collected from a single well as a check of laboratory accuracy. Blanks and duplicate containers, preservatives, handling, and transport procedures for surface water samples will be identical to those noted for ground water samples.

Sample containers shall be provided by the laboratory for each sampling event. Containers shall be cleaned by the laboratory based on the analyte of interest. Metal containers shall be thoroughly washed with non-phosphate detergent and tap water, and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water, and deionized water, in that order. Organic sample containers shall be thoroughly washed with non-phosphate detergent in hot water and rinsed with tap water, distilled water, acetone, and pesticide quality hexane, in that order. Other sample containers shall be thoroughly washed with non-phosphate detergent and tap water, rinsed with tap water, and rinsed with deionized water. The laboratory shall provide proper preservatives in the sample containers prior to shipment.

## 2.5 Surface Water Sample Collection

Surface water samples shall be obtained from areas of minimal turbulence and aeration. The following procedure will be implemented regarding sampling of surface waters:

1. Put on new latex or nitrile surgical gloves.
2. Hold the bottle at the bottom with one hand, and with the other, remove the cap.
3. Push the sample container slowly into the water and tilt up towards the current to fill. A depth of about 6 inches is satisfactory. Do not completely immerse the container to avoid breaching the surface while filling the container.
4. If there is little current movement, the container should be moved slowly, in a lateral direction.

## 2.6 Equipment Decontamination

All non-dedicated equipment that will come in contact with the well casing and water, i.e. water level indicator, will be decontaminated. The procedure for decontaminating non-dedicated equipment as follows:

1. Clean item with tap water and phosphate-free laboratory detergent (Liquinox® or equivalent), using a brush if necessary to remove particulate matter and surface films.
2. Rinse thoroughly with tap water
3. Rinse thoroughly with deionized or distilled water and allow to air dry
4. Rinse thoroughly with high grade isopropanol and allow to air dry
5, Wrap with aluminum foil, if necessary, to prevent contamination of equipment during storage or transport.

## 3.0 Field QA/QC Program

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of two types of QC blanks, trip blanks and field blanks, to verify that the sample collection and handling process has not affected the quality of the samples. The following sampling blanks will be analyzed for all of the required monitoring parameters:

**Trip Blank** - Fill one of each type of sample bottle with distilled or deionized water, transport to the site, handle like a sample, and return to the laboratory for analysis. One set of trip blanks will be analyzed per sampling event. Trip blanks should be prepared by the laboratory and transported with the sample glassware prior to sampling.

**Field blank** - To insure that any non-dedicated sampling device has been effectively cleaned, fill the device with distilled or deionized water, while wearing clean latex or nitrile surgical gloves, transfer to sample bottles(s), and return to the laboratory for analysis. If the samples are collected with bailers, a minimum of one field blank for each day that samples are collected is required. If dedicated pumps are used for sample collection, field blank samples are not necessary.

Sampling blanks will be placed in bottles of the specific type required for the analyzed parameters and taken from a bottle pack specifically assembled by the laboratory for each ground water sampling event. Trip blanks will be taken prior to the sampling event and transported with the empty bottle packs. Field blanks will be placed in contact with field sampling equipment and returned to the laboratory in a manner identical to the handling procedure used for the samples.

Contaminants found in the trip blanks could be attributed to the following:

1. Interaction between the sample and the container
2. Contaminated source water
3. A handling procedure that alters the sample
4. Interaction with the sampling device
5. A field handling procedure which taints the retrieved sample.

The concentration levels of any contaminants found in the trip blank will be reported but will not be used to correct the ground water data. In the event that elevated parameter concentrations are found in any blank, the analysis will be flagged for future evaluation and possible resampling.

All field instruments utilized in the field to measure ground water characteristics will be calibrated prior to entering the field, and recalibrated in the field as required, to insure accurate measurement for each sample. The specific conductivity and pH meter shall be recalibrated utilizing two prepared solutions of known concentration in the range of anticipated values (between 4 and 10). A permanent thermometer, calibrated against a National Bureau of Standards Certified thermometer, will be used for temperature meter calibration.

## 4.0 Sample Preservation and Shipment

In order to insure sample integrity, preservation and shipment procedures will be carefully monitored. Proper storage and transport conditions must be maintained in order to preserve the integrity of the sample. Generally, ice and chemical ice packs will be used as sample preservatives, as recommended by the commercial laboratory. <u>Dry ice is not to be used.</u>

For VOC analysis, hydrochloric acid will be used for sample preservation as well as by maintaining the samples at a temperature of 4°C. Nitric acid will be used as the preservative for samples needing metals analysis. Samples shall be delivered to the analytical laboratory within a 24-hour period using an overnight delivery service, if needed, to insure holding times are not exceeded. Shipment and receipt of samples will be coordinated with the laboratory.

Once collected, samples will be placed on ice and cooled to a temperature of 4°C. Samples are to be packed in high impact polystyrene coolers so as to inhibit breakage or accidental spills. Custody seals shall be placed on the outside of the cooler, in a manner to detect tampering of the samples. Chain-of-Custody control for all samples will consist of the following:

1. Labels will be placed on individual sample containers in the field, indicating the site, date and time of sampling, well number, and preservation method used for the sample.

2. Sample containers will be individually secured or placed in a secured area in iced coolers and will remain in the continuous possession of the field technician until transferral as provided by the Chain-of-Custody form has occurred.

3. Upon delivery to the laboratory, samples are given laboratory sample numbers and recorded into a logbook indicating client, well number, and date and time of delivery. The laboratory director or his designatee will sign the Chain-of-Custody control forms and formally receive the samples. The samples will be maintained at the appropriate

temperature at all times.

## 5.0 Field Logbook

The field technician will keep an up-to-date logbook documenting important information pertaining to the technician's field activities. The field logbook will document the following:

- Site Name and Location
- Date and Time of Sampling
- Climatic Conditions Immediately Before and After Sampling Event
- Well Identification Number
- Presence of Immiscible Layers and Detection Method
- Well Static Water Level
- Well Depth
- Height of Water Column in Well
- Volume of Three (3) Well Volumes
- Purged Water Volume and Well Yield (High or Low)
- Pumping or Bailing Rate
- Time Well Purged
- Observations on Purging and Sampling Event
- Time of Sample Collection
- Temperature, pH, Turbidity, and Conductivity Readings (4x)
- Signature of Field Technician.

## 6.0 Laboratory Analysis

The ground water samples will be analyzed for parameters specified by North Carolina Solid Waste Management Rules. All analytical methods are taken from Test Methods For Evaluating Solid Waste - Physical/Chemical Methods (SW-846) or Methods For the Chemical Analysis of Water and Wastes. Analysis will be performed by a laboratory certified by the North Carolina DEHNR for the analyzed parameters.

Quality Assurance/Quality Control (QA/QC) procedures are to be utilized at all times. The owner/operator of the landfill is responsible for selecting a laboratory and insuring that they are utilizing proper QA/QC procedures. The laboratory must have a QA/QC program based upon specific routine procedures outlined in a written laboratory Quality Assurance/Quality Control Manual. The QA/QC procedures listed in the manual provide the lab with the necessary assurances and documentation for accuracy and precision of analytical determinations. Internal quality control checks shall be undertaken, regularly by the lab, to assess the precision and accuracy of analytical procedures.

The internal quality control checks include the use of calibration standards, standard references, duplicate samples and spiked or fortified samples. Calibration standards shall be verified against a standard reference obtained from an outside source. Calibration curves shall be developed using at least one blank and three standards. Samples shall be diluted if necessary to insure that analytical measurements fall on the linear portion of the calibration curve. Duplicate samples shall be processed at an average frequency of 10 percent to assess the precision of testing methods, and standard references shall be processed monthly to assess accuracy of analytical procedures. Spiked or fortified samples shall be carried through all stages of sample preparation and measurement to validate the accuracy of the analysis.

During the course of the analyses, quality control data and sample data shall be reviewed by the laboratory manager to identify questionable data and determine if the necessary QA/QC requirements are being followed. If a portion of the lab work is subcontracted, it is the responsibility of the contracted laboratory to verify that all subcontracted work is completed by certified laboratories, using identical QA/QC procedures.

## 7.0 Statistical Evaluation

All statistical analysis will be performed in accordance with North Carolina State Regulations 15A NCAC 13B.1632. Other references for methods to evaluate the data are taken from one or more of the following:

- EPA RCRA Ground Water Monitoring Draft Technical Guidance Document
- EPA Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities - Addendum to Interim Final Guidance.
-

The North Carolina Solid Waste Rules requires that the owner or operator of the landfill specify a statistical method outlined in these rules to evaluate ground water monitoring data. The goal of the statistical analysis is to determine whether statistically significant evidence of contamination exists and to identify the point of contamination. Upon receipt of each monitoring event's data, the statistical database of analyses will be updated. The North Carolina Solid Waste Rules provide several methods for statistical analysis of ground water data. These methods are:

1. Parametric analysis of variance (ANOVA)
2. Rank-based (non-parametric) ANOVA with multiple comparisons
3. Tolerance prediction interval
4. Control chart
5. Test of Proportions
6. An alternative statistical test method that meets the performance standards of 40 CFR 258.53 (h)

Statistical evaluation of monitoring data shall be performed for the duration of the monitoring program, including the post-closure care period. The choice of an appropriate statistical test depends on the type of monitoring, the nature of the data, and the proportion of values in the data set that are below detection limits. The statistical analysis should be conducted separately for each detected constituent in each well.

## 8.0 Record Keeping and Reporting

Copies of laboratory results and water quality reports shall be kept on file at the Halifax County Landfill office. Summary reports shall be submitted to the NC DWM for each sampling event.

### 8.1 Notifications

Should a statistically significant increase in ground water concentrations as defined in North Carolina Solid Waste Management rules be detected during monitoring, the owner/operator of the landfill shall notify the NC DWM within 14 days and will place a notice in the operating record as to which constituents increased. At such point the ground water monitoring program shall be re-evaluated and may require modification.

### 8.2 Well Abandonment/Rehabilitation

Should any monitoring well become irreversibly damaged or require rehabilitation, it shall be abandoned in accordance with the requirements of 15 NCAC 02C .0100. The abandonment will consist of plugging the well with a chemically inert, impermeable sealant, e.g. neat cement and/or bentonite-cement grout. Where possible, it is preferred to overdrill and remove well casing, screen and filter pack prior to grouting.

### 8.3 Additional Well Installation

The static ground water surface elevation shall be used to create potentiometric maps (see Figure 2) to evaluate ground water flow directions. This data will be used to verify correct placement of existing wells and, if required, determine locations for future monitoring wells. Should additional wells be required to monitor potential releases of solid waste constituents into the ground water, new well locations and depths will be submitted to the NCDSWM for approval.

All future monitoring wells shall be installed under the supervision of a geologist or engineer who is registered in North Carolina and who will certify to the NCDSWM that the installation complies with the North Carolina Regulations. Construction documentation for each new well shall be submitted by the registered geologist or engineer within 30 days after completion.

## 8.4 Implementation

This Sampling and Analysis Plan will become effective upon approval by NC DWM and will remain in effect until further modifications are approved. Sampling of the new wells for the planned C&D facility prior to waste placement shall be conducted in accordance with NC DWM guidelines. Sampling of the new wells and surface water location for the planned C&D facility will resume with the current semi-annual facility monitoring schedule. Sampling is currently scheduled for February and August of each year.

Table 1

**Ground Water and Surface Water Monitoring Plan**
**Monitoring Well and Stream Sampling Locations**

**Halifax County Landfill**

**October, 1996**

| Monitoring Wells | Well Location | Monitoring Schedule |
|---|---|---|
| MW-1 | Background well | Semi-annually |
| MW-2a | Down gradient well | Semi-annually |
| MW-3ad | Down gradient well | Semi-annually |
| MW-6s | Down gradient well | Semi-annually |
| MW-6d | Down gradient deep well | Bi-annually |
| MW-7s | Down gradient well | Semi-annually |
| MW-7d | Down gradient deep well | Bi-annually |
| MW-15 | Up gradient well | Semi-annually |
| MW-16a | Up gradient well | Semi-annually |
| **Stream Sampling Point** | **Location of Sampling Point** | **Proposed Placement** |
| SW-1 | Up gradient of Unlined MSW landfill | Existing Sampling Location (Already Monitored) |
| SW-2 | Down gradient of Facility along Property Line | Existing Sampling Location (Already Monitored) |
| SW-3 | Up gradient of Lined and Unlined MSWLF Units | Existing Sampling Location (Already Monitored) |

The sampling schedule is currently conducted in February and August of each plan year.
No changes to this schedule are proposed.

Table 2

**Estimated Monitoring Well Completion Data**

**Halifax County Unlined Landfill**

**October, 1996**

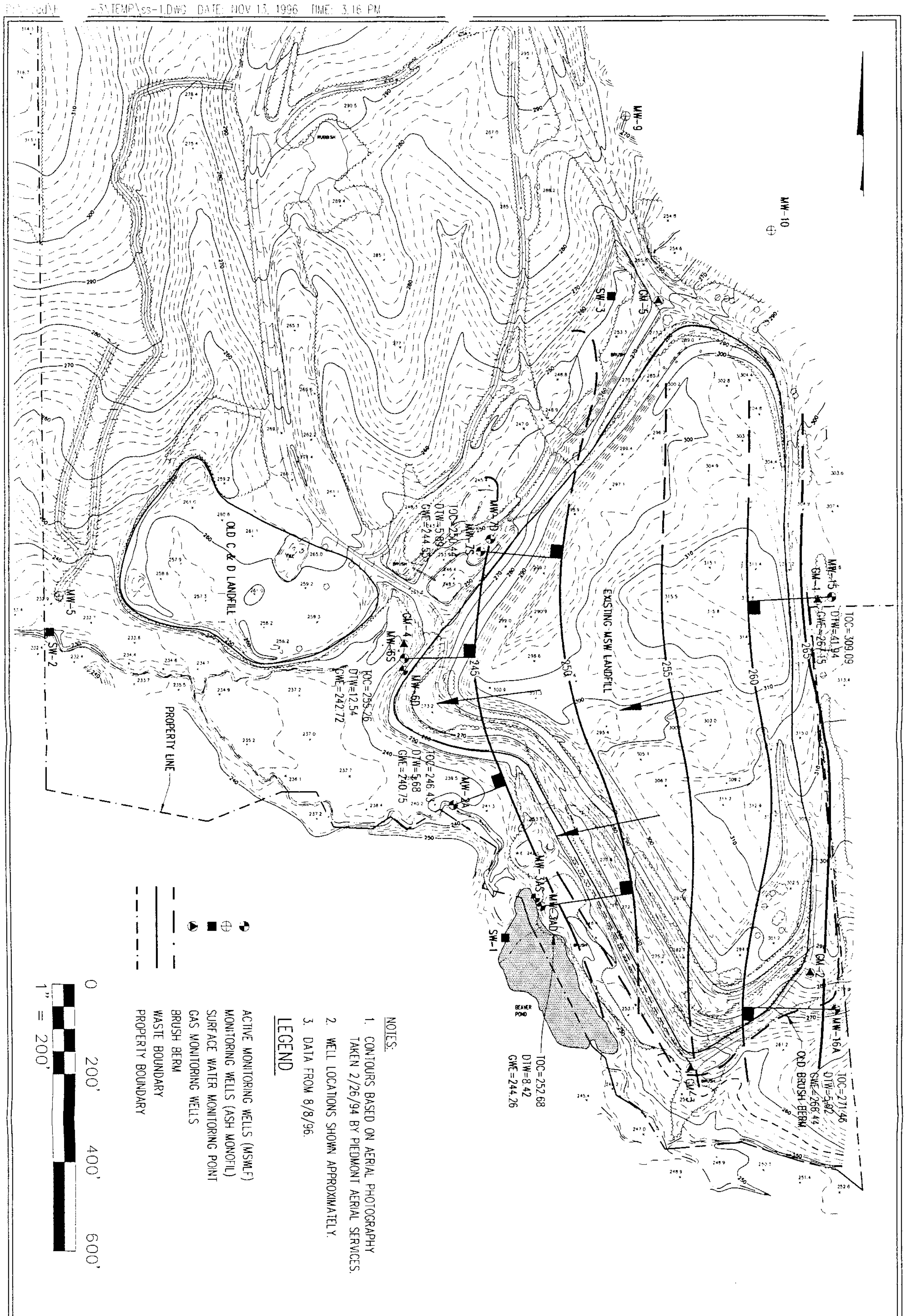
| Monitoring Well | Top of Casing Elevation | Depth to Bottom, ft. | Screened Interval, ft. |
|---|---|---|---|
| **MW-1** | 324.60 | 40 | 25.0 - 40.0 |
| **MW-2a** | 246.43 | 14 | 4.0 - 14.0 |
| **MW-3ad** | 252.68 | 19 | 9.0 - 19.0 |
| **MW-6s** | 253.26 | 23 | 8.0 - 23.0 |
| **MW-6d** | 253.22 | 40 | 25.0 - 40.0 |
| **MW-7s** | 250.44 | 17 | 2.5 - 17.5 |
| **MW-7d** | 249.09 | 40 | 25.0 - 40.0 |
| **MW-15** | 309.09 | 50 | 35.0 - 50.0 |
| **MW-16a** | 271.46 | 19 | 4.0 - 19.0 |

All measurements given in feet.

**Sampling and Analytical Schedule**

| | February | August |
|---|---|---|
| Old MSW Landfill | Appendix II | Appendix I and Triggered Appendix. II |
| Surface Water Points | Appendix I | Appendix I |

DATE: NOV 13, 1996 TIME: 3:16 PM




| TITLE: | SCALE: | CHECKED BY: | PROJECT NO. | |
|---|---|---|---|---|
| POTENTIOMETRIC SURFACE MAP<br>HALIFAX COUNTY LANDFILL | AS SHOWN | G.D.G. | HALIFAX-2 | G.N. RICHARDSON & ASSOCIATES, INC.<br>Engineering and Geological Services |
| | DRAWN BY: | DATE: | FIGURE NO. | 417 N. Boylan Avenue Raleigh, North Carolina<br>(919) 828-0577 Fax 828-3899 |
| | A.W.H. | SEPT, 1996 | 1 | |

# Appendix H

# Technical Specifications

## Halifax County
## Construction & Demolition Debris Landfill

Prepared for:

**Halifax County Solid Waste Department**
**Halifax, North Carolina**

**December 1997**

**PERMIT ISSUE DOCUMENTS**

**G.N. Richardson & Associates, Inc.**
Engineering and Geological Services
425 N. Boylan Avenue
Raleigh, North Carolina 27603

**HALIFAX COUNTY**
**CONSTRUCTION & DEMOLITION DEBRIS LANDFILL**

**TECHNICAL SPECIFICATIONS**

**TABLE OF CONTENTS**

## SECTION 02222

## EXCAVATION

Excavation: Excavation includes excavating, sealing, hauling, scraping, undercutting, removal of accumulated surface water or ground water, stockpiling, and all necessary and incidental items as required for closure construction.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment required to complete Excavation of the landfill containment area and related structures in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Embankment | 02223 |
| Erosion and Sedimentation Control | 02270 |
| CQA Manual | Attached |

3. Quality Assurance:

Quality Assurance during Excavation will be provided by the Owner as described in the accompanying Project CQA Manual.

4. Definitions:

a. Excavation: shall consist of the removal and satisfactory disposal and/or stockpiling of materials located with the limits of construction including widening cuts and shaping of slopes necessary for the preparation of roadbeds, landfill slope areas, cutting of any ditches, channels, waterways, entrances, and other work incidental thereto.

b. Borrow: shall consist of approved on-site material required for the construction of embankments/fills or for other portions of the work.

c. Select Borrow: shall consist of approved off-site material required for the construction of embankments/fills, roadway subgrade, backfilling, or for other portions of the work as shown on Contract Drawings or in these Specifications. The Contractor shall make his own arrangements for obtaining select borrow and pay all costs involved.

d. Unsuitable Material: is any in-place or excavated material which contains undesirable materials, or is in a state which is not appropriate; in the opinion of the Engineer, for the intended use or support of planned structures, embankment, or excavation. This may include but not be limited to organic material, waste/refuse, soft, or wet material not meeting required specifications, etc.

e. Unsuitable Materials Excavation (Overexcavation): shall consist of the removal and satisfactory disposal of all unsuitable material located within the limits of construction. Where excavation to the finished grade section shown results in a subgrade or slopes of unsuitable material, the Contractor shall overexcavate such material to below the grade shown on the Contract Drawings or as directed by the Engineer.

## B. MATERIALS

Excavation shall include the removal of all soil, weathered rock, boulders, conduits, pipe, and all other obstacles encountered and shown on the Contract Drawings or specified herein.

## C. SUBMITTALS

The Contractor shall submit the following to the Engineer before approval is given to proceed:

1. Plans of open cut excavations showing side slopes and limits of the excavation at grade.

2. List of disposal site(s) for waste and unsuitable materials.

3. Descriptive information on Excavation equipment to be used.

## D. CONSTRUCTION

1. The Contractor shall conduct Excavation activities in such a manner that erosion of disturbed areas and off site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. The Contractor shall excavate to the lines and grades shown on the Contract Drawings and stockpile all suitable excavated materials. As the excavation is made, the materials will be examined and identified to the Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Excavation, including pipe excavations, soil overexcavation, and anchor trenches.

3. Stockpiling:

   The Contractor shall stockpile the materials in appropriate stockpiles as approved by the Engineer. The Contractor shall use equipment and methods as necessary to maintain the moisture content of soils stockpiled (excluding topsoil) at or near their optimum moisture content.

   Stockpiles shall be properly sloped and the surfaces sealed by the Contractor at the end of each working day, or during the day in the event of heavy rain, to the satisfaction of the Engineer.

4. The Contractor shall protect all existing facilities and structures including, but not limited to, existing utilities, monitoring wells, signs, grade stakes, etc. during the grading and stockpiling operations.

5. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such sheeting, timbering, pumping, and drainage as may be required.

6. The Contractor shall be responsible for control of surface and subsurface water, when necessary.

7. Excavation slopes shall be flat enough to avoid sloughs and slides that will cause disturbance of the subgrade or damage of adjacent areas. Slides and overbreaks which occur due to negligence, carelessness, or improper construction techniques on the part of the Contractor shall be removed and disposed of by the Contractor as directed by the Engineer at no additional cost to the Owner.

8. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded. All protruding roots and other vegetation shall be removed from slopes.

9. The bottom of all excavations for structures and pipes shall be examined by the Engineer for bearing value and the presence of unsuitable material. If, in the opinion of the Engineer, additional Excavation is required due to the low bearing value of the subgrade material, or if the in-place materials are soft, yielding,

pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted structural fill, or material directed by the Engineer. No payment will be made for subgrade disturbance caused by inadequate Dewatering or improper construction methods.

10. Any areas excavated below design subgrade elevations by the Contractor, unless directed by the Engineer, shall be brought back to design elevations at no cost to the Owner. The Contractor shall place and compact such material in accordance with Section 02223, Embankment, of these Specifications.

11. The Contractor shall dispose of excess or unsuitable excavation materials on-site at location(s) approved by the Owner.

12. The Contractor shall properly level-off bottoms of all excavations. Proof-rolling shall be conducted with appropriate equipment.

13. Upon reaching subgrade elevations shown in excavation areas, the Contractor shall scarify subgrade soils to a minimum depth of 6" and obtain the Engineer's approval of quality. If unsuitable materials are encountered at the subgrade elevation, perform additional excavations as approved by the Engineer to remove unsuitable materials.

14. Where subgrade materials are determined to be unsuitable, such materials shall be removed by the Contractor to the lengths, widths and depths approved by the Engineer and backfilled with suitable material unless further excavation or earthwork is required. No additional payment will be made for such excavation and backfill 1 foot or less than the finished subgrade. Unsuitable material excavation greater than 1 foot beneath the finished subgrade shall be made on a unit price basis for excavation and backfill, only as approved by the Engineer prior to the work. Unit price for overexcavation and backfill greater than 1 foot in depth shall include disposal of unsuitable materials.

15. All cuts shall be brought to the grade and cross section shown on the Contract Drawings, or established by the Engineer, prior to final inspection.

16. The Contractor shall protect finished lines and grades of completed excavation against excessive erosion, damage from trafficking, or other causes and shall repair any damage at no additional cost to the Owner.

17. <u>Trench Excavation:</u>

    a. All pipe Excavation and trenching shall be done in strict accordance with these Specifications, all applicable parts of the OSHA Regulations, 29 CFR 1926, Subpart E, and other applicable regulations. In the event of any conflicts in this information, safe working conditions as established by the appropriate OSHA guidelines shall govern.

b. The minimum trench widths shall be as indicated on the Contract Drawings. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Contract Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing.

c. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.

d. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, obstructions, or structures.

e. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet.

f. Pipe Bedding: All pipe bedding shall be as shown on the Contract Drawings, unless otherwise specified herein.

18. Sheeting and Bracing:

a. The Contractor shall furnish, place, and maintain such sheeting and bracing which may be required to support sides of Excavation or to protect pipes and structures from possible damage and to provide safe working conditions in accordance with current OSHA requirements. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the sole expense of the Contractor. The Contractor shall be responsible for the adequacy of all sheeting and bracing used and for all damage resulting from sheeting and bracing failure or from placing, maintaining, and removing it.

b. The Contractor shall exercise caution in the installation and removal of sheeting to insure that excessive or unusual loadings are not transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to sheeting installation or removal.

c. All sheeting and bracing shall be removed upon completion of the work.

19. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed at the Contractor's sole expense.

## E. MEASUREMENT AND PAYMENT

All work required for Excavation shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

## SECTION 02223

## EMBANKMENT

Embankment: Embankment is the on-site compacted fill that provides berms, the subgrade for some access roadways and structures, and backfill around some structures and piping. Areas defined as Embankment are indicated on the Contract Drawings.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Embankment including hauling, screening, discing, drying, compaction, control of surface and subsurface water, final grading, sealing, and all necessary and incidental items as detailed or required to complete the Embankment, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Excavation | 02222 |
| Erosion and Sedimentation Control | 02270 |
| CQA Manual | Attached |

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

| | |
|---|---|
| ASTM D 698 | Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. |
| ASTM D 1556 | Test for Density of Soil in Place by the Sand-Cone Method. |
| ASTM D 2167 | Test for Density of Soil in Place by the Rubber-Balloon Method. |

| | |
|---|---|
| ASTM D 2216 | Standard Test Method for Laboratory Determination of Water Content of Soil and Rock. |
| ASTM D 2488 | Standard Practice for Description and Identification of Soils. |
| ASTM D 2922 | Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth). |
| ASTM D 2937 | Standard Test Method for Density of Soil in Place by the Drive Cylinder Method. |

4. Quality Assurance:

Quality Assurance during placement of Embankment will be provided by the Owner as described in the accompanying Project CQA Manual.

5. Definitions:

a Embankment: Shall include construction of all site earthwork including roadways, subgrade, perimeter berm embankments, including preparation of the areas upon which materials are to be placed. Embankment may also be referred to as structural and/or controlled fill. All Embankment materials may be either (off-site) Select Borrow or (on-site) Borrow unless otherwise noted on Contract Drawings or specified by the Engineer.

b. Prepared Subgrade: The ground surface after clearing, grubbing, stripping, excavation, scarification, and/or compaction, and/or proof rolling to the satisfaction of the Engineer.

c. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters. Well-graded is used to define a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

d. Unclassified Fill: The nature of materials to be used is not identified or described herein but must be approved by the Engineer prior to use.

B. MATERIALS

1. The Compacted Embankment shall consist of clean well-graded natural soil classified as SM, SP, SC, ML, MH, CL-ML, CL or CH (ASTM D 2488) containing no topsoil or other deleterious material.

2. Stones or rock fragments shall not exceed one half the maximum lift thickness as compacted in any dimension.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer before approval is given to proceed:

1. Descriptive information on compaction equipment to be used for construction of Embankment and appurtenant structures.

2. Descriptive information on the location and source of off-site borrow material to be used for Embankment, where applicable. Information shall include Standard Proctor curves (ASTM D698) for each borrow material.

D. CONSTRUCTION

1. The Contractor shall conduct Embankment activities in such a manner that erosion of disturbed areas and off-site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. All placement and compaction of Embankment shall be performed only when the Engineer is informed by the Contractor of intent to perform such work.

3. Embankment shall be placed and compacted to the lines and grades shown on the Contract Drawings. Placement of Embankment outside the construction limits shall occur only as directed and approved by the Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Embankment.

4. The Contractor shall protect all existing facilities including, but not limited to, utilities and monitoring wells.

5. Subgrade Preparation:

   a. The Engineer shall inspect the exposed subgrade prior to placement of Embankment to assure that all rocks, topsoil, vegetation, roots, debris, or other deleterious materials have been removed.

   b. Prior to placement of Embankment, the exposed subgrade shall be proofrolled using a static smooth-drum roller, loaded tandem axle dump truck, or other suitable equipment in the presence of the Engineer. Any soft or unsuitable materials revealed before or during the in-place compaction shall be removed as directed by the Engineer and replaced with suitable Embankment.

6. Surfaces on which Embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the Embankment with the existing surface.

7. The Contractor shall be responsible for preparing the materials for the Embankment, including but not limited to, in-place drying or wetting of the soil necessary to achieve the compaction criteria of these Specifications.

8. The Contractor shall be responsible for control of surface and subsurface water, when necessary.

9. Embankment materials shall be placed in a manner permitting drainage and in continuous, approximately horizontal layers.

10. Compaction Requirements:

   a. The Contractor shall compact Embankment in accordance with the requirements shown in Table 1 of this section. If Embankment does not meet the specified requirements, the Contractor shall rework the material, as may be necessary and continue compaction to achieve these requirements, or remove and replace the material to achieve the specified requirements, at Contractor's expense.

   b. Each lift shall be compacted prior to placement of succeeding lifts. In confined areas, mechanical equipment, suitable for small areas and capable of achieving the density requirements, shall be required.

   c. Lift compaction shall be performed with an appropriately heavy, properly ballasted, penetrating-foot or smooth-drum vibratory compactor depending on soil type. Compaction equipment shall be subject to approval by the Engineer.

11. Embankment that becomes excessively eroded, soft, or otherwise unsuitable shall be removed or repaired by the Contractor as directed by the Engineer, at no cost to the Owner.

12. The exposed surface of Embankment shall be rolled with a smooth-drum roller at the end of each work day to protect from adverse weather conditions.

13. Where Embankment is to be placed and compacted on slopes that are steeper than 3:1, the subgrade shall be benched to a minimum depth of 6 inches and the Embankment shall be placed in horizontal lifts.

14. Backfilling for Structures and Piping:

    a. All structures, including manholes and pipes shall be backfilled with Embankment as shown in the Contract Drawings and as described in these Specifications.

    b. Where sheeting is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when sheeting is removed. If significant volumes of soil cannot be prevented from clinging to the extracted sheets, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that sheeting will be driven in similar soil conditions or employ other appropriate means to prevent loss of support.

    c. When backfilling around structures, do not backfill until concrete has sufficiently cured (as determined by the Engineer) and is properly supported. Place backfill in a manner to avoid displacement or damage of structures.

## E. MEASUREMENT AND PAYMENT

All work required for Embankment shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

## TABLE 1: REQUIRED EMBANKMENT PROPERTIES

| ITEM | Required % Standard Proctor (ASTM D698) | Maximum Lift Thickness (Loose) (inches) |
|---|---|---|
| Embankment | 95 | 8 |
| Embankment Beneath Structures[1] | 98 | 6 |
| Backfill Around Structures | 95 | 8 |
| Backfill in Pipe Trenches | 95 | 6 |
| Unclassified Fill | N/A | N/A |

Notes:

1. Embankment beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope.

END OF SECTION

## SECTION 02240

## GEOTEXTILES

| |
|---|
| Geotextiles: For the proposed construction, a Type GT-S (Separator/Filter) Geotextile is specified. The Type GT-S Geotextile will be placed as the upper component of the Geonet Drainage Media, between soil subgrade and aggregate in access roads, and in some erosion control and drainage applications. |

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Geotextiles including all necessary and incidental items as detailed or required for the Contractor to complete the installation in accordance with the Contract Drawings and these Specifications, except as noted below:

a. Geotextiles used as a Silt Fence is covered under Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Erosion and Sedimentation Control | 02270 |
| Aggregate Surfacing | 02505 |
| Geonet Drainage Media | 02712 |
| CQA Manual | Attached |

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO) are hereby made a part of these specifications.

ASTM D 3786 — Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.

| | |
|---|---|
| ASTM D 4355 | Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus). |
| ASTM D 4491 | Test Methods for Water Permeability of Geotextiles by Permittivity. |
| ASTM D 4533 | Standard Test Method for Trapezoid Tearing Strength of Geotextiles. |
| ASTM D 4632 | Test Method for Grab Breaking Load and Elongation of Geotextile. |
| ASTM D 4751 | Test Method for Determining Apparent Opening Size of a Geotextile. |
| ASTM D 4833 | Test Methods for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products. |
| ASTM D 5261 | Standard Test Method for Measuring Mass per Unit Area of Geotextiles. |
| AASHTO M 288 | Standard Specification for Geotextiles. |

4. Quality Assurance:

Quality Assurance during installation of Geotextiles will be provided by the Owner as described in the accompanying Project CQA Manual.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each roll of Geotextile shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The Type GT-S Geotextile shall be a woven, nonwoven spunbonded, or nonwoven needlepunched synthetic fabric consisting of polyester or polypropylene manufactured in a manner approved by the Engineer and the

Owner. Note that Type GT-S Geotextile placed over geonet shall be a nonwoven fabric.

3. All Geotextiles shall conform to the properties listed in Table 1 of this section.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit one copy of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for each type of Geotextile attesting that the Geotextiles meet the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample (4" x 6") of each Geotextile to be used. The samples shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Quality Control Certificates: For Geotextiles delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided for every roll of each type of Geotextile supplied. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section.

4. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

All Geotextiles shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation of Geotextiles:

a. The surface receiving the Geotextiles shall be prepared to a relatively smooth condition, free of obstructions, excessive depressions, debris, and very soft or loose pockets of soil. This surface shall be approved by the Engineer prior to Geotextile placement.

b. Geotextiles shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, Geotextiles shall be rejected by the Engineer if they have defects, rips, holes, flaws, evidence of deterioration, or other damage.

c. The Geotextiles shall be placed smooth and free of excessive wrinkles.

d. On slopes, Geotextiles shall be anchored at the top and unrolled down the slope. In the presence of wind, all Geotextiles shall be weighted with sandbags or other material as approved by the Engineer. Geotextiles uplifted by wind may be reused upon approval by the Engineer.

e. Type GT-S Geotextile to be placed over geonet shall not be installed in areas that have excessive sediment buildup within the geonet. In any such areas, the geonet is to be removed and sediment cleaned prior to Geotextile placement.

3. Seams:

a. All Geotextile seams shall be sewn. On slopes greater than 10 percent, all seams shall be oriented parallel to (in the direction of) the slope unless otherwise approved by the Engineer.

b. Seams to be sewn shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of 4 to 7 stitches per inch. The minimum distance from the geotextile edge to the stitch line nearest to that edge (seam allowance) shall be 1.5 inches if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 1.0 inches. All seams must be approved by the Engineer.

c. Alternately, the Contractor may overlap or heat bond adjacent panels with methods approved by the Engineer.

d. Methods for seaming of Type GT-B Geotextile shall be approved by the Engineer prior to construction.

4. Repair Procedures:

a. Any Geotextile that is torn or punctured shall be repaired or replaced, as directed by the Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 18 inches from any point of the rupture. Patches shall be spot sewn so as not to shift during cover placement.

b. Slopes Less Than or Equal to 10 Percent: Damaged areas of a size exceeding 10 percent of the roll width shall be removed and replaced across the entire roll width with new material. Damaged areas of a size less than 10 percent of the roll width may be patched.

c. Slopes Greater Than 10 Percent: Geotextile panels which require repair shall be removed and replaced with new material. Replacement material shall be sewn as previously described in this specification.

5. Cover Placement:

Placement of cover over Geotextiles shall be performed in a manner as to ensure that the Geotextiles are not damaged. Cover material shall be placed such that excess tensile stress is not mobilized in the Geotextile.

E. MEASUREMENT AND PAYMENT

All work required for Geotextiles shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

## TABLE 1: REQUIRED GEOTEXTILE PROPERTIES

| PROPERTY | TEST METHOD | UNITS | VALUE TYPE GT-S |
|---|---|---|---|
| Geotextile Construction (NW = Nonwoven) (W = Woven) | ---------- | ---------- | NW[2] or W[3] |
| Mass per Unit Area (Unit Weight) | ASTM D 5261 | $oz/yd^2$ | N/A |
| Ultraviolet Resistance (500 hrs) | ASTM D 4355 | % | 70 |
| Strength Class[4] | AASHTO M 288 | Class | 2 |
| Apparent Opening Size (AOS) | ASTM D 4751 | U.S. Sieve | 70+ |
| Permittivity | ASTM D 4491 | $sec^{-1}$ | 1.0 |

Notes:

1. Minimum Average Roll Value (MARV).
2. Nonwoven geotextiles that have been heat calendered are not acceptable.
3. Woven geotextiles formed exclusively with slit film fibers are not acceptable.
4. AASHTO M 288 includes requirements for the following properties:
   - Grab Tensile Strength (ASTM D 4632),
   - Grab Tensile Elongation (ASTM D 4632),
   - Trapezoidal Tear Strength (ASTM D 4533),
   - Puncture Resistance (ASTM D 4833), and
   - Burst Strength (ASTM D 3786).

**TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA**

| PROPERTY | TEST METHOD | MINIMUM TEST FREQUENCY |
|---|---|---|
| Mass per Unit Area (Unit Weight) | ASTM D 5261 | 100,000 $ft^2$ |
| Ultraviolet Resistance (500 hrs) | ASTM D 4355 | 100,000 $ft^2$ |
| Grab Tensile Strength | ASTM D 4632 | 100,000 $ft^2$ |
| Grab Tensile Elongation | ASTM D 4632 | 100,000 $ft^2$ |
| Burst Strength (Diaphragm Methods) | ASTM D 3786 | 100,000 $ft^2$ |
| Apparent Opening Size (AOS) | ASTM D 4751 | 100,000 $ft^2$ |
| Permittivity | ASTM D 4491 | 100,000 $ft^2$ |
| Puncture Resistance | ASTM D 4833 | 100,000 $ft^2$ |
| Trapezoidal Tear Strength | ASTM D 4533 | 100,000 $ft^2$ |

END OF SECTION

# SECTION 02252

# COMPACTED SOIL BARRIER

Compacted Soil Barrier (CSB): The Compacted Soil Barrier is used as an infiltration barrier in the final cover system. Compacted on-site or imported soils will be used for CSB such that the compacted permeability of the layer is $\leq 1 \times 10^{-5}$ cm/sec.

## A. DESCRIPTION

### 1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of the CSB for the landfill cover, including hauling, screening, discing, compacting, drying, removal of rainfall and removal of all previously placed material unsuitable due to weather conditions, final grading and sealing and all necessary and incidental items as detailed or required to complete the CSB, all in accordance with the Contract Drawings and these Specifications.

### 2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Vegetative Soil Layer | 02258 |
| Geosynthetic Clay Liner | 02776 |
| CQA Manual | Attached |

### 3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

| | |
|---|---|
| ASTM D 422 | Standard Test Method for Particle Size Analysis of Soils. |
| ASTM D 698 | Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. |
| ASTM D 2216 | Standard Test Method for Laboratory Determination of Water Content of Soil and Rock. |

| | |
|---|---|
| ASTM D 2488 | Standard Practice for Description and Identification of Soils. |
| ASTM D 2922 | Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth). |
| ASTM D 2937 | Standard Test Method for Density of Soil in Place by the Drive Cylinder Method. |
| ASTM D 4318 | Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. |
| ASTM D 5084 | Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Material Using a Flexible Wall Permeameter. |

4. Quality Assurance:

Quality Assurance during placement of CSB will be provided by the Owner as described in the accompanying Project CQA Manual.

B. MATERIALS

All material for CSB shall conform to the requirements shown in Table 1 of this section.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Before approval is given to proceed with test fill construction, the Contractor shall submit descriptive information on compaction equipment to be used for construction of the CSB.

2. Survey Results:

After completion of a segment of CSB, survey results shall be submitted for review prior to placement of overlying layers.

D. CONSTRUCTION

1. General:

a. All placement and compaction of CSB shall be performed only when the Engineer is informed by the Contractor of intent to perform such work.

b. The Contractor shall place and compact the CSB to a minimum thickness of 18 inches and to the lines and grades shown on the Contract Drawings with the exception that a 2 inch overbuild at the Contractor's expense is allowed. The Contractor will perform all surveys necessary to establish and verify lines and grades for all CSB.

2. Test Fill Construction:

The Contractor shall construct a test fill prior to construction of CSB. The test fill shall be at least 20 feet wide by 50 feet long and consist of at least three compacted lifts. The Contractor shall use materials and equipment for test fill construction that the Contractor intends to use during construction.

No CSB construction may be performed until the test fill construction is confirmed to be adequate in accordance with the Project CQA Manual.

The Contractor shall amend construction techniques or equipment in order to meet all criteria outlined for CSB in these Specifications at no cost to the Owner.

3. Subgrade Preparation:

a. The Engineer shall inspect the exposed subgrade prior to placement of CSB to assure that all rocks, topsoil, vegetation, roots, debris, or other deleterious materials have been removed.

b. Surfaces on which CSB is to be placed, shall be scarified or stepped in a manner which will permit bonding of the CSB with the existing surface.

4. Placement and Compaction:

a. Prior to compaction, each lift of select soil fill material shall be thoroughly disced. Equipment or truck trafficking of the surface shall not be permitted during the period between scarifying and placement of the following lift.

b. After scarifying, representative samples will be taken by the Engineer and tested for moisture content prior to any compactive efforts. If the moisture content is within the range specified below, compaction may begin. If the moisture content is outside of this range, the select soil fill will be wetted or dried and reworked accordingly.

c. Each lift will be thoroughly compacted and must satisfy moisture and density controls through field testing before a subsequent lift is placed.

d. Compaction of lifts shall be as follows:

(1) All CSB shall be placed in loose lifts no greater than the height of the feet on the compaction equipment to be used.

(2) Compaction of lifts shall be performed with an appropriately heavy, properly ballasted penetrating-foot compactor (such as a CAT 815 or equivalent). Compaction equipment shall be the same as used in the test fill.

(3) The daily work area shall extend a distance no greater than necessary to maintain moist soil conditions (facilitate bonding) and continuous operations. Desiccation and crusting of the lift surface shall be avoided as much as possible.

(4) If desiccation and crusting of the lift surface occurs before placement of the next lift, this area shall be sprinkled with water and then scarified and tested for water content to ensure uniform moisture before placement of a subsequent lift.

(5) Transition from full depth cover to beginning of adjacent new section shall be accomplished by sloping (cutting back) the end of a full depth section at 5H:lV (horizontal to vertical) or flatter for tying in a new lift.

(6) Dozer or scraper equipment shall not be used for primary compaction efforts.

e. The in-place CSB shall conform to the requirements shown in Table 2 of this section. If CSB does not meet the above specified requirements, the Contractor shall rework the material, as may be necessary and continue compaction to achieve these requirements at his own expense, or remove and replace the material to achieve the specified requirements, at Contractor's expense.

f. No CSB shall be placed or compacted when the soil temperatures are so low as to produce ice lenses in the CSB borrow soil.

g. During construction, finished lifts or sections of CSB must be sprinkled with water as needed to prevent drying and desiccation.

h. The exposed surface of CSB shall be protected from adverse weather conditions or desiccation of the clay. This is commonly done by rolling the surface of the CSB with a smooth-drum roller at the end of each work day. Alternative means of protecting the CSB may be employed by the Contractor.

5. Surveying:

After completion of a segment of CSB, but before installation of subsequent layers, the CSB shall be surveyed on 100 foot centers and at slope breaks to ensure:

a. The specified thickness has been achieved.

b. The top of the CSB slopes at grades specified on the Contract Drawings; and

c. CSB placed more than 2 inches beyond the limits of the lines and grades as shown on the Contract Drawings will not be accepted and must be removed at the Contractor's expense if required by the Engineer. Such material which has been determined suitable for final cover construction may be re-incorporated into the final cover if needed.

This work shall be performed at the Contractor's cost by a surveyor registered in the State of North Carolina.

E. MEASUREMENT AND PAYMENT

All work required for Compacted Soil Barrier shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

**TABLE 1: COMPACTED SOIL BARRIER MATERIAL REQUIREMENTS**

| PROPERTY | TEST METHOD | VALUE |
|---|---|---|
| Visual Classification | ASTM D 2488 | Clean natural fine-grained soil free from organics, debris, or other detrimental material. USCS Classification CL, CH, MH, ML, CH-MH, or CL-ML |
| Clod Size | ----- | Maximum = ¾ inch |
| Gradation | ASTM D 422 | ≥ 30% Passing No. 200 U.S. Standard Sieve Max. = 1-½ inches |
| Coefficient of Permeability - Lab Remolded | ASTM D 5084[2] | ≤ 1 x $10^{-5}$ cm/s at a density of ≥ 95% Maximum Standard dry density and a moisture content 2 to 6 percent wet of optimum |

**TABLE 2: IN-PLACE COMPACTED SOIL BARRIER REQUIREMENTS**

| PROPERTY | TEST METHOD | VALUE |
|---|---|---|
| Moisture Content | ASTM D 2216 | 2 to 6 percent wet of optimum |
| Density | ASTM D 2922[1] | ≥ 95% Maximum Standard dry density |
| In-Place Coefficient of Permeability (Shelby Tube) | ASTM D 5084[2] | ≤ 1 x $10^{-5}$ cm/s |
| Thickness | Survey | 18 inches minimum<br>(2 inch overbuild allowed) |

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937.

END OF SECTION

## SECTION 02258

## VEGETATIVE SOIL LAYER

| |
|---|
| Vegetative Soil Layer (VSL): The Vegetative Soil Layer (VSL) is placed in the final cover system in order to support permanent vegetative cover. This section includes the topsoil to be placed as the upper 6 inches of the VSL. |

### A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of the VSL (including topsoil) for the landfill cover, including hauling, spreading, and final grading and all necessary and incidental items as detailed or required to complete the VSL, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Geonet Drainage Media | 02712 |
| Geosynthetic Clay Liner | 02776 |
| Revegetation | 02930 |

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

ASTM D 2488 — Standard Practice for Description and Identification of Soils.

### B. MATERIALS

Soil that meets all of the following requirements shall be classified as select soil fill for use in construction of the VSL.

1. Soil shall be classified according to the Unified Soil Classification System (USCS) as SM, SC, ML, MH, CL-ML, or CL (ASTM D 2488).

2. Select soil fill materials shall be reasonably free of gypsum, ferrous, and/or calcareous concretions and nodules, refuse, roots, or other deleterious substances.

3. Continuous and repeated visual inspection of the materials being used will be performed by the Contractor to ensure proper soils are being used. In addition, the Engineer shall make frequent inspections of the placement operations.

4. The VSL shall be uniform, smooth, and free of debris, rock, plant materials, and other foreign material larger than 3 inches in diameter. The material should contain no sharp edges. This material must be capable of supporting growth of vegetative cover.

5. Topsoil: The upper 6 inches of VSL shall contain a minimum of 2% by weight of organics evenly blended into the material in order to support the growth of vegetative cover. Also, the topsoil shall contain 10% by weight gravel size particles (1-½ inch maximum particle size) to aid in the prevention of excess wind erosion.

## C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Before approval is given to proceed, the Contractor shall submit descriptive information on placement equipment to be used in construction of the VSL.

2. Survey Results:

   After completion of a segment of VSL, survey results shall be submitted for review prior to VSL acceptance.

## D. CONSTRUCTION

1. The VSL is placed directly over geosynthetics and/or piping; thus, extreme caution shall be exercised by the Contractor to prevent damage to these materials.

2. All placement of VSL shall be performed only when the Engineer is informed by the Contractor of intent to perform such work.

3. VSL shall be placed over geosynthetics only after areas have been released by the Geosynthetics Installer and the Engineer. VSL shall be placed as specified below:

   a. The VSL, including topsoil, shall be placed and spread using low ground pressure (less than 6 psi) tracked equipment. The Engineer shall approve the equipment used to place the VSL.

b. Tracked equipment used to place VSL shall operate on at least 1 foot of VSL overlying geosynthetics and/or piping. Excessive turning of tracked equipment on the VSL will not be permitted.

c. VSL shall be placed to the lines and grades shown on the Contract Drawings with the exception that a 2 inch overbuild at Contractor's expense is allowed. The Contractor will perform all surveys necessary to establish and verify lines and grades for all VSL.

4. Stockpiling of VSL on the final cover shall be subject to advance approval by the Engineer. Any hauling equipment (dump trucks, etc.) operating over geosynthetics shall have a minimum of 3 feet of separation between the vehicle wheels and the Geomembrane.

5. The Engineer may require removal of VSL and/or other underlying layers to allow examination of the underlying geosynthetics and/or piping. Any damage to underlying layers during placement of the VSL shall be repaired in accordance with the applicable section of these Specifications at the Contractor's sole expense.

6. After the specified thickness has been achieved and verified, the Contractor shall proceed immediately with seeding.

7. Surveying:

After completion of a segment of VSL, the VSL shall be surveyed on 100 foot centers and at slope breaks to ensure:

a. The specified thickness has been achieved.

b. The top of the VSL slopes at grades specified on the Contract Drawings; and

c. VSL placed more than 2 inches beyond the limits of the lines and grades as shown on the Contract Drawings will not be accepted and must be removed at the Contractor's sole expense if required by the Engineer.

This work shall be performed at the Contractor's cost by a surveyor registered in the State of North Carolina.

E. MEASUREMENT AND PAYMENT

All work required for Vegetative Soil Layer shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

# SECTION 02270

# EROSION AND SEDIMENTATION CONTROL

Erosion and Sedimentation Control: Erosion and Sedimentation Control is a system of construction practices and engineered structures which act to minimize surface water induced erosion of disturbed areas and resulting sedimentation off-site. These Specifications meet or exceed the guidelines of the North Carolina Sediment Control Planning and Design Manual.

## A. DESCRIPTION

### 1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of and maintain Erosion and Sedimentation Control facilities and other construction in accordance with the Contract Drawings and these Specifications.

### 2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Geotextiles | 02240 |
| Rip Rap | 02271 |
| Revegetation | 02930 |

## B. MATERIALS

### 1. Permanent Sediment Basins:

Permanent sediment basins shall be constructed as shown on the Contract Drawings.

### 2. Permanent Ditches, Swales, and Drainage Channels:

Permanent ditches, swales, and drainage channels shall be constructed as shown on the Contract Drawings.

3. Silt Fence:

Silt fences shall be constructed as shown on the Contract Drawings and as needed, based on the Contractor's discretion and Engineer's approval. The silt fence is a permeable barrier erected within and downgradient of small disturbed areas to capture sediment from sheet flow. It is made of filter fabric buried at the bottom, stretched, and supported by posts and wire mesh backing. Silt fence shall conform to the following properties:

Posts: Posts shall be 3 feet long "U" or "T"-type steel or wood posts.

Filter Fabric: Filter fabric shall be a woven geotextile made specifically for sediment control. Filter fabric shall have the following minimum properties:

| PROPERTY | TEST METHOD | UNITS | MINIMUM VALUE |
|---|---|---|---|
| Grab Tensile Strength | ASTM D 4632 | lbs | 100 |
| Grab Elongation | ASTM D 4632 | % | 15 |
| Trapezoidal Tear Strength | ASTM D 4533 | lbs | 50 |
| Mullen Burst Strength | ASTM D 3786 | lbs | 265 |
| Puncture Strength | ASTM D 4833 | lbs | 55 |
| UV Resistance | ASTM D 4355 | % | 80 |

4. Geotextiles:

Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

5. Down Pipes:

Down pipes shall be constructed as shown on the Contract Drawings.

6. Filter Berms:

Filter Berms shall be constructed as shown on the Contract Drawings.

7. Rip Rap:

Rip Rap shall conform to the requirements outlined in Section 02271, Rip Rap, of these Specifications.

8. Turf Reinforcement Matting:

The matting shall consist of entangled nylon, polypropylene, or polyester monofilaments melt bonded at their intersections forming a three dimensional structure. The mat shall be crush-resistant, pliable, water-permeable, and highly resistant to chemical and environmental degradation. The matting shall also meet the following criteria:

Maximum Permissible Velocity $\geq$ 12 ft/sec
Maximum Permissible Shear Stress $\geq$ 6 lbs/ft$^2$.

9. Other Work:

In addition to the erosion control measures shown on the Contract Drawings, the Contractor shall provide adequate means to prevent any sediment from entering any storm drains, drop inlets, ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of off-site areas. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed. All paved areas shall be scraped and swept as necessary to prevent the accumulation of dirt and debris. Work associated with this provision shall be considered incidental to the project and no separate payment will be made.

10. Temporary Ground Cover:

The Contractor shall provide temporary or permanent ground cover adequate to restrain erosion on erodible slopes or other areas that will be left unworked for periods exceeding 30 calendar days.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Erosion and Sedimentation Control materials manufactured for the project have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Establishment of Erosion Control Devices:

a. All erosion control structures will be constructed according to the Contract Drawings and these Specifications.

b. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the erosion control devices may need to be adjusted on several occasions to reflect the current phase of construction.

c. Erosion control devices shall be established prior to the work in a given area. Where such practice is not feasible, the erosion control device(s) shall be established immediately following completion of the clearing operation.

d. The construction schedule adopted by the Contractor will impact the placement and need for specific devices required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and off-site sedimentation.

e. The location and extent of erosion control devices shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from construction areas. All deviations from the control provisions shown on the Contract Drawings shall have the prior approval of the Engineer.

2. Maintenance of Erosion Control Devices:

a. The Contractor shall furnish the labor, material, and equipment required for maintenance of all erosion control devices. Maintenance shall be scheduled as required for a particular device to maintain the removal efficiency and intent of the device.

b. All erosion control devices shall be inspected immediately after each significant rainfall event, and appropriate maintenance conducted.

c. Maintenance shall include, but not be limited to:

(1) The removal and satisfactory disposal of trapped sediments from basins or silt barriers;

(2) Replacement of filter fabrics used for silt fences upon loss of specified efficiency; and

(3) Replacement of any other components which are damaged or cannot serve the intended use.

d. Sediments removed from erosion control devices shall be disposed of in locations that will not result in off-site sedimentation as approved by the Engineer.

e. All erosion control structures shall be maintained to the satisfaction of the Engineer until the site has been stabilized.

3. Finish Grading:

All disturbed areas outside of the disposal area shall be uniformly graded to the lines, grades, and elevations shown on the Contract Drawings. Finished surfaces shall be reasonably smooth, compacted, and free from irregular surface changes. Unless otherwise specified, the degree of finish shall be that ordinarily obtainable from either blade or scraper operations. Areas shall be finished to a smoothness suitable for application of topsoil.

4. Seeding:

Seeding shall conform to the requirements of Section 02930, Revegetation, of these Specifications.

5. Cleanup:

a. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

b. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

## E. MEASUREMENT AND PAYMENT

All work required for Erosion and Sedimentation Control shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

## SECTION 02271

## RIP RAP

| |
|---|
| Rip Rap: This section includes all rip rap aprons and channel protection. |

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Rip Rap for protection of earthen slopes against erosion as indicated, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Geotextiles | 02240 |
| Erosion and Sedimentation Control | 02270 |

3. Reference Standards:

The latest revision of the following standards of the North Carolina Department of Transportation (NCDOT) are hereby made a part of these Specifications.

NCDOT Standard Specifications for Roads and Structures.

B. MATERIALS

1. Rip Rap: Rip Rap shall be of the size indicated on the Contract Drawings and shall conform to NCDOT Section 1042, Rip Rap Materials.

2. Geotextiles: Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results prior to installation, that all Rip Rap has been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Surface Preparation:

   a. Trim and dress all areas to conform to the Contract Drawings as indicated with tolerance of 2 inches from theoretical slope lines and grades.

   b. Bring areas that are below allowable minimum tolerance limit to grade by filling with compacted Embankment material similar to adjacent material.

   c. Geotextiles shall be placed as shown on the Contract Drawings and in accordance with Section 02240, Geotextiles, of these Specifications.

   d. Do not place any stone material on the prepared surface prior to inspection and approval to proceed from the Engineer.

2. Placing Rip Rap:

   Rip Rap shall be placed in accordance with NCDOT Section 868, Rip Rap.

E. MEASUREMENT AND PAYMENT

All work required for Rip Rap shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

# SECTION 02505

## AGGREGATE SURFACING

| |
|---|
| Aggregate Surfacing: Aggregate Surfacing will include wearing surface placement for vehicular traffic on final graded perimeter areas and access ramps/roads. |

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Aggregate Surfacing including crushed stone placement and grading in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Geotextiles | 02240 |

3. Reference Standards:

The latest revision of the following standards of the North Carolina Department of Transportation (NCDOT) are hereby made a part of these Specifications.

| | |
|---|---|
| NCDOT | Standard Specifications for Roads and Structures. |

B. MATERIALS

1. Aggregate Base Course (ABC): ABC materials shall be in accordance with NCDOT Section 520, Aggregate Base Course. Type "A" or "B" aggregate will be acceptable for this project.

2. Geotextiles: Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results prior to installation, that all materials required for Aggregate Surfacing have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Existing subgrade upon which ABC is to be placed shall be prepared in accordance with Section 02223, Embankment, of these Specifications.

2. Geotextiles shall be placed as shown on the Contract Drawings and in accordance with Section 02240, Geotextiles, of these Specifications.

3. Construct ABC to the grade, thickness, and typical section as indicated on the Contract Drawings.

4. ABC shall be constructed in accordance with NCDOT Section 520, Aggregate Base Course, except that mixing, moisture addition, and compaction testing may be omitted.

3. Compaction:

    a. Compact by vibrating or other methods approved by the Engineer.

    b. Any irregularities in the surface shall be corrected by scarifying, remixing, reshaping and recompacting until a smooth surface is secure.

    c. The Engineer may approve other stone surfacing materials and testing requirements (if any).

E. MEASUREMENT AND PAYMENT

All work required for Aggregate Surfacing shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

## SECTION 02712

## GEONET DRAINAGE MEDIA

Geonet Drainage Media (GDM): The Geonet Drainage Media consists of a layer of Geonet with a Type GT-S Geotextile bonded to the upper surface. The purpose of the GDM is to rapidly transmit infiltration to collection pipes. Thus, it is important that this layer remain hydraulically connected and clog-free.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of GDM, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Geotextiles | 02240 |
| CQA Manual | Attached |

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

| | |
|---|---|
| ASTM D 413 | Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate. |
| ASTM D 1505 | Standard Test Method for Density of Plastics by the Density-Gradient Technique. |
| ASTM D 4716 | Standard Test Method for Constant Head Hydraulic Transmissivity (In-Plane Flow) of Geotextiles and Geotextiles Related Products. |
| ASTM D 5199 | Standard Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes. |

4. Quality Assurance:

Quality Assurance during installation of GDM will be provided by the Owner as described in the accompanying Project CQA Manual.

B. MATERIALS

1. General:

The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

Labels on each roll of GDM shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. The Geonet shall be manufactured by extruding polyethylene strands to form a three dimensional structure to provide planer water flow.

3. A Type GT-S Geotextile shall be heat bonded to the upper side of the Geonet. Heat bonding shall be performed by the Manufacturer prior to shipping to the site. The Type GT-S Geotextile shall be a nonwoven needlepunched synthetic fabric meeting the property requirements of Section 02240, Geotextiles, of these Specifications.

4. The Geonet shall contain UV inhibitors to prevent ultraviolet light degradation.

5. Physical properties of the GDM shall be as shown in Table 1 of this section.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit one copy of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the GDM attesting that the GDM meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample (4" x 6") of the GDM to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Quality Control Certificates: For GDM delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided for every roll of GDM. Each certification shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section.

4. Furnish copies of delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

All GDM shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation:

a. GDM shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, the GDM shall be rejected, if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.

b. The GDM shall be placed only on Geomembrane that has been approved by the Geomembrane Installer and accepted by the Engineer.

c. The Contractor shall provide temporary anchorage of the GDM at the top of perimeter and interior berms during installation to prevent movement during construction. Such anchorage may include sandbags and the like, as approved by the Engineer. Permanent bonding to the Geomembrane shall be prohibited.

d. Adjacent rolls of GDM shall be overlapped a distance of at least 3 inches and secured using polyethylene ties. For GDM placed on slopes, the ties shall be placed every 5 feet. For GDM placed on the facility floor, tie spacing shall be every 10 feet.

The overlying Type GT-S Geotextile, where applicable, shall extend at least 6 inches past the geonet joint and shall be permanently bonded to the Type GT-S Geotextile of the adjacent rolls by heat bonding or sewing as approved by the Engineer.

No end (transverse) GDM joints shall be constructed on landfill side slopes or within 10 feet of the toe of the side slope, except where approved in advance by the Engineer.

e. Any GDM that is torn, crushed, or punctured shall be repaired or replaced by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of material, placed over the failed area and shall overlap the existing material a minimum of 12 inches from any point of the rupture. The patch shall be connected to the Geonet using polyethylene ties at a 5 foot spacing.

f. Where applicable, the Contractor shall remove debris, including sediment to the degree possible, from the sump areas prior to placement of the GDM. The sump areas shall be approved by the Engineer prior to GDM placement.

3. Cover Placement:

Placement of cover over GDM shall be performed in a manner as to ensure that GDM and the underlying geomembrane are not damaged; minimal slippage of GDM on the underlying geomembrane occurs; and no excess tensile stresses occur in the GDM.

E. MEASUREMENT AND PAYMENT

All work required for Geonet Drainage Media shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

**TABLE 1: REQUIRED GEONET DRAINAGE MEDIA PROPERTIES**

| PROPERTY | TEST METHOD | UNITS | VALUE |
|---|---|---|---|
| Thickness (geonet only) | ASTM D 5199 | inches | 0.20 |
| Resin Density (geonet only) | ASTM D 1505 | $g/cm^3$ | 0.92 |
| Ply Adhesion | ASTM D 413 | lb/inch | 2.0 |
| Transmissivity | ASTM D 4716 | gpm/ft ($m^3/m/sec$) | 2.0[1] ($4.1 \times 10^{-4}$) |

Notes:

1. Conduct test for transmissivity at a normal compressive load of 1000 psf and at a hydraulic gradient of 0.25 after a seating period of at least 24 hours.

**TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA**

| PROPERTY | TEST METHOD | MINIMUM TEST FREQUENCY |
|---|---|---|
| Thickness (geonet only) | ASTM D 5199 | Every Roll |
| Resin Density (geonet only) | ASTM D 1505 | 50,000 $ft^2$ |
| Ply Adhesion | ASTM D 413 | 50,000 $ft^2$ |
| Transmissivity | ASTM D 4716 | 100,000 $ft^2$ |

END OF SECTION

# SECTION 02720

## STORM WATER SYSTEMS

| |
|---|
| Storm Water Systems: Storm Water Systems shall include all piping, pipe fittings, headwalls, flared end sections, drop inlets, and other appurtenances designated to convey stormwater. |

A. DESCRIPTION

1. General:

The contractor shall furnish all labor, material, and equipment to complete installation of Storm Water Systems in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Erosion and Sedimentation Control | 02270 |

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO) are hereby made a part of these specifications.

| | |
|---|---|
| ASTM C 76 | Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe. |
| ASTM C 150 | Specification for Portland Cement. |
| ASTM D 1248 | Standard Specification for Polyethylene Plastics Molding and Extrusion Materials. |
| ASTM D 2321 | Standard Specification for Underground Installation of Flexible Thermoplastic Sewer Pipe. |
| ASTM D 3350 | Standard Specification for Polyethylene Plastics Pipe and Fitting Materials. |

| | |
|---|---|
| AASHTO M 36 | Specification for Corrugated Steel Pipe. |
| AASHTO M 252 | Specification for Corrugated Polyethylene Drainage Tubing, 3 to 10 Inch Diameter. |
| AASHTO M 294 | Specification for Corrugated Polyethylene Pipe, 12 to 36 Inch Diameter. |

B. MATERIALS

1. Concrete Culvert and Drain Pipe:

   a. All reinforced concrete culvert and drain pipe shall be manufactured in accordance with ASTM C 76, Wall Type B or C, and shall be of the class that equals or exceeds the pipe class as shown on the Contract Drawings. All pipe shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site.

   b. Minimum pipe laying lengths shall be four (4) feet.

   c. Joints for the reinforced concrete culvert and drain pipe shall have bell and spigot ends with flexible preformed plastic gaskets.

2. Corrugated Metal Pipe (CMP):

   a. Corrugated metal pipe and fittings shall be of the sizes shown or specified and shall conform to every aspect of AASHTO M 36.

   b. Corrugated metal pipe shall be fabricated from galvanized steel sheets. Corrugation profile shall be 2-2/3 inch crest to crest and ½ inch crest to valley, and sheet thickness shall be 16 gage/.064 inch minimum.

   c. Pipe sections shall be helically corrugated with each pipe end rerolled to obtain no less than two (2) annular corrugations.

   d. Coupling Bands: CMP shall be firmly joined by coupling bands in accordance with the manufacturer's recommendations. These bands shall be not more than two nominal sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than 0.052 inches.

   e. All CMP utilized for permanent installation shall have gasketed joints.

   f. Asphaltic or bituminous coatings shall be applied in conformance with the manufacturer's requirements, as applicable.

3. Corrugated Polyethylene (CPE) Pipe:

CPE Pipe and fittings shall be of the sizes and type shown on the Contract Drawings and shall conform to every aspect of AASHTO M 252 (3 to 10 inch diameters) or AASHTO M 294 (12 to 36 inch diameters).

4. Drop Inlets, Headwalls, and Flared End Sections:

Drop inlets, headwalls, and flared end sections shall be as described in the Contract Drawings.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Storm Water Systems have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. All piping shall be installed by skilled workmen and in accordance with the best standards for piping installation. Proper tools and appliances for the safe and convenient handling and installation of the pipe and fittings shall be used.

2. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced at the Contractor's expense.

3. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade.

E. MEASUREMENT AND PAYMENT

All work required for Storm Water Systems shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

**SECTION 02776**

# GEOSYNTHETIC CLAY LINER (GCL)

| |
|---|
| Geosynthetic Clay Liner (GCL): The GCL is used as a hydraulic barrier within the final cover. |

## A. DESCRIPTION

### 1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of GCL in accordance with the Contract Drawings and these Specifications.

### 2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Compacted Soil Barrier | 02252 |
| Geonet Drainage Media | 02712 |
| CQA Manual | Attached |

### 3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these specifications.

| | |
|---|---|
| ASTM D 1777 | Method for Measuring Thickness of Textile Materials. |
| ASTM D 3776 | Test Methods for Weight (mass) per Unit Area of Woven Fabric. |
| ASTM D 4632 | Test Method for Grab Breaking Load and Elongation of Geotextile. |
| ASTM D 5084 | Test Method for Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter. |

ASTM D 5321 — Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.

4. Quality Assurance:

Quality Assurance during installation of GCL will be provided by the Owner as described in the accompanying Project CQA Manual.

5. Manufacturer Qualifications:

The GCL shall be furnished by a Manufacturer that has previously produced a minimum of 10,000,000 square feet of the material for use in similar projects.

6. Installer Qualifications:

The GCL Installer shall have installed a minimum of 500,000 square feet of GCL in the past two (2) years in similar landfill installations.

7. Warranties:

a. General: Should a defect occur, which is covered under warranty, the Warrantor shall bear all costs for repair and/or relocation and replacement of the GCL.

b. Workmanship: The Contractor shall furnish the Owner a warranty from the GCL Installer which warrants their workmanship to be free of defects on a non-prorata basis for five (5) years after the final acceptance of the Work. This warranty shall include but not be limited to overlapped seams, anchor trenches, attachments to appurtenances, and penetration seals, as applicable.

c. Manufacturer's Warranty: The Contractor shall furnish the Owner a warranty from the GCL Manufacturer for the materials used. The material warranty shall be for defects or failures related to manufacture on a non-prorata basis for five (5) years after date of shipment.

B. MATERIALS

1. General:

The GCL shall consist of bentonite encased, front and back, with geotextile. GCL consisting of bentonite backed with geomembrane can be used only if approved by the Engineer. The materials supplied under these Specifications shall be first quality products designed and manufactured specifically for the purposes of this work.

The GCL shall be supplied in rolls which have a minimum width of 12 feet. The roll length shall be maximized to provide the largest manageable sheet for the fewest overlaps. Labels on the roll shall identify the length, width, lot and roll numbers, name of Manufacturer, proper direction of unrolling, and minimum recommended overlap.

2. Physical Properties:

Physical properties of GCL shall be as shown in Table 1 of this section.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Pre-Installation Requirements:

Prior to GCL installation the Contractor shall submit the following:

a. Mill Certificate and Sample: Prior to shipping to the site, the Contractor shall submit one copy of a mill certificate or affidavit signed by a legally authorized official of the Manufacturer for the GCL attesting that the GCL meets the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample (4" x 6") of the GCL to be used. The sample shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

b. Qualifications:

(1) Submit list of equipment and personnel proposed for the Project. Include equipment type and quantities. Include personnel experience on similar projects.

(2) Submit resume and references of Installation Supervisor to be assigned to the Project, including data and duration of employment and pertinent experience information.

c. Shipping, Handling, and Storage Instructions: The Manufacturer's recommendations for shipping, handling, and storage shall be submitted for review.

d. Delivery Date: Submit notification of the scheduled delivery date for the materials.

e. Installation Drawings, Procedures, and Schedules:

Submit installation (shop) drawings, procedures, and a schedule for carrying out the work. Procedures addressed by the Contractor shall include but not be limited to material unloading, storage, installation, repair, and protection to be provided in the event of rain. A schedule showing the order of placement, location of panels, seams, and penetrations shall be submitted for the Engineer's review. Submit drawings showing the panel layout, seams, and associated details including pipe penetrations. Following review, these drawings will be used for installation of the GCL. Any deviations from these drawings must be approved by the Engineer.

f. Quality Control Certificates: For GCL delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided for every roll of GCL. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section.

g. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

2. Post-Installation Requirements:

Upon completion of GCL installation the Contractor shall submit the following:

a. A certificate stating that the GCL has been installed in accordance with the Drawings, Specifications, and the Manufacturer's recommendations.

b. Completed Manufacturer's and Workmanship Warranties.

c. Record Information: Record information shall include but not be limited to: drawings showing the area of GCL coverage.

Finalization of payment for GCL installation shall not be made until the above submittals have been reviewed by the Engineer.

D. CONSTRUCTION

1. Shipping , Handling, and Storage:

The GCL shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Failing CQA Material Control Tests:

GCL that is rejected upon testing shall be removed from the project site and replaced at Contractor's cost. Sampling and CQA testing of GCL supplied as replacement for rejected material shall be performed by the Engineer at Contractor's cost.

3. Installation of GCL:

a. GCL shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, GCL shall be rejected by the Engineer if it has defects, rips, holes, flaws, evidence of deterioration, or other damage.

b. The surface receiving the GCL shall be prepared to a relatively smooth condition, free of obstructions, excessive depressions, debris, and very soft or loose pockets of soil. This surface shall be approved by the Engineer prior to GCL placement.

c. The GCL shall be placed smooth and free of excessive wrinkles.

d. The GCL shall be installed on side slopes with vertical seams only.

e. When GCL is placed with upslope and downslope portions, the upslope portion shall be lapped such that it is the upper or exposed surface.

f. The GCL shall not be placed in standing water or while raining. Any material that becomes hydrated shall be removed and replaced at Contractor expense.

g. The GCL shall be laid with a 6 inch minimum overlap seam along roll edges and a 12 inch minimum overlap seam along roll ends.

h. GCL shall be temporarily secured in a manner approved by the Engineer prior to placement of overlying materials.

i. Any GCL that is torn or punctured shall be repaired or replaced as directed by the Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of GCL placed over the failed areas and shall overlap the existing GCL a minimum of 12 inches from any point of the rupture.

j. If in-place GCL is not otherwise protected from hydration due to rainfall, the GCL shall be covered with a minimum of 6 inches of the overlying design material within 24 hours of GCL placement.

E. MEASUREMENT AND PAYMENT

All work required for Geosynthetic Clay Liner shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

**TABLE 1: REQUIRED GCL PROPERTIES**

| PROPERTY | TEST METHOD | UNITS | VALUE[1] |
|---|---|---|---|
| Hydraulic Conductivity | ASTM D 5084[2] | cm/s | $5 \times 10^{-9}$ |
| Bentonite Content | ASTM D 3776[3] | psf | 0.95 (@ 20% moisture) |
| Thickness | ASTM D 1777 | inches | 0.20 |
| Grab Tensile Strength | ASTM D 4632 | lbs | 88 |
| Minimum Shear Strength | ASTM D 5321[4] | psf | 500 |

**TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA**

| PROPERTY | TEST METHOD | MINIMUM TEST FREQUENCY |
|---|---|---|
| Hydraulic Conductivity | ASTM D 5084[2] | Weekly |
| Bentonite Content | ASTM D 3776[3] | 50,000 $ft^2$ |
| Thickness | ASTM D 1777 | 50,000 $ft^2$ |
| Grab Tensile Strength | ASTM D 4632 | 50,000 $ft^2$ |
| Minimum Shear Strength | ASTM D 5321[4] | Periodic |

Notes:

1. Minimum Average Roll Values (MARV)
2. Conduct test at 30 psi effective stress.
3. Alternatively, use new ASTM Draft Standard on Standard Test Method For Measuring The Mass Per Unit Area of Geosynthetic Clay Liners.
4. Conduct test at 3 psi effective stress and hydrate the GCL.

END OF SECTION

## SECTION 02930

## REVEGETATION

| |
|---|
| Revegetation: Revegetation includes permanent Revegetation of disturbed site areas as indicated on the Contract Drawings. Note that the seeding schedule provided in this section is based on Table 6.11p of the North Carolina Erosion and Sediment Control Planning and Design Manual. |

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Revegetation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Vegetative Soil Layer | 02258 |
| Erosion and Sedimentation Control | 02270 |

B. MATERIALS

1. Limestone: Unless otherwise defined by specific soil tests, supply agricultural grade ground limestone conforming to the current "Rules, Regulations, and Standards of the Fertilizer Board of Control."

2. Fertilizer: Unless otherwise defined by specific soil tests, supply commercial fertilizer of 10-10-10 analysis, meeting applicable requirements of State and Federal law. Do not use cyanamic compounds of hydrated lime. Deliver fertilizer in original containers labeled with content analysis.

3. Grass Seed: Supply fresh, clean, new-crop seed as specified in Table 1 of this section. Do not use seed which is wet, moldy, or otherwise damaged. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

4. Mulch: Supply clean, seed-free, threshed straw of oats, wheat, barley, rye, beans, or other locally available mulch material.

   a. Do not use mulch containing a quantity of matured, noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.

   b. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.

5. Binder: Supply emulsified asphalt or synthetic binder.

6. Water: Supply potable, free of substances harmful to growth.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Certificates for each grass seed mixture, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed. Certify that each container of seed delivered is fully labeled in accordance with Federal Seed Act and equals or exceeds specification requirements.

2. Copies of invoices for fertilizer, showing grade furnished and total quantity applied.

D. CONSTRUCTION

1. The Contractor shall establish a smooth, healthy, uniform, close stand of grass from the specified seed. The Engineer will perform the observations to determine when successful Revegetation is achieved.

2. Soil Preparation:

   a. Limit preparation to areas which will be planted soon after preparation.

   b. Loosen surface to minimum depth of four (4) inches.

   c. Remove stones, sticks, roots, rubbish and other extraneous matter over three (3) inches in any dimension.

   d. Spread lime uniformly over designated areas at the rate specified in Table 1 of this section.

e. After application of lime, prior to applying fertilizer, loosen areas to be seeded with double disc or other suitable device if soil has become hard or compacted. Correct any surface irregularities in order to prevent pocket or low areas which will allow water to stand.

f. Distribute fertilizer uniformly over areas to be seeded at the rate specified in Table 1 of this section.

(1) Use suitable distributor.

(2) Incorporate fertilizer into soil to depth of a least two (2) inches.

(3) Remove stones or other substances which will interfere with turf development or subsequent mowing.

g. Grade seeded areas to smooth, even surface with loose, uniformly fine texture.

(1) Roll and rake, remove ridges and fill depressions, as required to meet finish grades.

(2) Fine grade just prior to planting.

5. Seeding:

a. Use approved mechanical power driven drills or seeders, mechanical hand seeders, or other approved equipment.

b. Distribute seed evenly over entire area at the rate specified in Table 1 of this section.

c. Stop work when work extends beyond most favorable planting season for species designated, or when satisfactory results cannot be obtained because of drought, high winds, excessive moisture, or other factors.

d. Resume work only when favorable condition develops, or as directed by the Engineer.

e. Lightly rake seed into soil followed by light rolling or cultipacking.

f. Immediately protect seeded areas against erosion by mulching or placing erosion control matting or netting, where applicable.

(1) Spread mulch in a continuous blanket at the rate specified in Table 1 of this section.

(2) Immediately following spreading mulch, secure with evenly distributed binder at the rate specified in Table 1 of this section.

6. Maintenance:

a. Regrade and revegetate all eroded areas until stabilized by grass.

b. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

c. Replant bare areas using same materials specified.

E. MEASUREMENT AND PAYMENT

All work required for Revegetation shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

**TABLE 1: SEEDING SCHEDULE**

| MATERIAL | SEED TYPE | MINIMUM SEED PURITY (%) | APPLICATION RATE[1] |
|---|---|---|---|
| Lime | ----- | ----- | 4000 lbs/acre |
| Fertilizer | ----- | ----- | 1000 lbs/acre |
| Seed | Kentucky 31 Tall Fescue<br>Pensacola Bahiagrass<br>Sericea Lespedeza[3]<br>Kobe Lespedeza<br>Seasonal Nurse Crop[2] | 97<br>97<br>97<br>97<br>97 | 80 lbs/acre<br>50 lbs/acre<br>30 lbs/acre<br>10 lbs/acre<br>See Note 2 |
| Mulch | ----- | ----- | 1500 lbs/acre |
| Binder | ----- | ----- | 150 gallons/acre |

Notes:

1. Application rates and/or chemical analysis shall be confirmed or established by a soil test.

2. Use seasonal nurse crop in accordance with seeding dates as stated below:

| | |
|---|---|
| April 15 - August 15 | 10 lbs/acre German Millet or<br>15 lbs/acre Sudangrass |
| August 15 - April 15 | 25 lbs/acre Rye (grain). |

3. From September 1 - March 1, use unscarified sericea seed.

END OF SECTION

## SECTION 13250

## METHANE GAS VENTS

| |
|---|
| Methane Gas Vents: Methane Gas Vents are installed under the landfill cover in order to vent landfill gases, particularly methane, which builds up due to the decomposition of waste. |

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Methane Gas Vents in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

| Work | Section |
|---|---|
| Geotextiles | 02240 |

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the North Carolina Department of Transportation (NCDOT) are hereby made a part of these specifications.

| | |
|---|---|
| ASTM D 1785 | Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120. |
| NCDOT | Standard Specifications for Roads and Structures. |

B. MATERIALS

1. All pipe used for construction of Methane Gas Vents shall be either solid (riser pipe) or perforated (collector pipe) 6 inch diameter schedule 80 polyvinyl chloride (PVC) pipe as shown on the Contract Drawings.

2. Backfill for Methane Gas Vents shall be NCDOT #57 stone.

3. Geotextiles used for Methane Gas Vents shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall furnish copies of the delivery tickets or other approved receipts to the Engineer as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

All Methane Gas Vents shall be constructed at the locations and according to the details shown on the Contract Drawings. Care shall be taken to ensure that these locations are not in areas which are prone to pond water.

E. MEASUREMENT AND PAYMENT

All work required for Methane Gas Vents shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

# Appendix I

# Construction Quality Assurance Manual

## Halifax County
## Construction & Demolition Debris Landfill

Prepared for:

**Halifax County Solid Waste Department**

**Halifax, North Carolina**

**December 1997**

**PERMIT ISSUE DOCUMENTS**


**G.N. Richardson & Associates, Inc.**

Engineering and Geological Services

425 N. Boylan Avenue

Raleigh, North Carolina 27603

**HALIFAX COUNTY**
**CONSTRUCTION & DEMOLITION DEBRIS LANDFILL**

**CONSTRUCTION QUALITY ASSURANCE MANUAL**

**TABLE OF CONTENTS**

**Table of Contents (Continued)**

## Table of Contents (Continued)

# SECTION 1.0
# GENERAL

## 1.1 INTRODUCTION

This Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, Engineer, and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations.

More specifically, this CQA Manual addresses the soils and geosynthetics components of the final cover system.

The CQA Manual is divided into the following sections:

- Section 1.0 General
- Section 2.0 CQA Documentation
- Section 3.0 Earthwork CQA
- Section 4.0 Geotextile CQA
- Section 5.0 Geonet Drainage Media CQA
- Section 6.0 Geosynthetic Clay Liner CQA
- Section 7.0 Compacted Soil Barrier CQA

## 1.2 DEFINITIONS RELATING TO CONSTRUCTION QUALITY

### 1.2.1 Construction Quality Assurance (CQA)

In the context of this Manual, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the final cover system installation with the project drawings and the project specifications. CQA is provided by the CQA Engineer as a representative of the Owner and is independent from the Contractor and all manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

### 1.2.2 Construction Quality Control (CQC)

Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, and/or the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only. A complete updated version of each geosynthetic component manufacturer's QC Plan shall be incorporated as part of the Contractor's CQC Plan.

### 1.2.3 CQA Certification Document

At the completion of construction, a certification document will be prepared by the CQA Engineer and submitted to State Solid Waste Regulators. The certification report will include all QC testing performed by the Geosynthetics Manufacturers, all CQC testing performed by the Geosynthetic Installers, and all CQA testing performed by the CQA Engineer.

### 1.2.4 Discrepancies Between Documents

The CQA Manual is intended to be a supporting document to improve the overall documentation of the work. The CQA Manual is less specific than the project specifications, and conflicts may exist between the documents. The Contractor is instructed to bring discrepancies to the attention of the CQA Engineer for resolution who shall then notify the Engineer. The Engineer has the sole authority to determine resolution of discrepancies existing within the Contract Documents. Unless otherwise determined by the Engineer, the more stringent requirement shall be the controlling resolution.

## 1.3 PARTIES TO CONSTRUCTION QUALITY ASSURANCE

### 1.3.1 Description of the Parties

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, Geosynthetics Manufacturer, Geosynthetics Installer, CQA Engineer, Geosynthetics CQA Laboratory, and Soils CQA Laboratory.

#### 1.3.1.1 Owner

The Owner is Halifax County, who owns and/or is responsible for the facility.

#### 1.3.1.2 Engineer

The Engineer is responsible for the engineering design, drawings, and project specifications for the final cover system. The Engineer is an official representative of the Owner. The Engineer serves as communications coordinator for the project, initiating the meetings outlined in Section 1.7. The Engineer shall also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is G.N. Richardson & Associates, Inc.

#### 1.3.1.3 Contractor

The Contractor is responsible for the construction of the final cover system. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the CQA Engineer. Additional responsibilities of the Contractor are defined by the project specifications.

1.3.1.4 Geosynthetics Manufacturer

The Geosynthetics Manufacturer(s) is (are) responsible for the production of the geosynthetic components used in landfill construction. The Manufacturer(s) is (are) responsible for Quality Control (QC) during manufacture of the geosynthetic components, certification of the properties of the geosynthetic components, and field installation criteria.

1.3.1.5 Geosynthetics Installer

The Geosynthetics Installer(s) is (are) routinely a subcontractor of the Contractor and is (are) responsible for field handling, storing, placing, seaming, protection of (against wind, etc.), and other aspects of the geosynthetics installations. The Installer may also be responsible for transportation of these materials to the site, and for the preparation and completion of anchor trenches.

1.3.1.6 CQA Engineer

The CQA Engineer is a representative of the Owner, is independent from the Contractor, and is responsible for observing, testing, and documenting activities related to the CQA of the earthworks at the site, and the installation of the geosynthetic components of the final cover system. The CQA Engineer may make field observations and review submittals for the Engineer and is responsible for notifying the Owner and Engineer of all quality issues that arise during construction. The CQA Engineer is also responsible for issuing a facility certification report, sealed by a Professional Engineer registered in The State of North Carolina.

1.3.1.7 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory is a party, independent from the Owner, that is responsible for conducting tests on conformance samples of geosynthetics used in the final cover system. The Geosynthetics CQA Laboratory service cannot be provided by any party involved with the manufacture, fabrication, or installation of any of the geosynthetic components.

1.3.1.8 Soils CQA Laboratory

The Soils CQA Laboratory is a party, independent from the Owner, that is responsible for conducting geotechnical tests on conformance samples of soils used in the final cover system.

### 1.3.2 Qualifications of the Parties

The following qualifications are required of all parties involved with the manufacture, fabrication, installation, transportation, and CQA of all materials for the final cover system. Where applicable, these qualifications must be submitted by the Contractor to the Owner and Engineer for review and approval.

#### 1.3.2.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Manual.

#### 1.3.2.2 Geosynthetics Manufacturers

Each Geosynthetics Manufacturer must satisfy the qualifications presented in the project specifications.

The physical properties of each geosynthetic product must be certified by the geosynthetics manufacturer. The properties certified must include, at a minimum, those identified in the project specifications. Manufacturer's certification(s) must be approved by the CQA Engineer before the product is used.

#### 1.3.2.3 Geosynthetic Installer(s)

The Geosynthetic Installer(s) will be trained and qualified to install the geosynthetics components of the liner system. Each Geosynthetics Installer must meet the requirements of the project specifications and be approved by the Engineer. The Geomembrane Installer must be approved by the Geomembrane Manufacturer.

#### 1.3.2.4 CQA Engineer

The CQA Engineer will act as the Owner's and Engineer's CQA Representative. The CQA Engineer will perform CQA testing to satisfy the requirements of this CQA Plan and will prepare the CQA certification document. The CQA Engineer will have experience in the CQA aspects of landfill final cover system construction and soils testing, and be familiar with ASTM and other related industry standards. The activities of the CQA Engineer will be performed under the supervision of a Registered Professional Engineer.

#### 1.3.2.5 Geosynthetics CQA Laboratory

The Geosynthetics CQA Laboratory will have experience in testing geosynthetics and be familiar with ASTM, NSF, and other applicable test standards. The Geosynthetics CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples depending on the test(s) to be run, as agreed to at the outset of the project by the Owner, Engineer, CQA Engineer, and Contractor and will maintain that standard throughout the installation.

1.3.2.6 Soils CQA Laboratory

The Soils CQA Laboratory will have experience in testing structural fills, and be familiar with ASTM and other applicable test standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after, as agreed to at the outset of the project, receipt of samples, and will maintain that standard throughout the installation.

## 1.4 SCOPE OF CONSTRUCTION QUALITY ASSURANCE MANUAL

The scope of this CQA Manual includes the CQA of the soils and geosynthetic components of the final cover system for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope.

## 1.5 UNITS

In this CQA Manual, all properties and dimensions are expressed in U.S. units.

## 1.6 REFERENCES

The CQA Manual includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM), the National Sanitation Foundation (NSF), and the Geosynthetic Research Institute (GRI).

## 1.7 SITE AND PROJECT CONTROL

To facilitate the specified degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

### 1.7.1 Geosynthetics CQA Meeting

A CQA Meeting will be held at the site prior to placement of the geosynthetics. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and the Geosynthetic Installation Superintendent.

The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems which might cause difficulties and delays in construction, and, above all, review the CQA Manual to all of the parties involved. It is very important that the rules regarding testing, repair, etc., be known and accepted by all.

This meeting should include all of the activities referenced in the project specifications. The meeting will be documented by the Engineer and minutes will be transmitted to all parties.

### 1.7.2 Monthly CQA Progress Meetings

A monthly progress meeting will be held between the Engineer, the CQA Engineer, the Contractor, the Geosynthetic Installation Superintendent, and representatives from any other involved parties. This meeting will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Engineer will log any problems, decisions, or questions arising at this meeting in his daily report. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties.

### 1.7.3 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Engineer and minutes will be transmitted to affected parties.

## 1.8 CONTROL VERSES RECORD TESTING

### 1.8.1 Control Testing

In the context of this CQA Manual, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

### 1.8.2 Record Testing

Record Tests are those tests performed during the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications.

# SECTION 2.0
# CQA DOCUMENTATION

## 2.1 DOCUMENTATION

An effective CQA plan depends largely on recognition of construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Engineer will document that quality assurance requirements have been addressed and satisfied.

The CQA Engineer will provide the Owner and Engineer with his daily and weekly progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports shall also identify potential quality assurance problems. The CQA Engineer will also maintain at the job site a complete file of project drawings, reports, project specifications, a CQA Manual, checklists, test procedures, daily logs, and other pertinent documents.

## 2.2 DAILY CQA REPORT

The CQA Engineer's reporting procedures will include preparation of a daily report which, at a minimum, will include the following information, where applicable:

- an identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced-scale Site Plan showing all proposed work areas and test locations;
- descriptions and locations of ongoing construction;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- off-site materials received, including quality verification documentation;

- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;
- summaries of pertinent discussions with the Contractor and/or Geosynthetic Installers; and
- the CQA Engineer's signature.

The daily report must be completed at the end of each CQA Engineer's shift, prior to leaving the site. This information will be submitted weekly to and reviewed by the Owner and Engineer.

## 2.3 CQA PROGRESS REPORTS

The CQA Engineer will prepare a summary progress report each week, or at time intervals established at the pre-construction meeting. As a minimum, this report will include the following information, where applicable:

- a unique identifying sheet number for cross-referencing and document control;
- the date, project name, location, and other information;
- a summary of work activities during the progress reporting period;
- a summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period;
- summary of all test results, failures and retests, and
- signature of the CQA Engineer.

The CQA Engineer's progress reports must summarize the major events that occurred during that week. Critical problems that occur shall be communicated verbally to the Engineer immediately as well as being included in the weekly reports. The CQA Engineer's weekly report must be submitted to the Owner and Engineer no later than the Monday following the week reported.

## 2.4 CQA PHOTOGRAPHIC REPORTING DATA SHEETS

Photographic reporting data sheets, where used, will be cross-referenced with CQA observation logs and testing data sheets and/or CQA construction problem and solution data sheets. Photographs shall be taken at regular intervals during the construction process and in all areas deemed critical by the CQA Engineer.

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints; negatives will also be stored in a separate file in chronological order. These records will be presented to the Engineer upon completion of the project.

In lieu of photographic documentation, videotaping may be used to record work progress, problems, and mitigation activities. The Engineer may require that a portion of the documentation be recorded by photographic means in conjunction with videotaping.

## 2.5 DEFICIENCIES

The Owner and Engineer will be made aware of any significant recurring non-conformance with the project specifications. The Engineer will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and any revision to procedures or project specifications will be approved by the Owner and Engineer.

## 2.6 DESIGN AND/OR PROJECT TECHNICAL SPECIFICATION CHANGES

Design and/or project specification changes may be required during construction. In such cases, the CQA Engineer will notify the Engineer. The Engineer will then notify the appropriate agency, if necessary.

Design and/or project specification changes will be made only with the written agreement of the Engineer, and will take the form of an addendum to the project specifications. All design changes shall include a detail (if necessary) and state which detail it replaces in the plans.

## 2.7 FINAL CQA REPORT

At the completion of each major construction activity at the landfill unit, the CQA Engineer will certify all required forms, observation logs, field and laboratory testing data sheets including sample location plans, construction problem and solution data sheets. The CQA Engineer will also provide a final report which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The CQA Engineer will also provide summaries of all the data listed above with the report. The Record Drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the Record Drawings will be done by the Contractor's Construction Surveyor. These documents will be certified by the Contractor and delivered to the CQA Engineer and included as part of the CQA documentation (Certification) report.

It may be necessary to prepare interim certifications, as allowed by the regulatory agency to expedite completion and review.

## 2.8 STORAGE OF RECORDS

All handwritten data sheet originals, especially those containing signatures, will be stored by the CQA Engineer in a safe repository on site. Other reports may be stored by any standard method which will allow for easy access. All written documents will become property of the Owner.

# SECTION 3.0
# EARTHWORK CQA

## 3.1 INTRODUCTION

This section of the CQA Manual addresses earthwork (excavation and embankment) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, field control and record tests, and resolution of problems.

## 3.2 EMBANKMENT MATERIAL APPROVAL

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries shall be made in the daily log.

## 3.3 SUBGRADE APPROVAL

The CQA Engineer shall verify that the compacted embankment subgrade is constructed in accordance with the project specifications.

## 3.4 EARTHWORK CONSTRUCTION

### 3.4.1 Construction Monitoring

A. Earthwork shall be performed as described in the project specifications.

B. Only soil previously approved by the CQA Engineer (see Section 3.2) shall be used in construction of the compacted embankment. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. The CQA Engineer shall monitor protection of the earthwork during and after construction.

### 3.4.2 Judgmental Testing

During construction, field and/or laboratory testing may be performed at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem.

## 3.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

## SECTION 4.0
## GEOTEXTILE CQA

## 4.1 INTRODUCTION

This section of the CQA Manual addresses geotextiles and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

## 4.2 GEOTEXTILE MATERIAL APPROVAL

### 4.2.1 Geotextile Product Data

For each type of geotextile to be used, the CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

### 4.2.2 Shipment And Storage

During shipment and storage, all geotextiles will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

### 4.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

## 4.3 GEOTEXTILE INSTALLATION

### 4.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all geotextiles in such a manner as required by the project specifications.

### 4.3.2 Seams And Overlaps

All geotextiles will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

### 4.3.3 Repairs

Any holes or tears in the geotextile will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

### 4.3.4 Placement Of Overlying Materials

All soil materials located on top of a geotextile shall be placed in accordance with the project specifications.

## 4.4 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

# SECTION 5.0
# GEONET DRAINAGE MEDIA CQA

## 5.1 INTRODUCTION

This section of the CQA Manual addresses geonet drainage media (GDM) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

## 5.2 GDM MATERIAL APPROVAL

### 5.2.1 GDM Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

### 5.2.2 Shipment And Storage

During shipment and storage, all GDM will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

### 5.2.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

## 5.3 GDM INSTALLATION

### 5.3.1 Handling And Placement

The Geosynthetic Installer will handle and place all GDM in such a manner as required by the project specifications.

### 5.3.2 Stacking And Joining

When several layers of GDM are stacked, care should be taken to ensure that stacked GDM are placed in the same direction. Stacked GDM will never be laid in perpendicular directions to the underlying GDM (unless otherwise specified by the Engineer). The CQA Engineer will observe the stacking of GDM.

Adjacent rolls of GDM will be joined according to construction drawings and project specifications.

### 5.3.3 Repairs

Any holes or tears in the GDM will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

### 5.3.4 Placement Of Overlying Materials

All soil materials located on top of GDM shall be placed in accordance with the project specifications.

## 5.4 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

# SECTION 6.0
# GEOSYNTHETIC CLAY LINER (GCL) CQA

## 6.1 INTRODUCTION

This section of the CQA Manual addresses geosynthetic clay liner (GCL) and outlines the CQA program to be implemented with regard to material approval, material control tests, repairs, and resolution of problems.

## 6.2 GCL MANUFACTURER AND INSTALLER APPROVAL

The Contractor shall submit the qualifications of the GCL Manufacturer and the GCL Installer, as described in the specifications, to the CQA Engineer for approval.

## 6.3 GCL MATERIAL APPROVAL

### 6.3.1 GCL Product Data

The CQA Engineer will review the Contractor's submittals for conformance with the project specifications.

### 6.3.2 Shipment And Storage

During shipment and storage, GCL will be protected as required by the project specifications. The CQA Engineer will observe rolls upon delivery at the site.

### 6.3.3 Quality Control Certificates

Upon delivery, the CQA Engineer will:

- verify that the Manufacturer's quality control certificates have been provided at the specified frequency and that each certificate identified the rolls related to it; and

- review the Manufacturer's quality control certificates and verify that the certified properties meet the project technical specifications.

### 6.3.4 GCL Material Control Tests

Samples for material control tests, as shown on Table 1, will be obtained at the indicated frequencies upon delivery of the GCL.

Samples will be taken across the entire width of the roll and will not include the first lineal 3 feet. Unless otherwise specified, samples will be 3 feet long by the roll width. The CQA Engineer will mark the machine direction on the samples with an arrow.

All material control tests will be performed by the Geosynthetics CQA Laboratory.

All test results must be available at the site prior to the deployment of all GCL. The CQA Engineer will examine all results from laboratory testing.

6.3.4.1 Material Control Test Failure

The following procedure will apply whenever a sample fails a material control test:

A. The Geosynthetic Installer will replace the roll of GCL that is in nonconformance with the project specifications with a roll that meets project specifications.

B. The Geosynthetic Installer will remove samples for testing by the Geosynthetics CQA Laboratory from the closest numerical roll on both sides of the failed roll. These two samples must both conform to project specifications. If either of these samples fail, then the next numerical roll will be tested until a passing roll is found. This additional testing will be at the expense of the Geosynthetic Installer. If either of the two closest rolls fail, the Engineer will dictate the frequency of additional testing.

The CQA Engineer will document actions taken in conjunction with material control test failures.

## 6.4 GCL INSTALLATION

### 6.4.1 Handling And Placement

The Geosynthetic Installer will handle and place all GCL in such a manner as required by the project specifications.

### 6.4.2 Seams And Overlaps

All GCL will be seamed or overlapped in accordance with project specifications or as approved by the CQA Engineer and Engineer.

### 6.4.3 Repairs

Any holes or tears in the GCL will be repaired in accordance with the project specifications. The CQA Engineer will observe any repair.

### 6.4.4 Placement Of Overlying Materials

All soil materials located on top of the GCL shall be placed in accordance with the project specifications.

## 6.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

## TABLE 1: CQA TESTING PROGRAM FOR MATERIAL APPROVAL

| PROPERTY | TEST METHOD | TEST FREQUENCY |
|---|---|---|
| **CONTROL TESTS:** | | |
| Hydraulic Conductivity | ASTM D 5084 (@ 30 psi effective stress) | 100,000 $ft^2$ or 1 per Lot[1] |
| Bentonite Content | ASTM D 3776[2] (@ 20% moisture) | 100,000 $ft^2$ or 1 per Lot[1] |
| Grab Tensile Strength | ASTM D 4632 | 100,000 $ft^2$ or 1 per Lot[1] |

Notes:

1. Whichever provides the larger number of tests.
2. Alternatively, use new ASTM Draft Standard on Standard Test Method For Measuring The Mass Per Unit Area of Geosynthetic Clay Liners.

# SECTION 7.0
# COMPACTED SOIL BARRIER CQA

## 7.1 INTRODUCTION

This section of the CQA Manual addresses the compacted soil barrier component of the final cover system and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, test fill construction, field and laboratory control and record tests, and resolution of problems.

## 7.2 COMPACTED SOIL BARRIER MATERIAL APPROVAL

All material to be used as compacted soil barrier shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

### 7.2.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries shall be made in the daily log.

During stockpiling operations, control tests, as shown on Table 1, will be performed prior to placement of any compacted soil barrier material.

## 7.3 SUBGRADE APPROVAL

The CQA Engineer shall verify that the soil barrier subgrade is constructed in accordance with the project specifications.

## 7.4 TEST FILL CONSTRUCTION

A test fill meeting the requirements of the project specifications will be constructed using the same construction methods, equipment, and material to be used for the compacted soil barrier component. The test fill construction will be conducted prior to or coincide with the beginning of construction of the soil barrier component.

Construction equipment and methods shall be reviewed by the CQA Engineer prior to test fill placement.

### 7.4.1 Control Tests

The control tests, as shown on Table 2, will be performed prior to compaction of compacted soil barrier material in the test fill.

### 7.4.2 Record Tests

The record tests, as shown on Table 2, will be performed during placement of compacted soil barrier material in the test fill.

### 7.4.3 Test Fill Completion

The test fill program is completed when the Contractor has shown that the soil barrier constructed using the same construction methods, equipment, and material to be used in construction of the compacted soil barrier will satisfy project specifications. No compacted soil barrier can be placed until the test fill program is completed.

## 7.5 COMPACTED SOIL BARRIER CONSTRUCTION

### 7.5.1 Construction Monitoring

A. Compacted soil barrier shall be placed as described in the project specifications using the construction methods, equipment, and material demonstrated in the test fill construction.

B. Only soil previously approved by the CQA Engineer (see Section 7.2) shall be used in construction of the compacted soil barrier. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g. wetting, drying, scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer shall monitor protection of the soil barrier during and after construction.

E. The soil barrier surface shall be sprinkled with water as needed to prevent desiccation. Should desiccation occur, the last lift shall be reconstructed in accordance with the project specifications. Standing water should not be present on the compacted soil barrier.

F. Frost heave or other damage due to freezing shall require lift reconstruction in accordance with the project specifications.

G. The CQA Engineer shall inspect the compacted soil barrier and certify that it is in accordance with the project specifications and approved plans prior to the Contractor beginning installation of overlying layers.

H. The finished compacted soil barrier shall be free of all rock protrusions. All cracks and voids shall be filled and the surface made uniform. This shall be accomplished by final dressing of the soil barrier with smooth drum rollers and hand raking. No rubber tired vehicles are permitted on the final dressed surface unless authorized by the CQA Engineer.

### 7.5.2 Control Tests

The control tests, as shown on Table 3, will be performed prior to compaction of compacted soil barrier material.

### 7.5.3 Record Tests

The record tests, as shown on Table 3 and as described below, will be performed during placement of compacted soil barrier material.

A. Each lift shall be checked visually for soil clods, rocks, debris, plant materials and other foreign material. Any such material which will not pass through a 1-½" screen shall be identified and removed prior to and during the compaction process.

B. The thickness of the loose lift shall be measured at random locations after spreading and leveling is completed. Loose lift thickness should not exceed 10 inches for a final 6-inch compacted lift thickness.

C. Moisture content will be monitored by the CQA Engineer or his representative prior to compaction. If the soil is drier than the specified minimum moisture content, water will be added and the lift will be disced to distribute the moisture evenly.

Results of testing shall be certified within 7 days of compacted soil barrier placement.

7.5.3.1 <u>Record Test Failure</u>

The following procedures shall be used in the event of density or permeability test failure:

A. <u>Failed Density Test:</u> Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

B. Failed Permeability Test: The area of failure shall be localized and reconstructed in accordance with the project specifications. This area shall be retested as outlined within the plan. Optionally, at least five replicate samples shall be obtained in the immediate vicinity of the failed test. If all five samples pass, then the initial failing test will be discounted. However, should the replicate samples confirm the failure of the compacted soil barrier to meet specifications, the area of failure shall be localized, reconstructed, and retested as described above.

### 7.5.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

### 7.5.5 Perforations In Compacted Soil Barrier

All holes shall be patched with sodium bentonite compacted and hydrated in the holes.

## 7.6 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

**TABLE 1: CQA TESTING PROGRAM FOR MATERIAL APPROVAL**

| PROPERTY | TEST METHOD | MINIMUM TEST FREQUENCY/ SOIL |
|---|---|---|
| **CONTROL TESTS:** | | |
| Visual Classification | ASTM D 2488 | Each Soil |
| Moisture Content | ASTM D 2216 | 2,000 CY per Each Soil |
| Grain Size Analysis | ASTM D 422 | 2,000 CY per Each Soil |
| Atterberg Limits | ASTM D 4318 | 2,000 CY per Each Soil |
| Moisture-Density Relationship | ASTM D 698 | 5,000 CY per Each Soil |
| Permeability - Lab Remolded | ASTM D 5084 | 10,000 CY per Each Soil |

**TABLE 2: CQA TESTING PROGRAM FOR TEST FILL**

| PROPERTY | TEST METHOD | MINIMUM TEST FREQUENCY/SOIL |
|---|---|---|
| **CONTROL TESTS:** (See Table 1) | | |
| **RECORD TESTS:** | | |
| Loose Lift Thickness | ----- | Each Lift |
| Atterberg Limits | ASTM D 4318 | 1 per lift |
| Grain Size Analysis | ASTM D 422 | 1 per lift |
| Moisture Content | ASTM D 2216 | 3 per lift |
| In-Place Density | ASTM D 2922[1] | 3 per lift |
| Permeability - In-Place (Shelby Tube) | ASTM D 5084 | 1 per lift |

**TABLE 3: CQA TESTING PROGRAM FOR COMPACTED SOIL BARRIER**

| PROPERTY | TEST METHOD | MINIMUM TEST FREQUENCY |
|---|---|---|
| **CONTROL TESTS:** (See Table 1) | | |
| **RECORD TESTS:** | | |
| Loose Lift Thickness | ----- | Each Lift |
| Moisture Content | ASTM D 2216 | 40,000 $ft^2$ per lift |
| In-Place Density | ASTM D 2922[1] | 40,000 $ft^2$ per lift |
| Permeability - In-Place (Shelby Tube) | ASTM D 5084 | 100,000 $ft^2$ per lift |

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

# Appendix J

# Operations Manual

# Halifax County
# Construction & Demolition Debris Landfill

Prepared for:

**Halifax County Solid Waste Department**

**Halifax, North Carolina**

**December 1997**

**PERMIT ISSUE DOCUMENTS**

**G.N. Richardson & Associates, Inc.**
Engineering and Geological Services
425 N. Boylan Avenue
Raleigh, North Carolina 27603

**HALIFAX COUNTY**
**CONSTRUCTION AND DEMOLITION DEBRIS LANDFILL**

**OPERATIONS MANUAL**

**TABLE OF CONTENTS**

## Table Of Contents (Continued)

## SECTION 1.0 GENERAL FACILITY OPERATIONS

This operations manual was prepared for the Halifax County Construction and Demolition Debris (C&D) Landfill. The information contained herein was prepared to provide the County landfill personnel with a clear understanding of how the Design Engineer assumed that the facility would be operated. While deviations from the operations outlined here may be acceptable, they should be reviewed and approved by the Design Engineer.

**Responsible Persons:**

In an emergency, the following persons are to be contacted:

| | | |
|---|---|---|
| Solid Waste Director: | Richard Garner | 919-586-4748 |
| County Manager: | Charles Archer | 919-583-1131 |
| Fire, Police, Rescue: | | 911 |

### 1.1 Access Control

Access to active areas of the landfill will be controlled by a combination of fences and natural barriers, such as the creeks, and strictly enforced operating hours. A landfill attendant will be on duty at all times when the facility is open for public use to enforce access restrictions.

#### 1.1.1 Physical Restraints

The site will be accessed by the existing entrance along State Road 1417. Scales, a scale house, an administration building, a waste inspection area, and a public convenience/recycling area will all be located near the entrance. All waste trucks entering the facility will be weighed upon entering and exiting. The entrance has a gate which will be securely locked during non-operating hours.

#### 1.1.2 Security

Frequent inspections of gates and fences will be performed by landfill personnel. The County Solid Waste Director will arrange for a random security patrol of the main gate to further discourage trespassing. Evidence of trespassing, vandalism or illegal operation will be reported to the Halifax County Solid Waste Director.

### 1.2 Signage

A prominent sign containing the information required by NCDENR will be placed just inside the main gate. This sign will provide information on operating hours, operating procedures, and acceptable wastes. Additional signage will be provided within the landfill complex to distinctly distinguish the roadway to the C&D landfill active cell. Service and maintenance roads for use by operations personnel will be clearly marked and barriers (e.g., traffic cones, barrels, etc.) will be provided as required.

## 1.3 Communications

Two way radio communication will be maintained between the C&D landfill and the landfill scale house. The scale house has telephones in case of emergency and for the conduct of day-to-day business. Emergency telephone numbers are displayed in the scale house.

## 1.4 Fire and Safety

### 1.4.1 Fire Control

The possibility of fire within the landfill or a piece of equipment must be anticipated in the daily operation of the landfill. A combination of factory installed fire suppression systems and/or portable fire extinguishers will be operational on all heavy pieces of equipment at all times. For larger or more serious outbreaks, the Halifax County Fire Department will respond.

Fires within the landfill will be limited by the use of periodic cover soil and control of "hot" loads entering the landfill. Landfill personnel at the scale house will turn away all trucks containing waste that is suspected to be hot. If a hot load is placed on the working face, then daily cover soil will be immediately placed on the waste to extinguish the fire. The use of a periodic cover soil will limit the amount of MSW available to the fire.

### 1.4.2 Safety

All aspects of the Halifax County Landfill operation were developed with the health and safety of the landfill's operating staff, customers, and neighbors in mind. Prior to commencement of operations in the new landfill, a member of the landfill operating staff will be designated site safety officer. This individual, together with the facility's management will modify the site safety and emergency response program to remain consistent with National Solid Waste Management Association and OSHA guidance.

Safety equipment provided includes equipment rollover protective cabs, seat belts, audible reverse warning devices, hard hats, safety shoes, and first aid kits. Landfill personnel will be encouraged to complete the American Red Cross Basic First Aid Course. Other safety requirements as designated by the County will also be implemented.

## 1.5 Equipment Requirements

The Halifax County Landfill will maintain on-site equipment required to perform the necessary landfill activities. Periodic maintenance of all landfilling equipment, and minor and major repair work will be performed at the maintenance building away from the landfill area.

## 1.6 Utilities

Electrical power, water, telephone, and restrooms will be provided at the existing administration building adjacent to the scale area.

## SECTION 2.0 LANDFILL OPERATIONS

Halifax County will operate this facility in accordance with applicable sections of the North Carolina Solid Waste Management Rules, this Operations Manual (as revised), and the Permit to Operate.

### 2.1 Acceptable Wastes

The Halifax County C&D Landfill will only accept for disposal the following wastes generated within approved areas of service:

- Construction and Demolition Debris Waste: (Waste or debris from construction, remodeling, repair, or demolition operations on pavement or other structures)
- Land Clearing and Inert Debris Waste: (Waste from land clearing, concrete, brick, concrete block, uncontaminated soils and rock, untreated and unpainted wood, and yard trash)
- Other Wastes as Approved by the Solid Waste Section of the Division of Waste Management

In addition, the special wastes described in Section 2.3 may also be accepted at this facility.

### 2.2 Unacceptable Wastes

No municipal solid (MSW), hazardous (as defined by 15A NCAC 13A including hazardous waste from conditionally exempt small quantity generators), or liquid waste will be accepted at this facility. In addition, no polychlorinated biphenyl (PCB) waste will be accepted. The County will implement a waste screening program, described in Section 2.4, to control this type of waste.

### 2.3 Special Wastes

#### 2.3.1 Animal Carcasses

Any animal carcasses will be disposed of in special trenches outside of the C&D landfill and immediately covered with soil. Animal carcasses will only be accepted after advance notification by the generator.

#### 2.3.2 Asbestos

Halifax County may accept asbestos materials through the life of this facility. Asbestos will only be accepted if it has been processed and packaged in accordance with State and Federal (40 CFR 61) regulations. Asbestos will arrive at the site in vehicles that contain only the asbestos waste and only after advance notification by the generator.

Once the hauler brings the asbestos to the landfill, the hauler will be directed to the active face by operations personnel. A designated disposal area will be prepared at the toe of the active face by operations personnel by leveling a small area using a dozer or loader. Prior to disposal, the landfill operators will stockpile cover soil near the designated asbestos disposal area. The volume of soil stockpiled will be sufficient to cover the waste and to provide any berms, etc. to maintain temporary separation from other landfill traffic.

Once placed in the prepared area, the asbestos waste will be covered with a minimum of 18-inches of cover soil placed in a single lift. The surface of the cover soil will be compacted and graded using a tracked dozer or loader. The landfill compactor will be prohibited from operating over asbestos disposal areas until at least 18-inches of cover are in-place.

The landfill operations manager will record the location and elevation of the asbestos waste once cover is in-place. The landfill operations manager will then review pertinent disposal and location information to assure compliance with regulatory requirements and enter the information into the Operating Record.

Once disposal and recording for asbestos waste is completed, the disposal area may be covered with C&D. No excavation into designated asbestos disposal areas will be permitted.

## 2.4 Waste Screening

Halifax County will not accept or dispose of wastes identified in Section 2.2 at the C&D landfill. Excluded wastes will be screened using a monitoring program described below.

### 2.4.1 Frequency of Inspections

Halifax County landfill operations personnel will perform waste inspections on a daily basis. These inspections include preliminary inspections at the scales and detailed inspections at the operating face. Preliminary inspections will be carried out by the scale operators. Any uncovered loads or roll-off boxes will be visually inspected for unacceptable wastes. In addition to daily visual inspections, vehicles are selected for screening at random a minimum of three times per quarter (i.e. three months). These random inspections will be documented using the form provided in Appendix A.

### 2.4.2 Waste Inspections - Active Face

Waste unloaded on the active face will be inspected by the equipment operators before and during spreading and compaction. Operators will be trained to spot unacceptable or dangerous (e.g. explosive, etc.) wastes. In the event that unacceptable wastes are discovered, the landfill manager will be immediately notified. If the waste is spotted while the hauler is still on-site, the waste will be reloaded onto the truck, if possible, and the truck will be instructed to leave the landfill. If the waste is discovered after the hauler has left, or it is not possible to safely reload the waste, County personnel will take immediate action to contain the waste and call in a hazardous materials clean-up company and County emergency personnel if necessary. In this case, the landfill operations manager will attempt to determine where the waste originated for further action.

If an attempt is made to dump hazardous waste at this facility, the landfill operations manager will immediately notify the County Emergency Management services. The Solid Waste Section will be notified verbally within 24 hours and in writing within 30 days of the attempt. All documentation will be incorporated in the Operating Record.

## 2.5 Record Keeping

The Halifax County Solid Waste Director will keep an Operating Record on file at the landfill. A copy of the Operating Record will be kept at the Halifax County offices in Halifax. This copy will be updated quarterly. A list of items to be incorporated into the Operating Record includes:

1. Landfill Personnel Training Procedures and Records of Training Completed,

2. A record of all waste received by weight and source of generation,

3. Quantity, location of disposal, generator, and special handling procedures for all special wastes disposed of at the site.

4. All groundwater and surface water quality information including:

   a. Monitoring well construction records,
   b. Semi-annual sampling dates and results,
   c. Statistical analyses, and
   d. Results of inspections, repairs, etc.

5. Annual Landfill Report for the last three calendar years.

6. A list of generators and haulers that have attempted to dispose of restricted wastes.

7. All closure information where applicable including:

   a. Testing and
   b. Certification.

8. All cost estimates.

9. All Financial Assurance documentation.

This Operating Record will be kept up to date by the Solid Waste Director or his assistant. It will be present upon request to the Solid Waste Section for inspection. A copy of this Operations Manual will be kept at the landfill and available for use at all times.

## SECTION 3.0 WASTE HANDLING OPERATIONS

Waste handling operations at the Halifax County C&D Landfill will be modified to reflect operational criteria promulgated in the NCDENR regulations.

### 3.1 Waste Placement

Waste will be placed in such a manner that the active face is minimized. An active face width of no more than 75 feet is recommended, with a target of 50 feet desirable. The waste lift should be relatively thick in order to minimize the active face and the distance waste is spread by the compactor.

C&D waste will be unloaded at the upper limit of the working face and inspected (according to Section 2.4.2) prior to being spread on the face and compacted.

#### 3.1.1 Access Ramp

The location of the access ramp during waste placement will be determined by operations personnel in order to reflect waste placement strategy.

Traffic will be clearly directed to the ramp and all vehicles entering the cell will use the active ramp. Traffic speed on the ramp should be less than 10 MPH. Rutting of the gravel roadway surface must be repaired by placement of additional gravel on the roadway and not solely by grading the rut.

#### 3.1.2 Limits of Waste

The active working face for each day shall be less than 1/4 acre in size and have a slope flatter than 4H:1V. The surface of the active area must be graded to drain.

#### 3.1.3 Waste Compaction

Waste spread over the working face will be placed in lifts at least 5-ft thick and will receive a minimum of five passes of the compaction equipment over each lift. The 5 foot thick lift layer will be placed over the entire active area to be used that day. Once the area has received a full lift layer, subsequent lift layers that day will be placed above the previous lift. Each lift layer will be no more than 3 feet thick in compacted thickness. The entire day's lift should be approximately 8-10 feet thick at the end of a given working day. The maximum slope of the working face will be flatter than 4H:1V to ensure proper compaction and stability of the waste.

### 3.2 Periodic Cover

At the completion of waste placement each week or sooner if the area of exposed waste exceeds one acre in size, a 6-inch layer of earthen material will be placed over the exposed waste. This periodic cover is intended to control vectors, fire, odors, and blowing debris.

### 3.3 Severe Weather Conditions

Unusual weather conditions can directly affect the operation of the landfill. Some of these weather conditions and recommended operational responses are as follows:

#### 3.3.1 Ice Storms

An ice storm can make access to the cell dangerous, prevent movement or placement of periodic cover, and thus may require closure of the landfill until the ice is removed or has melted.

#### 3.3.2 Heavy Rains

Exposed soil surfaces can create a muddy situation in some portions of the landfill during rainy periods. The control of drainage and use of crushed stone on unpaved roads should provide all-weather access for the site and promote drainage away from critical areas. In areas where the aggregate surface is washed away or otherwise damaged, new aggregate from an on-site stockpile should be used for repair.

Intense rains can affect newly constructed drainage structures such as swales, diversions, cover soils, and vegetation. After such a rain event, inspection by landfill personnel will be initiated and corrective measures taken to repair any damage found before the next rainfall.

#### 3.3.3 Electric Storms

The open area of a landfill is susceptible to the hazards of an electric storm. If necessary, landfilling activities will be temporarily suspended during such an event. To guarantee the safety of all field personnel, refuge will be taken in the maintenance building or in rubber-tired vehicles.

#### 3.3.4 Windy Conditions

During particularly windy periods, work will be temporarily shifted to a more sheltered area.

#### 3.3.5 Violent Storms

In the event of hurricane, tornado, or severe winter storm warning issued by the National Weather Service, landfill operations will be temporarily suspended until the warning is lifted. Buildings and equipment will be properly secured.

### 3.4 Height Monitoring

On a weekly basis, the landfill operations manager will monitor landfill top and side slope elevations as well as slopes. When such elevations approach the grades shown on the Final Cover Grading Plan, the final top-of-waste grades will be staked to limit over-placement of waste.

## SECTION 4.0 ENVIRONMENTAL MANAGEMENT

This section reviews the overall environmental management tasks required for the successful operation of the landfill. Surface waters as described herein are waters resulting from precipitation or site run-on that have not contacted the waste.

### 4.1 Erosion and Sediment Control

The erosion and sediment control system consists of four major components:

1. Benches/Berms
2. Ditches
3. Down Pipes
4. Sediment Basins.

The landfill side slopes are designed with 4H:1V slopes with diversion berms and/or benches. These features are designed to keep water volumes and velocities low enough to minimize erosion of the landfill cover. Maintenance of the cover system will involve periodic mowing and repair of any erosion problems and bare spots. These items will be inspected at least once a month and after any significant rainfall events.

The down pipes are designed to carry concentrated flows of surface water off of the landfill. The down pipes will be anchored at 10 foot intervals along the side slopes. The down pipes will be inspected at least once a month and after any significant rainfall event.

Stormwater run-off from the landfill is conveyed to the sedimentation basins located on the south and west sides of the landfill. The basins should be inspected regularly for sediment build-up or erosion damage. The basins should be cleaned out when sediments fill the lower half of the basin.

Additional erosion control measures have been taken at points of stormwater discharge. All final cover should be inspected quarterly for erosion damage and promptly repaired.

### 4.2 Landfill Gas Control

#### 4.2.1 Passive Gas Vents

A passive gas venting system is fitted in the final cover. The performance of the system will be monitored quarterly using an explosimeter placed at the vent outlet. Gas generation levels that produce exhaust gas methane concentrations below 25% Lower Explosive Limit (LEL) at a distance of 10 feet from the passive gas vents are acceptable. If the methane concentrations exceed 25% LEL at 10 feet, then the number of passive gas vents will be increased.

### 4.2.2 Perimeter Methane Monitoring

Based on the facility location, setting, and distance to nearby buildings (>1000 ft), the landfill is at low risk for dangerous gas migration. The two creeks form a natural barrier to gas migration. Therefore, no monitoring bill be performed opposite the landfill on either creek.

Five permanent monitoring locations have been designated. The first location, GM1, is adjacent to the access road along the east side of the landfill. The second location, GM2, is along the southeast side of the landfill. The third and fourth locations, GM3 and GM4, are along the south and southwest sides of the landfill, respectively. The final location, GM5, is at the northwest corner of the landfill immediately south of the creek.

The monitoring locations will be checked four times per year, once per season for gas concentrations. The results from these tests will be reported as both concentration of methane and percent of Lower Explosive Limit (LEL). A qualified County employee will perform the testing using a MSA Gascope Combustible Gas Indicator, Model 62, or equivalent. This machine must be able to read methane-in-air and LEL methane-in-air.

## 4.3 Vector Control

Due to the nature of the waste disposed in this landfill, vector control will not be of concern. Note that the use of periodic cover will discourage animals from nesting in the waste.

## 4.4 Odor Control

Due to the nature of the waste disposed in this landfill, odor control will not be of concern.

## 4.5 Dust Control

Dust related to waste hauler traffic on the access roads will be minimized by using a water truck to limit dust on the gravel portion of the road. Dust generated by excavation of cover soil will be limited by watering the cut soil areas if accessible to the water truck.

## SECTION 5.0 CLOSURE PLAN

A closure plan is provided in the Design Drawings. The closure plan incorporates 4H:1V side slopes and a 5 percent cap along with erosion control structures.

### 5.1 Final Cover and Vegetation

The final cover over the waste includes the following layers:

- 12-inch intermediate cover,
- 18-inch compacted $1 \times 10^{-5}$ cm/sec soil barrier,
- geosynthetic clay liner (GCL) (slopes $\leq$ 8% only),
- geonet drainage media (slopes $\leq$ 8% only), and
- 18-inch (6-inches on 4H:1V slopes) vegetative soil layer.

This final cover profile is shown on Drawing FC3 of the Design Drawings. With the exception of the 18-inch compacted soil barrier layer, all layers of the final cover are designed for installation by the landfill operator. Placement of the compacted soil barrier will require use of a self-propelled compactor or contracting this phase out.

Placement of the vegetative soil layer over the cap geosynthetics must be done with care to avoid damage. This soil layer should be placed using a small dozer equipped with low ground contact pressure (6 psi or less) tracks. A minimum of 12-inches of soil should be maintained between the dozer tracks and the geosynthetics. The soil buffer should receive no compaction other than that provided by the dozer tracks. Pans or other heavy equipment should not operate on the vegetative soil layer.

The final cover surface must be vegetated immediately after completion according to the project seeding specifications.

### 5.2 Gas Venting System

Passive gas vents are provided in the final cover design. Each vent ties into a gravel collection trench that sits on top of the waste. The collection trench is dug into the intermediate cover and should be placed before the compacted soil barrier layer is constructed. Compaction of soil adjacent to the vent pipe must be accomplished using a small walk behind compactor.

The level of methane being discharged from each vent pipe must be monitored quarterly using a simple explosimeter. If the gas concentration at a distance of 10 feet from a given vent exceeds 25% of the Lower Explosive Limit (LEL), then additional passive gas vents must be installed within 100 feet of the vent.

## 5.3 Surface Water Run-Off System

Precipitation falling on the cover will infiltrate into the cover or run off the cover. The run-off is collected in berms or benches built into the side slopes. Water captured at berms or benches is carried to the base of the landfill in a down pipe.

### 5.3.1 Incremental Operation

Operations must strive to provide operational grading that encourages run-off from the intermediate cover to drain to the perimeter drainage channels. Corrugated plastic piping and temporary soil berms must be installed if required to accomplish this run-off routing.

### 5.3.2 Required Maintenance

The stormwater run-off system must be inspected annually and immediately after every major storm. Sediment build-up in the channels must be cleaned out on a regular basis to promote run-off. Sediments removed from the channels can be used as periodic cover.

## 5.4 Closure Verification

The following procedures will be implemented following closure:

- A Construction Quality Assurance (CQA) report shall be submitted to the NCDENR Division of Solid Waste Management. This report shall describe the observations and tests used before, during, and upon completion of construction to ensure that the construction materials meet the cap design specifications and the construction and certification requirements. The CQA report shall contain as-built drawings.

- A signed certification from a registered Professional Engineer verifying that closure has been completed in accordance with the closure plan will be submitted to the NCDENR Division of Solid Waste Management.

- At least one sign notifying all persons of the closing of the phase and that wastes are no longer accepted will be posted. Suitable barriers will be installed as necessary at former access points to prevent new waste from being deposited.

- Within 90 days, a survey plat, prepared by a registered Professional Land Surveyor, indicating the location and dimensions of landfill disposal areas, will be prepared.

- A notation shall be recorded on the deed notifying any potential purchaser of the property that the land has been used as a landfill facility and that future use is restricted under the approved closure plan. A copy of the deed notation as recorded shall be filed with the operating record.

# SECTION 6.0 POST-CLOSURE PLAN

This Post-Closure Plan has been developed to outline steps to be taken to ensure the environmental soundness of the landfill during its post-closure care period. The post-closure care period will last at least 30 years after final closure and, at a minimum, will consist of the following:

- Maintaining integrity and effectiveness of final cover system,
- Performing groundwater and surface water monitoring,
- Performing gas monitoring, and
- Maintaining run-on/run-off controls.

No wastes will remain exposed after closure of the unit. Access to the closed site by the public will not pose a health hazard.

## 6.1 Post-Closure Contact

All correspondence and questions concerning the post-closure care of the unit should be directed to:

Mr. Charles Archer
Halifax County Manager
P.O. Box 327
Halifax, NC 27839
(919) 583-1131.

## 6.2 Description of Use

After filling operations cease at the landfill and the unit is officially closed in accordance with the Closure Plan, the area will be allowed to return to its natural vegetative state. Halifax County will maintain control of the property and prevent public access to it during the post-closure period.

There will be an access road on the cap to allow proper maintenance during post-closure. Precise location of the access will be determined as a part of operations. Low ground pressure and rubber tire vehicles will be used for maintenance.

## 6.3 Maintenance

### 6.3.1 Repair of Security Control Devices

All security control devices will be inspected and maintained as necessary to ensure access to the site is controlled. Locks, vehicular gates, and fencing will be replaced if functioning improperly. Warning signs will be kept legible at all times and will be replaced if damaged by inclement weather or vandalism.

### 6.3.2 Erosion Damage Repair

If erosion of the final cover occurs during post-closure, the affected area will be repaired and reseeded as necessary. If necessary, erosion control fabrics will be used to expedite rapid revegetation of slopes and to secure topsoil in place.

### 6.3.3 Correction of Settlement, Subsidence, and Displacement

Minimum slopes of 5 percent will be maintained after settlement in order to prevent ponding and allow for proper drainage without infiltration. If vertical or horizontal displacement occurs due to differential settlement, cracks will be filled with appropriate material and final cover will be reestablished. Excessive vertical displacement is not anticipated.

### 6.3.4 Repair of Run-On/Run-Off Control Structures

All run-on/run-off control structures will be repaired, cleaned, or realigned in order to maintain the original condition. Any culverts that are damaged will be replaced.

### 6.3.5 Passive Gas Venting System

The landfill passive gas venting system will be maintained by the County. Proper operation of the system is verified through testing at the landfill gas monitoring wells and probes.

If passive gas vents do not function as a result of irregular settlement, accumulation of liquids (condensate, leachate, water), binding or corrosion, replacement vents can be installed if necessary. Non-functioning vents will be reset if necessary. Passive gas vents will be decommissioned if no gas venting is detected for a time period exceeding 5-years. Such decommissioning will establish the continuity of the barrier, drainage, and vegetative support layers.

### 6.3.6 Groundwater Monitoring System

Procedures outlined in the current Ground Water Sampling and Analysis Plan (SAP) or subsequent revision will take precedence; however, a brief description follows. All groundwater monitoring wells have been installed with concrete pads and protective casings to prevent accidental damage by vehicles and equipment. The wells are also equipped with a locking cap to discourage vandalism. Groundwater wells will be inspected regularly (at the time of sampling) to ensure integrity. Persons inspecting a well should look for signs of well tampering, cracking or degradation of the concrete pad, and overall condition of the well. Should a well require replacement, the defective well should be abandoned in accordance with specifications provided in the SAP, and a new well installed at a location that is approved by the Solid Waste Section.

## 6.4 Monitoring Plan

The closed unit shall be monitored for a minimum of 30 years. A series of inspections shall be scheduled to ensure the integrity and effectiveness of the final cover system, storm water control system, groundwater monitoring system, gas control system, and to protect human health and the environment.

### 6.4.1 Inspection Frequencies

Inspections to be conducted during the post-closure care period will occur regularly as follows:

**TABLE 6.4.1 Post-Closure Inspection Frequencies**

| INSPECTION ACTIVITY | YEAR 1 | YEARS 2-30 |
|---|---|---|
| Security Control Devices | Quarterly | Quarterly |
| Cover Drainage System | Quarterly* | Semi-Annually |
| Passive Gas Venting System | Quarterly | Semi-Annually |
| Groundwater Monitoring System | Semi-Annually | Semi-Annually** |
| Erosion Damage | Quarterly* | Quarterly |
| Cover Settlement, Subsidence, and Displacement | Quarterly* | Semi-Annually |
| Vegetative Cover Condition | Quarterly* | Quarterly |
| Stormwater Control System | Quarterly* | Quarterly |
| Benchmark Integrity | Annually | Annually |

* These items will be inspected after each major storm event (i.e. $\geq$ 1 inch in any 24 hours).
** Or in accordance with groundwater monitoring schedule described in current SAP.

### 6.4.2 Quarterly Inspections

Quarterly inspections of the closed site will be conducted by the County. These inspections will include examination of the security control devices for signs of deterioration or vandalism to ensure access to the site is limited to authorized persons. The disposal area will be checked to ensure the integrity of the final cover system is maintained, erosion damage is repaired, vegetative cover persists, and that cover settlement, subsidence, and displacement are minimal. Drainage ditches will be cleared of litter and debris and benchmark integrity will be noted and maintained.

### 6.4.3 Semi-Annual Inspections

Semi-annual inspections of the site during the post-closure period will be conducted by the

County with attention paid to integrity and drainage of the final cover system and proper functioning of the groundwater and gas monitoring systems. A report of findings will be made to the responsible party, including recommendations for actions deemed necessary to ensure the site continues to meet the closure performance standard.

## 6.5 Engineering Certification

Based on the County's monitoring reports, annual certifications by a registered engineer will be placed in the operating record. They will certify that the closure plan has been followed, noting discrepancies along with the corrective actions undertaken. At the end of the post closure period, the individual certifications will be compiled into a final document and forwarded to the Solid Waste Section.

## Appendix A

## Waste Screening Form

Halifax County Solid Waste Department
Halifax County Landfill
Permit No. 42-04
(919) 586-4748

**WASTE SCREENING FORM**

Day / Date: ______________________ Time Weighed in: ______________________
Truck Owner: ______________________ Driver Name: ______________________
Truck Type: ______________________ Vehicle ID / Tag No: ______________________
Weight ______________________ Tare: ______________________
Waste Generator / Source: ____________________________________________

---

Reason Load Inspected: Random Inspection ______ Staff Initials ______
Detained at Scales ______ Staff Initials ______
Detained by Operating Staff ______ Staff Initials ______

Inspection Location: ____________________________________________

Approved Waste Determination Form Present? Yes ______ No ______ N/A ______

Description of Load: ____________________________________________

Load Accepted (signature) ______________________ Date ____________
Load Not Accepted (signature) ______________________ Date ____________

---

Reason Load Not Accepted (complete only if load not accepted)

Description of Suspicious Contents: Color ____________ Haz. Waste Markings ____________
Texture ____________
Drums Present ____________ Smell ____________
Est. Cu. Yds. Present in Load ____________
Est. Tons Present in Load ____________

Halifax County Emergency Management Contacted? Yes ______ No ______

Company or Authority Contacted? ____________________________________________
Hazardous Materials Present: ____________________________________________

Hauler Notified (if waste not accepted) Phone: Time Contacted:
Other Observations: ____________________________________________

Final Disposition
Signed ______________________ Date ____________
Waste Screening Inspector or Solid Waste Department Director

Attach related correspondence to this form.
File completed form in Operating Record.

# Appendix K

# HALIFAX COUNTY
# CONSTRUCTION & DEMOLITION DEBRIS LANDFILL

## APPENDIX K: CALCULATIONS

## TABLE OF CONTENTS

| | | | |
|---|---|---|---|
| PROJECT | Halifax County - C&D Landfill | SHEET | 1 OF 3 |
| | | JOB NO. | HALIFAX-13 |
| | | DATE | 12/17/97 |
| SUBJECT | Landfill Life Expectancy | COMPUTED BY | PKS |
| | | CHECKED BY | |

**Objective** To determine the expected life of the landfill given the proposed contours and the current loading rate.

**Assumptions**

1. Density of Waste.
2. Waste to Periodic Cover (i.e. daily and intermediate) Ratio.

**Analysis** The volume will be calculated by taking cross sections of the landfill, using a planimeter to measure the area of the cross sections, and using the average end area method. Alternatively, AutoCAD will be used to generate volumes.

## G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2 / 3
JOB #: HALIFAX-13
DATE: 11/20/97
BY: PKS
CHKD BY:

### Halifax County - MSW Landfill / C&D Expn.
### Analysis of Life Expectancy

**Waste Parameters:**

**MSW**

| | |
|---|---|
| Unit Weight (pcy) = | 1200 |
| Unit Weight (tcy) = | 0.6 |
| Percentage of Periodic Cover = | 25 |

**C&D**

| | |
|---|---|
| Unit Weight (pcy) = | 1720 |
| Unit Weight (tcy) = | 0.86 |
| Percentage of Periodic Cover = | 10 |

**Waste Loading Parameters:**

11/10/97 - 12/31/97:

| | |
|---|---|
| Daily Tonnage = | 180 |
| Daily Waste Volume (cy) = | 300.00 |
| Days of Operation in Period = | 40 |

1/1/98 - ???: (C&D Waste)

| | |
|---|---|
| Daily Tonnage = | 30 |
| Daily Waste Volume (cy) = | 34.88 |
| Days of Operation per Year = | 280 |

**Volume Calculations:**

Volume From AutoCAD = 122861 cy (Top of Intermediate Cover)

**Adjustment For Other Layers:**

0 feet of Final Cover = cy

Sum = 0 cy

| | |
|---|---|
| **Volume of Waste and Periodic Cover (cy) =** | 122861 |
| **Volume of Periodic Cover Used 11/10/97 to 12/31/97 (cy) =** | 3000 |
| **Volume of Waste Used 11/10/97 to 12/31/97 (cy) =** | 12000 |
| **Volume of Waste and Periodic Cover Available Beyond 12/1/97 (cy) =** | 107861 |
| **Volume of Periodic Cover Used Beyond 12/31/97 (cy) =** | 10786 |
| **Volume of Waste Used Beyond 12/31/97 (cy) =** | 97075 |
| **Landfill Life Beyond 12/31/97 (years) =** | 9.94 |

→ DEVELOP AS 2 5-YEAR PHASES

**Note: Landfill life beyond 12/31/97 may be significantly less than predicted if additional C&D volume is brought to the landfill.**

LIFE.WB3

3/3

User Name: ANTHONY
Project: HALIFAX MSW LANDFILL
FILENAME: d:\-cad\halfax-3\topomswl.DWG

Date: 11-20-97
Time: 11:12:11
Page: 1

S I T E   D E S I G N - VOLUME CALCULATIONS

---

PRISMOIDAL METHOD

| | |
|---|---|
| ORIGINAL SURFACE | EXIST SURFACE |
| FINAL SURFACE | TOP OF INTRMED COVER |
| CUT COMPACTION FACTOR | 0.00 % |
| FILL COMPACTION FACTOR | 0.00 % |
| RAW CUT VOLUME | 59.79 CY |
| RAW FILL VOLUME | 122861.16 CY |

BASED ON 11/10/97 SURVEY + Projected End of 97 MSW CONTOURS

State of North Carolina
Department of Environment,
Health and Natural Resources
Raleigh Regional Office

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary

DEHNR

*DIVISION OF LAND RESOURCES*
*January 16, 1997*

RECEIVED
JAN 22 1997

*Halifax County Solid Waste Department*
*PO Box 327*
*Halifax, NC 27839*
*ATTN: Richard Garner, Director*

*RE: Letter of Approval*
*Project Name: Halifax County Landfill*
*Location: Halifax County*
*Submitted by: G.N. Richardson & Associates*
*Date Received: 1-3-97*
*Date Processing Initiated: 1-3-97*
*Watershed: Tar-Pamlico #1/03-03-04*
*New Submittal ( ) Revised (X)*

*Dear Mr. Garner:*

*This office has reviewed the subject Erosion and Sedimentation Control Plan. We find the plan to be acceptable and hereby issue this letter of approval. If any modifications, performance reservations, or recommendations are applicable, a list is enclosed and is incorporated as a part of this letter of approval. If any modifications are not incorporated into the plan and implemented in the field, the site will be in violation of the Sedimentation Pollution Control Act of 1973 (North Carolina General Statute, hereinafter NCGS, 113A-61.1). In addition, it should be noted that this plan approval shall expire three (3) years following the date of approval in accordance with Title 15A, North Carolina Administrative Code (NCAC) 4B.0029, if no land-disturbing activity has been undertaken.*

*The land-disturbing activity described in the plan for this site may be subject to the approval of other Local, State or Federal agencies. This could include the Division of Water Quality under stormwater or other water quality regulations, the U.S. Army Corps of Engineers under Article 404 jurisdiction, county, city or town agencies under other local ordinances, or other approvals that may be required. The approval issued in this letter cannot supersede any other required permit or approval.*

*Mr. Garner*
*January 16, 1997*
*page 2*

*Please be advised that Title 15A, North Carolina Administrative Code, 4B .0018(a) requires that a copy of the approved plan be on file at the job site. Also, please consider this letter as notice in accordance with the requirements of NCGS 113A-61.1 concerning our right to perform periodic inspections to ensure compliance with the approved plan.*

*North Carolina's sedimentation pollution control program is performance oriented, requiring protection of the natural resources and adjoining properties. If at any time during this project it is determined that the Erosion and Sedimentation Control Plan is inadequate to meet the requirements of the Sedimentation Pollution Control Act of 1973 (NCGS 113A-51 through 66), this office may require revisions in the plan and its implementation to ensure compliance with the Act.*

*Please note that this approval is based in part on the accuracy of the information provided concerning financial responsibility. You are requested to file an amended Financial Responsibility Form if any changes become necessary. In addition, it would be helpful if you would notify this office of the proposed starting date for the activity at the subject site.*

*Your cooperation is appreciated and we look forward to working with you on this project. If there are any questions, please do not hesitate to contact this office.*

*Sincerely,*

Wyatt Brown

*Wyatt Brown, CPESC*
*Assistant Regional Engineer*
*Land Quality Section*
*Raleigh Regional Office*

*WB/gb*
*cc: Pieter K. Scheer, P.E.*

# Erosion & Sedimentation Control Plan

## Halifax County MSW Landfill
## Halifax County, North Carolina

Prepared for:
**Halifax County Solid Waste Dept.**
Halifax, North Carolina

**December 1996**

**G.N. Richardson & Associates**
Engineering and Geological Services
417 N. Boylan Avenue
Raleigh, North Carolina 27603

# Erosion & Sedimentation Control Plan

## Halifax County MSW Landfill
## Halifax County, North Carolina

Prepared for:
**Halifax County Solid Waste Dept.**
Halifax, North Carolina

To the Attention of:
**Mr. Richard Garner**
Director

GNRA Project No. HALIFAX-7

NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PIETER K. SCHEER 12/18/96

Pieter K. Scheer, P.E.
Project Engineer

NORTH CAROLINA PROFESSIONAL SEAL 8895 ENGINEER GREGORY N. RICHARDSON 12/18/96

Gregory N. Richardson, PhD., P.E.
President

**December 1996**

**G.N. Richardson & Associates**
Engineering and Geological Services
417 N. Boylan Avenue
Raleigh, North Carolina 27603

# HALIFAX COUNTY MSW LANDFILL
# EROSION AND SEDIMENTATION CONTROL PLAN

## 1.0 OVERVIEW

The operation and closure of the municipal solid waste landfill at this site will create the potential for erosion and the transportation of sediment. Erosion and sedimentation control measures have been designed to counter this threat of erosion.

Sedimentation occurs when cleared areas are allowed to remain disturbed for extended periods of time without a vegetative cover being established. Once such a cover has been established on the disturbed areas, the erosion potential is greatly reduced.

This plan discusses the methods and practices used to design the erosion and sedimentation control measures used on this project. It will also discuss, in general, the various types of temporary erosion control measures used on the site and specifically the designs of the permanent measures used.

Both the temporary and permanent erosion and sedimentation control measures employed in this project use a combination of filtration and settling to remove sediment from run-off in order to prevent sediments from being deposited off site.

The temporary measures used for erosion control include temporary channel linings. The permanent measures are two existing sediment basins with a riser/barrel outlet control devices, permanent drainage channels and down pipes, and permanent channel linings.

## 2.0 PROCEDURES AND GUIDELINES

The erosion and sediment control design for the landfill was conducted based on guidelines and procedures as set forth in the North Carolina Erosion and Sediment Control Planning and Design Manual (E&SCP&DM) and "Elements of Urban Stormwater Design" (EOUSD), by H. Rooney Malcom, P.E. Design calculations are provided as an attachment to this plan.

All stormwater flow volumes were calculated using the Rational Method based on the maximum rate of runoff from a 10-year storm event. Note that the maximum rate of runoff from a 10-year storm exceeds the rate of runoff from a 25-year, 24-hour storm. Runoff coefficients for various ground cover conditions are referenced to Table 8.03a in the E&SCP&DM. Rainfall intensities used in the Rational Method were derived from an analysis of design storms for the site. Times of concentration were calculated with the Kirpich Equation. Drainage areas were computed using a planimeter or AutoCAD on overall topographic sheets of the project area.

## 3.0 EROSION AND SEDIMENTATION CONTROL MEASURES

The sediment and erosion control measures to be used at this site include permanent drainage channels, down pipes, and two existing permanent sediment basins.

Drainage channel calculations were conducted using a reformulation of Manning's Equation to calculate normal depth of flow, as set forth in EOUSD, for given conditions to establish channel capacity and velocity of flow. For conservatism, the channel calculations assume peak flow over maximum slope of channel reach in determining velocity. Channels were first checked assuming just constructed, bare earth, conditions. The maximum allowable velocity for bare earth was assumed to be 2.5 feet per second (Table 8.05d E&SCP&DM). If velocity exceeded this value, a temporary liner was chosen if appropriate. Normal depth and velocity were then calculated assuming grass lining as a minimum constructed condition. The allowable velocity for grass lining was assumed to be 4.5 feet per second (Table 8.05a, E&SCP&DM). If velocity exceeded this, a permanent liner was designed. Both temporary and permanent channel linings were designed for shear stress using the Tractive Force Procedure as outlined in E&SCP&DM.

Down pipes were sized based on the orifice equation which governs the amount of flow carried by each pipe. Down pipes will be adequately anchored to the landfill side slopes and each will have a stable outlet structure. Down pipes not draining to one of the on-site sediment basins will have filter berms placed around the pipe inlet prior to the stabilization of slopes draining to the down pipe. The maximum area served by a filter berm will be 1.2 acres.

There are two permanent sediment basins which serve the site. This basins use a riser/barrel type principal spillway and an emergency spillway weir. The existing sediment basins were found to adequately filter sediment in a 10 year design storm.

Permanent sediment basin design is subject to several requirements. The sediment basin must provide a volume of 1800 $ft^3$/acre of disturbed area and meet surface area requirements set forth in E&SCP&DM. Other E&SCP&DM requirements for permanent basins include riser/barrel principal spillways and emergency weir-type spillways. The principal spillway must have a capacity of 0.2 $ft^3$ /second/acre of drainage area. This flow must be met with one foot of driving head. The crest of the emergency spillway is set one foot above the invert of the riser and must pass the peak run-off from the 10-year storm event with one foot of freeboard to crest of berm. The principal spillways were checked using a spreadsheet based on methods provided in EOUSD. These methods provide a more detailed design than provided in E&SCP&DM while meeting the above requirements.

## 4.0 MAINTENANCE AND SEDIMENT DISPOSAL

All erosion and sedimentation control devices will be inspected at regular intervals and immediately following any significant rainfall event. Repairs will then be made as needed and accumulated sediment removed if necessary. In the case of the permanent sediment basins, sediments will be removed when one half of the basin volume is filled with sediment.

All sediments which are removed from erosion and sedimentation control measures will be disposed of in an approved manner at a location to be designated by the Engineer in such a manner that further erosion and sedimentation will not occur.

## 5.0 SCHEDULE FOR IMPLEMENTATION

All erosion control measures will be placed before any land disturbance or waste placement may begin in that portion of the site which drains to the erosion control measures. All areas reaching final elevations will be vegetated.

The following information completes this plan:

Erosion and Sedimentation Control Technical Specifications,
Erosion and Sedimentation Control Calculations, and
Erosion and Sedimentation Control Plans and Details.

| | |
|---|---|
| PROJECT Halifax County Landfill - Transition Plan | SHEET 1 OF 2 |
| | JOB NO. HALIFAX-7 |
| | DATE 11/14/96 |
| SUBJECT Erosion & Sedimentation Control | COMPUTED BY PKS |
| | CHECKED BY |

**Objective** To design ditches, sedimentation basins, and other structures to remove and contain storm water flow from the 10 year storm at the proposed facility.

Calculations will be based on:

- Rational Method
- Manning's Equation
- Tractive Force Procedure
- Rainfall Frequencies for the Site

**Analysis** The main design criteria will be to ensure that all storm water conveyance and retention structures will be able to accommodate the peak rate of run off from the 10 year storm without erosion.

The erosion control measures will be designed to control sedimentation from time of construction until the site is stabilized.

**References** North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Malcom, H. Rooney, Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC, 1989.

**Calculations**

- Rational Method (Flow Rate, Q):

$Q = CIA$ (cfs) (Malcom Eq. I -1)

where:
- C = Rational Runoff Coefficient
- I = Applicable Rainfall Intensity (in/hr) of storm event (Based on Time of Concentration)
- A = Drainage Area (Acres)

- Time of Concentration ($t_c$) (Kirpich Equation):

$$t_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$ (minutes) (Malcom Eq. I-2)

where: L = Hydraulic Length of Watershed to Point of Interest (ft)
H = Fall Along L (ft)

Note: I is found by calculating $t_c$ and using a rainfall intensity - duration - frequency graph or table suitable to the site. $t_c$ (minimum) = 5 minutes.

- Manning's Equation:

$$Q = \frac{1.49 AR^{2/3}S^{1/2}}{n} = AV$$ (Malcom Eq. I-8)

where: Q = Discharge/Flow Rate (cfs)
n = Manning's Roughness Coefficient
A = Cross Sectional Area of Flow ($ft^2$)
R = Hydraulic Radius (ft) = A/Wetted Perimeter
S = Slope of Channel (ft/ft)
V = Average Channel Velocity (ft/sec)

- Tractive Force Procedure:

T = yds

where: T = Shear Stress on Channel Lining ($lb/ft^2$)
y = Unit Weight of Water (62.4 $lb/ft^3$)
d = Depth of Flow (ft)
s = Channel slope (ft/ft)

**Attachments**
- Drainage Area Determination
- Down Pipe Analysis
- Existing Sedimentation Basin Analysis
- Analysis of Design Storms
- Normal Depth Analyses

| PROJECT | Halifax County MSWLF | SHEET | 1 OF 2 |
|---|---|---|---|
| SUBJECT | Drainage Area Determination | JOB NO. | HALIFAX-7 |
| | | DATE | 11/20/96 |
| | | COMPUTED BY | PKS |
| | | CHECKED BY | |

| DRAINAGE AREA # | AREA ($ft^2$)* | AREA (Ac) |
|---|---|---|
| 1 | 54093 | 1.24 |
| 2 | 46271 | 1.06 |
| 3 | 53658 | 1.23 |
| 4 | 37771 | 0.87 |
| 5 | 31427 | 0.72 |
| 6 | 33918 | 0.78 |
| 7 | 24235 | 0.56 |
| 8 | 50812 | 1.17 |
| 9 | 39915 | 0.92 |
| 10 | 39004 | 0.90 |
| 11 | 70630 | 1.62 |
| 12 | 76941 | 1.77 |
| 13 | 22532 | 0.52 |
| 14 | 30948 | 0.71 |
| 15 | 43483 | 1.00 |
| 16 | 42720 | 0.98 |
| 17 | 44206 | 1.01 |
| 18 | 181710 | 4.17 |
| 19 | 21961 | 0.50 |
| 20 | 58533 | 1.34 |

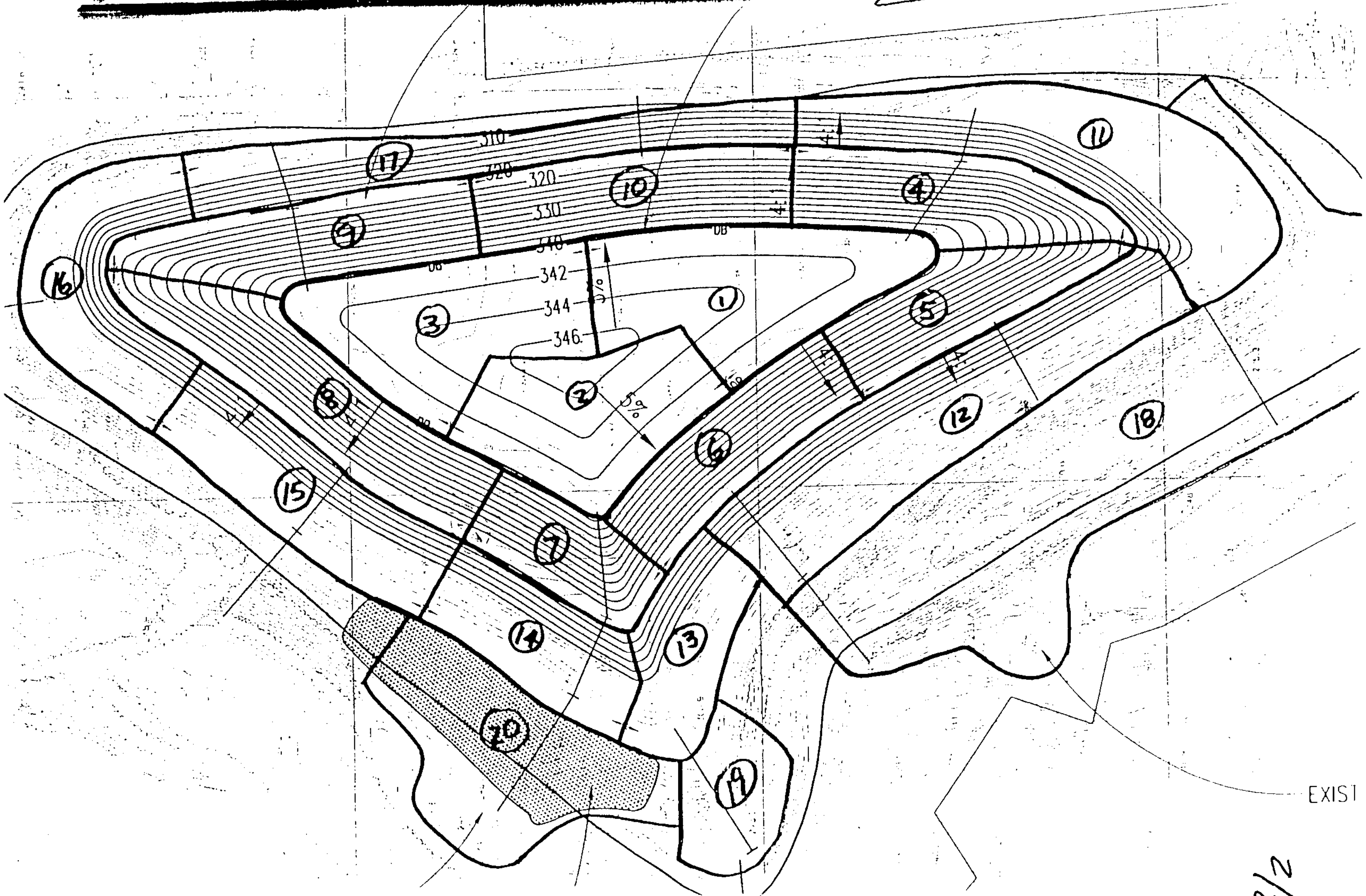
*– Areas Determined By AUTOCAD.

– See Attached Sketch.

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services
417 N. BOYLAN AVENUE RALEIGH, N.C. 27603
PHONE-919-828-0577 FAX-919-828-3899

# DRAINAGE AREAS:

1" = 200'




2/2

| | |
|---|---|
| PROJECT Halifax County Landfill - Transition Plan | SHEET 1 OF 2 |
| | JOB NO. HALIFAX-7 |
| | DATE 11/14/96 |
| SUBJECT Analysis of Design Storms | COMPUTED BY PKS |
| | CHECKED BY |

**Objective**

To compile the expected design storm depths and intensities over various return periods. These design storm values will be used in various calculations.

**References**

Rainfall data was obtained from the following references:

Frederick, R.H., V.A. Myers, and E.P. Anciello, "Five to 60-Minute Precipitation Frequency for the Eastern and Central United States," NOAA Technical Memo. NWS HYDRO-35, National Weather Service, NOAA, U.S. Dept. Of Commerce, Silver Spring, MD, 1977.

U.S. Weather Bureau, "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," U.S. Weather Bureau Technical Paper 40, 1961.

# G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2/2
JOB #: Halifax-7
DATE: 1/26/96
BY: PKS
CHKD BY:

## Halifax County
## Analysis of Design Storms

INPUT DATA:
LOCATION: Aurelian Springs, NC

| DURATION | 2-YR P (in) | 100-YR P (in) | SOURCE |
|---|---|---|---|
| 5 min | 0.48 | 0.81 | NOAA HYDRO-35 |
| 15 min | 1.02 | 1.81 | NOAA HYDRO-35 |
| 60 min | 1.70 | 3.50 | NOAA HYDRO-35 |
| 2 hr to 24 hr Rainfall Events | **USER INPUT** | | USWB TP-40 |

DEPTH-DURATION-FREQUENCY TABLE
LOCATION: Aurelian Springs, NC

RETURN PERIOD

| DURATION | 2-YR (in) | 5-YR (in) | 10-YR (in) | 25-YR (in) | 50-YR (in) | 100-YR (in) | |
|---|---|---|---|---|---|---|---|
| 5 min | 0.48 | 0.55 | 0.60 | 0.68 | 0.75 | 0.81 | |
| 10 min | 0.80 | 0.93 | 1.02 | 1.17 | 1.29 | 1.40 | |
| 15 min | 1.02 | 1.19 | 1.32 | 1.51 | 1.66 | 1.81 | |
| 30 min | 1.35 | 1.65 | 1.86 | 2.16 | 2.40 | 2.64 | |
| 60 min | 1.70 | 2.12 | 2.41 | 2.84 | 3.17 | 3.50 | |
| 2 hr | 2.15 | 2.75 | 3.20 | 3.70 | 4.20 | 4.70 | **USER INPUT** |
| 3 hr | 2.40 | 3.05 | 3.55 | 4.05 | 4.55 | 5.05 | **USER INPUT** |
| 6 hr | 2.80 | 3.60 | 4.10 | 4.90 | 5.50 | 6.10 | **USER INPUT** |
| 12 hr | 3.40 | 4.20 | 4.95 | 5.90 | 6.50 | 7.30 | **USER INPUT** |
| 24 hr | 3.60 | 4.90 | 5.80 | 6.50 | 7.40 | 8.20 | **USER INPUT** |

INTENSITY-DURATION-FREQUENCY TABLE
LOCATION: Aurelian Springs, NC

RETURN PERIOD

| DURATION | 2-YR (in/hr) | 5-YR (in/hr) | 10-YR (in/hr) | 25-YR (in/hr) | 50-YR (in/hr) | 100-YR (in/hr) |
|---|---|---|---|---|---|---|
| 5 min | 5.76 | 6.58 | 7.22 | 8.19 | 8.96 | 9.72 |
| 10 min | 4.79 | 5.56 | 6.15 | 7.02 | 7.71 | 8.40 |
| 15 min | 4.08 | 4.76 | 5.27 | 6.04 | 6.64 | 7.24 |
| 30 min | 2.71 | 3.29 | 3.71 | 4.32 | 4.80 | 5.28 |
| 60 min | 1.70 | 2.12 | 2.41 | 2.84 | 3.17 | 3.50 |
| 2 hr | 1.08 | 1.38 | 1.60 | 1.85 | 2.10 | 2.35 |
| 3 hr | 0.80 | 1.02 | 1.18 | 1.35 | 1.52 | 1.68 |
| 6 hr | 0.47 | 0.60 | 0.68 | 0.82 | 0.92 | 1.02 |
| 12 hr | 0.28 | 0.35 | 0.41 | 0.49 | 0.54 | 0.61 |
| 24 hr | 0.15 | 0.20 | 0.24 | 0.27 | 0.31 | 0.34 |

| | | | |
|---|---|---|---|
| PROJECT | Halifax County LF - Transition Plan | SHEET | 1 OF 3 |
| | | JOB NO. | HALIFAX-7 |
| SUBJECT | Stormwater/Down Pipe Sizing | DATE | 11/22/96 |
| | | COMPUTED BY | PKS |
| | | CHECKED BY | |

- *Objective:* Evaluate the required size of down pipes stormwater pipes based on the peak Flow From a 10 yr storm.

- *Analysis:* Use the Rational Method to determine the peak Flow which needs to be handled by each pipe. Pipe Flow will be governed by the orifice equation.

*Equations:*

*Rational Method:*

$$Q_p = CIA$$

where: $Q_p$ = Peak Flow (cfs)
$C$ = Runoff Coef.
$I^*$ = Rainfall Intensity (in/hr)
$A$ = Contributing Area (Ac)

*I is based on time of concentration (tc)

*Orifice Equation:*

$$Q = C_D A \sqrt{2gh}$$

where: $Q$ = Pipe Discharge (cfs)
$C_D$ = Discharge Coef. (.6 = Default)
$A$ = Area of Pipe @ Inlet ($ft^2$)
$g$ = Acceleration of Gravity (32.2 $ft/s^2$)
$h$ = Driving Head (ft) To Centroid of A

G.N. RICHARDSON & ASSOCIATES
CONSULTING ENGINEERING

| DRAWN | JOB NO. | APPROVED | DATE | REVISED DATE |
|---|---|---|---|---|
| | | | | |

# G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2 / 3
JOB #: HALIFAX-7
DATE: 11/20/96
BY: PKS
CHKD BY:

## Halifax Co. Landfill
## Stormwater Down Pipe Sizing

10 Year, 5 Min Design Storm Intensity = **7.2** in/hr (From NOAA HYDRO-35)

**Flow Parameters (Orifice Eqn.)**

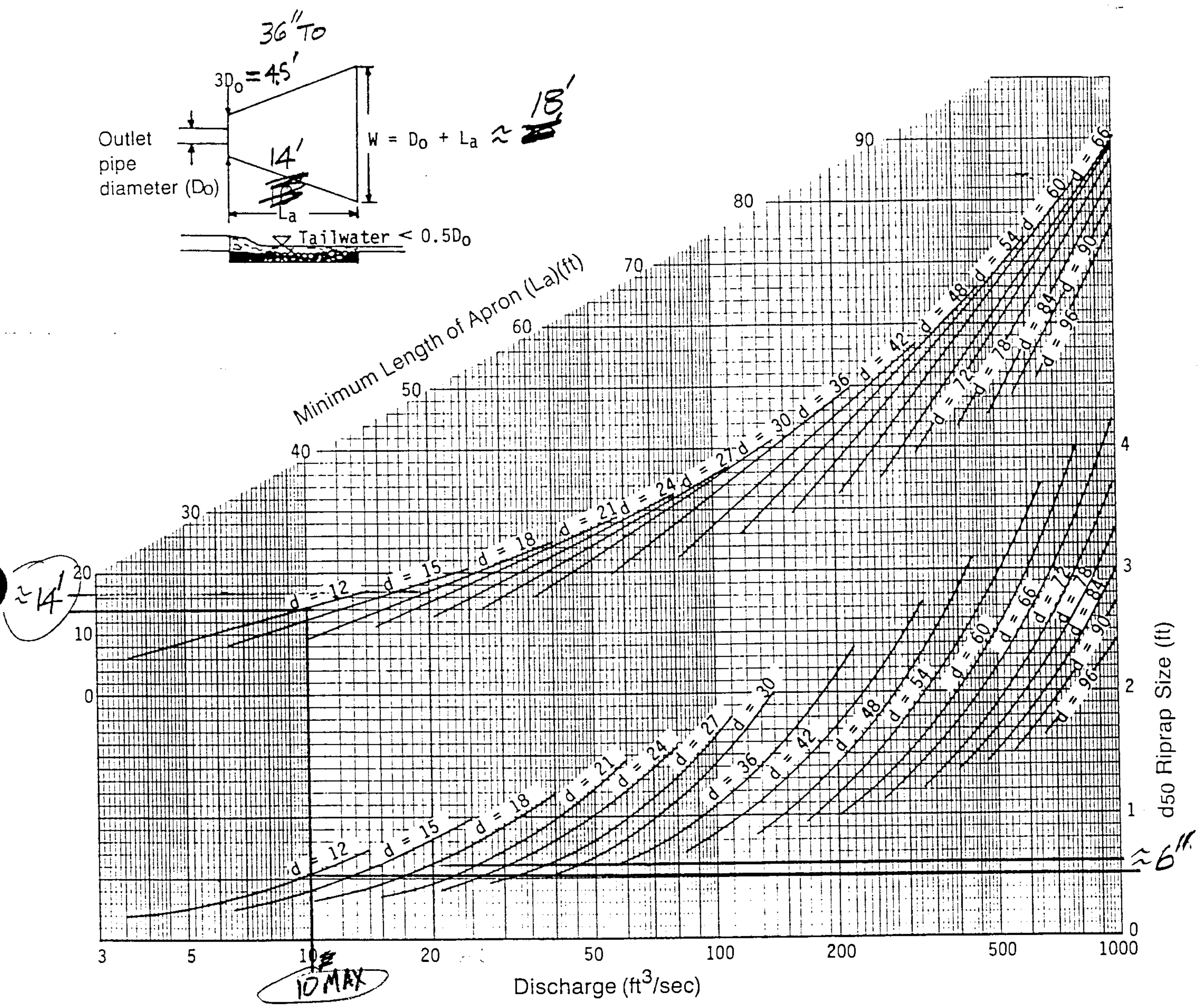
Coef. of Discharge = 0.6
Height of Water Above Top of Pipe = 6 in

| Pipe Section | Drainage Areas Served* | Total Drainage Area (Ac.) | Runoff Coef. (c) | Qreq (cfs) | Select D (in) | Qallow (cfs) | Comment |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1.24 | 0.35 | 3.1 | 12.0 | 3.8 | O.K. |
| 1A | 1,4 | 2.11 | 0.35 | 5.3 | 15.0 | 6.3 | O.K. |
| 2 | 2 | 1.06 | 0.35 | 2.7 | 12.0 | 3.8 | O.K. |
| 2A | 2,7 | 1.62 | 0.35 | 4.1 | 15.0 | 6.3 | O.K. |
| 2B | 2,7,14 | 2.33 | 0.35 | 5.9 | 15.0 | 6.3 | O.K. |
| 3 | 3 | 1.23 | 0.35 | 3.1 | 12.0 | 3.8 | O.K. |
| 3A | 3,9 | 2.15 | 0.35 | 5.4 | 15.0 | 6.3 | O.K. |
| 4 | 5 | 0.72 | 0.35 | 1.8 | 12.0 | 3.8 | O.K. |
| 5 | 6 | 0.78 | 0.35 | 2.0 | 12.0 | 3.8 | O.K. |
| 5A | 6,5,12 | 3.27 | 0.35 | 8.3 | 18.0 | 9.5 | O.K. |
| 6 | 8 | 1.17 | 0.35 | 3.0 | 12.0 | 3.8 | O.K. |
| 6A | 8,15 | 2.17 | 0.35 | 5.5 | 15.0 | 6.3 | O.K. |
| 7 | 10 | 0.90 | 0.35 | 2.3 | 12.0 | 3.8 | O.K. |
| 8 | 1,4,11 | 3.73 | 0.35 | 9.4 | 18.0 | 9.5 | O.K. |
| 9 | 13 | 0.52 | 0.35 | 1.3 | 12.0 | 3.8 | O.K. |
| 9A | 13,19 | 1.02 | 0.35 | 2.6 | 12.0 | 3.8 | O.K. |
| 10 | 16 | 0.98 | 0.35 | 2.5 | 12.0 | 3.8 | O.K. |

Note: *See Drainage Area Calculations.

DOWNPIP.WB1

DOWN PIPE OUTLET PROTECTION: 3/3




Curves may not be extrapolated.

**Figure 8.06a** Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition ($T_w$ < 0.5 diameter).

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 1 / 1
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County**
**Normal Depth Analysis**
**Existing Drainage Channel No. 1**

**Ditch/Swale Parameters: (User Entry)**

| | | |
|---|---|---|
| Drainage Area (Ac.) = | 3.73 | → {Drainage Areas 1+4+11} |
| Hydraulic Length (ft) = | 1000 | |
| Fall Along Length (ft) = | 46 | |
| Lining: | Grass | |
| Slope (ft/ft) | 0.02 | |
| n = | 0.032 | |
| B (ft) = | 0 | |
| M = | 3 | |

**Flow Volume:**

| | | |
|---|---|---|
| Time of Conc. (min.) = | 5.2 | |
| Intensity (in/hr) = | 7.18 | **(User Entry) (10 Year Storm)** |
| Runoff Coefficient = | 0.35 | **(User Entry)** |
| Q (cfs) = | 9.4 | |

**Normal Depth Calculations:**

| | | |
|---|---|---|
| nQ/(1.49s^0.5) = | 1.42347562 | |
| y (ft) = | 0.91 | **(Iterate)** |
| accuracy | 0.1 | |
| f(M,y,B) = | 1.41892362 | |
| Normal Depth (ft) = | 0.91 | |

**Velocity:**

V (ft/s) = 3.76 GRASS O.K

**Liner Shear Stress:**

T (lb/ft^2) = 1.14

NDEPTH.WB1(3)

## G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 1 / 1
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County**
**Normal Depth Analysis**
**Existing Drainage Channel No. 2**

**Ditch/Swale Parameters: (User Entry)**

| | |
|---|---|
| Drainage Area (Ac.) = | 2.49 → Drainage Areas 5+12 |
| Hydraulic Length (ft) = | 750 |
| Fall Along Length (ft) = | 50 |
| Lining: | Grass |
| Slope (ft/ft) | 0.02 |
| n = | 0.032 |
| B (ft) = | 0 |
| M = | 3 |

**Flow Volume:**

| | |
|---|---|
| Time of Conc. (min.) = | 3.6 |
| Intensity (in/hr) = | 7.22 **(User Entry) (10 Year Storm)** |
| Runoff Coefficient = | 0.35 **(User Entry)** |
| Q (cfs) = | 6.3 |

**Normal Depth Calculations:**

| | |
|---|---|
| nQ/(1.49s^0.5) = | 0.95554975 |
| y (ft) = | 0.78 **(Iterate)** |
| accuracy | 0.1 |
| f(M,y,B) = | 0.94066335 |
| Normal Depth (ft) = | 0.78 |

**Velocity:**

V (ft/s) = 3.39 GRASS O.K.

**Liner Shear Stress:**

T (lb/ft^2) = 0.97

NDEPTH.WB1(4)

## G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 1 / 1
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County**
**Normal Depth Analysis**
**Drainage Channel No. 3**

**Ditch/Swale Parameters: (User Entry)**

| | |
|---|---|
| Drainage Area (Ac.) = | 5.12 → Drainage Areas 1+4+11 + 1/3 18 |
| Hydraulic Length (ft) = | 1500 |
| Fall Along Length (ft) = | 100 |
| Lining: | Synthetic TRM |
| Slope (ft/ft) | 0.04 |
| n = | 0.032 |
| B (ft) = | 2 |
| M = | 2 |

**Flow Volume:**

| | |
|---|---|
| Time of Conc. (min.) = | 6.2 |
| Intensity (in/hr) = | 6.96 **(User Entry) (10 Year Storm)** |
| Runoff Coefficient = | 0.31 **(User Entry)** |
| Q (cfs) = | 11.0 |

**Normal Depth Calculations:**

| | |
|---|---|
| nQ/(1.49s^0.5) = | 1.18624558 |
| y (ft) = | 0.65 **(Iterate)** |
| accuracy | 0.1 |
| f(M,y,B) = | 1.23549575 |
| Normal Depth (ft) = | 0.65 |

**Velocity:**

V (ft/s) = 5.36

**Liner Shear Stress:**

T (lb/ft^2) = 1.62

## G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 1 / 1
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County**
**Normal Depth Analysis**
**Bench Swales**

**Ditch/Swale Parameters: (User Entry)**

| | |
|---|---|
| Drainage Area (Ac.) = | 1.2 |
| Hydraulic Length (ft) = | 80 |
| Fall Along Length (ft) = | 20 |
| Lining: | Grass |
| Slope (ft/ft) | 0.02 |
| n = | 0.032 |
| B (ft) = | 2 |
| M = | 1.5 |

→ Drainage Area 8 is Maximum

**Flow Volume:**

| | |
|---|---|
| Time of Conc. (min.) = | 0.4 |
| Intensity (in/hr) = | 7.22 **(User Entry) (10 Year Storm)** |
| Runoff Coefficient = | 0.35 **(User Entry)** |
| Q (cfs) = | 3.0 |

**Normal Depth Calculations:**

| | |
|---|---|
| nQ/(1.49s^0.5) = | 0.4605059 |
| y (ft) = | 0.4 **(Iterate)** |
| accuracy | 0.1 |
| f(M,y,B) = | 0.46826993 |
| Normal Depth (ft) = | 0.4 |

**Velocity:**

V (ft/s) = 2.96

**Liner Shear Stress:**

T (lb/ft^2) = 0.50

Bench Swales Will Be Stabilized Before Slopes Above Benches Are Built
— USE JUTE NET IF DESIRED TO AID STABILIZATION —

BNCHSWAL.WB1

## G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 1 / 1
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County**
**Normal Depth Analysis**
**Drainage Swale - Access Ramp**

**Ditch/Swale Parameters: (User Entry)**

| | | |
|---|---|---|
| Drainage Area (Ac.) = | 1.0 | → 1/2 Drainage Areas 10+17 |
| Hydraulic Length (ft) = | 80 | |
| Fall Along Length (ft) = | 20 | |
| Lining: | Synthetic TRM | |
| Slope (ft/ft) | 0.08 | |
| n = | 0.032 | |
| B (ft) = | 0 | |
| M = | 3 | |

**Flow Volume:**

| | | |
|---|---|---|
| Time of Conc. (min.) = | 0.4 | |
| Intensity (in/hr) = | 7.22 | **(User Entry) (10 Year Storm)** |
| Runoff Coefficient = | 0.35 | **(User Entry)** |
| Q (cfs) = | 2.5 | |

**Normal Depth Calculations:**

| | | |
|---|---|---|
| nQ/(1.49s^0.5) = | 0.19187746 | |
| y (ft) = | 0.43 | **(Iterate)** |
| accuracy | 0.1 | |
| f(M,y,B) = | 0.19220488 | |
| Normal Depth (ft) = | 0.43 | |

**Velocity:**

V (ft/s) = 4.56

**Liner Shear Stress:**

T (lb/ft^2) = 2.15

NDEPTH.WB1(1)

## G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 1 / 1
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County**
**Normal Depth Analysis**
**Drainage Swale - Access Road**

**Ditch/Swale Parameters: (User Entry)**

| | | |
|---|---|---|
| Drainage Area (Ac.) = | 4.06 | → Drainage Areas 3+9+10+17 |
| Hydraulic Length (ft) = | 600 | |
| Fall Along Length (ft) = | 46 | |
| Lining: | Synthetic TRM | |
| Slope (ft/ft) | 0.067 | |
| n = | 0.032 | |
| B (ft) = | 2 | |
| M = | 2 | |

**Flow Volume:**

| | | |
|---|---|---|
| Time of Conc. (min.) = | 2.9 | |
| Intensity (in/hr) = | 7.22 | **(User Entry) (10 Year Storm)** |
| Runoff Coefficient = | 0.35 | **(User Entry)** |
| Q (cfs) = | 10.3 | |

**Normal Depth Calculations:**

| | | |
|---|---|---|
| nQ/(1.49s^0.5) = | 0.8512509 | |
| y (ft) = | 0.54 | **(Iterate)** |
| accuracy | 0.1 | |
| f(M,y,B) = | 0.86754079 | |
| Normal Depth (ft) = | 0.54 | |

**Velocity:**

V (ft/s) = 6.29

**Liner Shear Stress:**

T (lb/ft^2) = 2.26

**Objective** To evaluate the ability of the existing sediment basin(s) to handle the maximum flow from the 10-year design storm.

**References** North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Malcom, H. Rooney, Elements of Urban Stormwater Design, N. C. State University, Raleigh, NC, 1989.

**Analysis** The following approach is used to properly size and evaluate the sediment basin:

1. Determine Flow into Basin
2. Formulate Design Hydrograph.
3. Determine Stage-Storage Function.
4. Route for Flow Check.
5. Check Settling Efficiency.

## Calculations

- Determine Flow Into Basin:

Use Rational Method ($Q_P$=CIA)

- Formulate Design Hydrograph:

Estimate Volume of Runoff from 6 hour storm for the design return period (i.e. 6 hr. 10 yr., or 6 hr. 25 yr. storm). The six hour storm for the return period of interest is typically included in the design hydrograph (Malcom).

$$Q^* = \frac{(P - 0.2\underline{S})^2}{(P + 0.8\underline{S})}$$ (Malcom Equation III-6)

Where: $Q^*$ = Volume of Runoff from 6 hr, x year storm (in.)

$\underline{S}$ = $\frac{1000}{CN} - 10$

CN = Runoff Curve Number

P = 6 hr, x year Storm Depth (in.)

Set Time to Peak Using Step Function as Pattern Hydrograph

$$Tp = \frac{Q^* A}{1.39 Qp}$$ (Malcom Eq. III-4)

Where: $T_p$ = Time to Peak (min)

$Q^*$ = Volume of Runoff (in.)

A = Area Flowing to Basin (Ac)

Qp = Peak Flow into Basin (cfs)

Design Hydrograph

$$Q = \frac{Qp}{2} \left| 1 - COS\left( \frac{\pi t}{Tp} \right) \right|$$ (Malcom Eq. III-1)

for $0 \leq t \leq 1.25$ Tp

$$Q = 4.34\, Qp \exp \left| -1.30 \left( \frac{t}{Tp} \right) \right|$$ (Malcom Eq. III-2)

for $t > 1.25$ Tp

Where: Q = Flow into Basin at Time t (cfs)

- Determine Stage-Storage Function:

Determine Stage-Storage Function

$$S = K_S Z^b \qquad \text{(Malcom Eq. III-7)}$$

Where:

- $S$ = Storage Volume ($ft^3$)
- $K_S$&$b$ = Linear Regression Constants Describing the Stage-Storage Relationship
- $Z$ = Stage Referenced to the Bottom of the Basin (ft)

- Route for Flow Check:

Route design hydrograph through the sediment basin to determine peak stage and outflow.

- Check Settling Efficiency:

Settling Velocity of Design Particle

$$V_o = \frac{g}{18}\left[\left(S_s - 1\right)/\upsilon\right] d^2 \qquad \text{(Malcom Eq. IV-3)}$$

Where:

- $V_o$ = Settling Velocity (ft/s) - convert from (m/s)
- $g$ = Gravitational Acceleration ($m/s^2$)
- $S_s$ = Specific Gravity of Design Particle
- $\upsilon$ = Kinematic Viscosity of the Fluid ($m^2/s$)
  (= $1.14 \times 10^{-6}$ $m^2/s$ @ 15°C Rf. Streeter, 1975)
- $d$ = Diameter of Design Particle (m)

Settling Constant

$$C_s = \frac{bK_s(V_o)}{N\left[(1-E)^{-1/N}-1\right]}$$ (Malcom Eq. IV-10)

Where: N = Number of Effective Cells (N=Z=>Conservative)

E = Settling Efficiency (Decimal Fraction )

Settling Envelope

$$Q = C_S Z^{(b-1)}$$ (Malcom Eq. IV-9)

Where: Q = Discharge Limit at Given Stage Z (ft)

Surface Area

$$A_s = bK_s Z^{(b-1)}$$ (Malcom Eq. IV-7)

Settling Efficiency

$$E = 1 - \left[1 + \frac{V_o A_s}{NQ}\right]^{-N}$$ (Malcom Eq. IV-1)

## G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 5/12
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

**Halifax County Landfill - Transition Plan**
**Existing Sedimentation Basin No. 1 Analysis**

**Areas Draining Into Basin:**

Hydraulic Length (ft) = 700 **(User Input)**
Fall Along Length (ft) = 100 **(User Input)**

| Drainage Area | Area (Ac.) | C | |
|---|---|---|---|
| Drainage Areas 2+7+14+20 | 3.67 | 0.35 | **(User Input)** |

Total = 3.67 Acres

Avg. C = 0.35

**Peak Flow Volume:**

Time of Conc. = 2.6
Intensity (in/hr) = 7.22 **(User Input)(10 yr Storm)**
Qp (cfs) = 9.3

**Estimate Volume of Runoff:**

P6,10 (in) = 4.1 **(User Input)(6 hr, 10 yr Storm)**

Runoff Curve # (CN) = 79 **(User Input)(NC Sed. & Erosion Control Man., Fair Condition Soil Type C)**

Q* (in) = 2.04

**Set Time to Peak:**

Tp (min) = 35.2

6/12

**Determine Stage-Storage Function:**

| Contour | Area (sq ft) | Incr Vol (cu ft) | Accum Vol (cu ft) | Stage (ft) | ln S | ln Z | Z est |
|---|---|---|---|---|---|---|---|
| 246 | 5660 | | 0 | 0 | | | |
| 248 | 7050 | 12710 | 12710 | 2 | 9.45 | 0.69 | 2.00 |
| 250 | 9688 | 16738 | 29448 | 4 | 10.29 | 1.39 | 4.00 |

***REGRESSION ANALYSIS IS NOT RUN AUTOMATICALLY!**

| Regression Output: | | |
|---|---|---|
| Constant | | 8.609907 |
| Std Err of Y Est | | ERR |
| R Squared | | 1.000000 |
| No. of Observations | | 2 |
| Degrees of Freedom | | 0 |
| X Coefficient(s) | 1.2122056245 | |
| Std Err of Coef. | ERR | |

Ks = 5486
b = 1.21

EXISTSB1.WB1(2)

**Riser Barrel Routing - Design:**

7/12

Input Data:

| | | | |
|---|---|---|---|
| | Qp (cfs) = | 9.3 | (user input) |
| | Tp (min) = | 35.2 | (user input) |
| | dT (min) = | 2 | (user input) |
| | Ks = | 5486 | |
| | b = | 1.21 | |
| | Zo (ft) = | 246 | (user input) |
| | Zinitial (ft) = | 246 | (user input) |
| Riser: | Dr (in) = | 48 | (user input) |
| | Cw = | 3.3 | (user input) |
| | Zcr (ft) = | 249 | (user input) |
| Barrel: | Db (in) = | 30 | (user input) |
| | Zi (ft) = | 246 | (user input) |
| | Cd = | 0.59 | (user input) |

Wksht. Assumes Riser Acts As A Weir.

Norm. Surf Area = 0.19 ac

Peak Outflow = 2.59 cfs

Peak Stage = 249.16 ft

| TIME (min) | INFLOW (cfs) | STORAGE (cu ft) | STAGE (ft) | OUTFLOW (cfs) | RISER (cfs) | BARREL (cfs) |
|---|---|---|---|---|---|---|
| 0 | 0.0 | 0 | 246.00 | 0.00 | na | na |
| 2 | 0.1 | 0 | 246.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.3 | 9 | 246.00 | 0.00 | 0.00 | 0.00 |
| 6 | 0.7 | 44 | 246.02 | 0.00 | 0.00 | 0.02 |
| 8 | 1.1 | 122 | 246.04 | 0.00 | 0.00 | 0.06 |
| 10 | 1.7 | 258 | 246.08 | 0.00 | 0.00 | 0.15 |
| 12 | 2.4 | 466 | 246.13 | 0.00 | 0.00 | 0.31 |
| 14 | 3.2 | 757 | 246.20 | 0.00 | 0.00 | 0.57 |
| 16 | 4.0 | 1139 | 246.27 | 0.00 | 0.00 | 0.94 |
| 18 | 4.8 | 1617 | 246.37 | 0.00 | 0.00 | 1.45 |
| 20 | 5.6 | 2195 | 246.47 | 0.00 | 0.00 | 2.12 |
| 22 | 6.4 | 2872 | 246.59 | 0.00 | 0.00 | 2.96 |
| 24 | 7.2 | 3643 | 246.71 | 0.00 | 0.00 | 3.97 |
| 26 | 7.8 | 4503 | 246.85 | 0.00 | 0.00 | 5.16 |
| 28 | 8.4 | 5441 | 246.99 | 0.00 | 0.00 | 6.52 |
| 30 | 8.8 | 6446 | 247.14 | 0.00 | 0.00 | 8.04 |
| 32 | 9.1 | 7503 | 247.29 | 0.00 | 0.00 | 9.70 |
| 34 | 9.3 | 8596 | 247.45 | 0.00 | 0.00 | 11.48 |
| 36 | 9.3 | 9709 | 247.60 | 0.00 | 0.00 | 13.35 |
| 38 | 9.2 | 10824 | 247.75 | 0.00 | 0.00 | 15.27 |
| 40 | 8.9 | 11922 | 247.90 | 0.00 | 0.00 | 17.21 |
| 42 | 8.5 | 12988 | 248.04 | 0.00 | 0.00 | 19.13 |
| 44 | 7.9 | 14004 | 248.17 | 0.00 | 0.00 | 21.00 |
| 46 | 7.4 | 14957 | 248.29 | 0.00 | 0.00 | 22.78 |
| 48 | 6.9 | 15843 | 248.40 | 0.00 | 0.00 | 24.46 |
| 50 | 6.4 | 16665 | 248.50 | 0.00 | 0.00 | 25.95 |
| 52 | 5.9 | 17430 | 248.60 | 0.00 | 0.00 | 26.91 |
| 54 | 5.5 | 18139 | 248.68 | 0.00 | 0.00 | 27.77 |
| 56 | 5.1 | 18799 | 248.76 | 0.00 | 0.00 | 28.54 |
| 58 | 4.7 | 19411 | 248.84 | 0.00 | 0.00 | 29.23 |
| 60 | 4.4 | 19980 | 248.90 | 0.00 | 0.00 | 29.85 |
| 62 | 4.1 | 20508 | 248.97 | 0.00 | 0.00 | 30.41 |
| 64 | 3.8 | 20998 | 249.03 | 0.18 | 0.18 | 30.93 |
| 66 | 3.5 | 21433 | 249.08 | 0.90 | 0.90 | 31.37 |
| 68 | 3.3 | 21748 | 249.12 | 1.62 | 1.62 | 31.69 |
| 70 | 3.0 | 21947 | 249.14 | 2.14 | 2.14 | 31.89 |
| 72 | 2.8 | 22055 | 249.15 | 2.44 | 2.44 | 32.00 |
| 74 | 2.6 | 22101 | 249.16 | 2.57 | 2.57 | 32.04 |
| 76 | 2.4 | 22108 | 249.16 | 2.59 | 2.59 | 32.05 |
| 78 | 2.3 | 22089 | 249.16 | 2.54 | 2.54 | 32.03 |
| 80 | 2.1 | 22056 | 249.15 | 2.44 | 2.44 | 32.00 |

8/12

## Riser Barrel Routing - Settling Efficiency:

Input Data:

Particle Data:

| | | | |
|---|---|---|---|
| Diam. (microns) = | 50 **(user input)** | Settling Veloc. (ft/s) = | 0.0064683 |
| Specific Gravity = | 2.65 **(user input)** | Reynolds No. (<0.5) = | 0.086493 |

Efficiency Data:

| | | | |
|---|---|---|---|
| Desired Efficiency (%) = | 70 **(user input)** | Cs = | 26.0451 |
| No. of Effective Cells = | 2 **(user input)** | | |

| TIME (min) | INFLOW (cfs) | STORAGE (cu ft) | STAGE (ft) | OUTFLOW (cfs) | SURF. AREA (ft^2) | SET ENV. (cfs) | SET EFF. (%) |
|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 0 | 246.00 | 0.00 | 0 | na | na |
| 2 | 0.1 | 0 | 246.00 | 0.00 | 0 | 0 | ERR |
| 4 | 0.3 | 9 | 246.00 | 0.00 | 2158 | 8 | ERR |
| 6 | 0.7 | 44 | 246.02 | 0.00 | 2858 | 11 | ERR |
| 8 | 1.1 | 122 | 246.04 | 0.00 | 3416 | 13 | ERR |
| 10 | 1.7 | 258 | 246.08 | 0.00 | 3895 | 15 | ERR |
| 12 | 2.4 | 466 | 246.13 | 0.00 | 4319 | 17 | ERR |
| 14 | 3.2 | 757 | 246.20 | 0.00 | 4701 | 18 | ERR |
| 16 | 4.0 | 1139 | 246.27 | 0.00 | 5050 | 20 | ERR |
| 18 | 4.8 | 1617 | 246.37 | 0.00 | 5370 | 21 | ERR |
| 20 | 5.6 | 2195 | 246.47 | 0.00 | 5665 | 22 | ERR |
| 22 | 6.4 | 2872 | 246.59 | 0.00 | 5938 | 23 | ERR |
| 24 | 7.2 | 3643 | 246.71 | 0.00 | 6190 | 24 | ERR |
| 26 | 7.8 | 4503 | 246.85 | 0.00 | 6424 | 25 | ERR |
| 28 | 8.4 | 5441 | 246.99 | 0.00 | 6640 | 26 | ERR |
| 30 | 8.8 | 6446 | 247.14 | 0.00 | 6840 | 27 | ERR |
| 32 | 9.1 | 7503 | 247.29 | 0.00 | 7025 | 28 | ERR |
| 34 | 9.3 | 8596 | 247.45 | 0.00 | 7194 | 28 | ERR |
| 36 | 9.3 | 9709 | 247.60 | 0.00 | 7349 | 29 | ERR |
| 38 | 9.2 | 10824 | 247.75 | 0.00 | 7490 | 29 | ERR |
| 40 | 8.9 | 11922 | 247.90 | 0.00 | 7618 | 30 | ERR |
| 42 | 8.5 | 12988 | 248.04 | 0.00 | 7733 | 30 | ERR |
| 44 | 7.9 | 14004 | 248.17 | 0.00 | 7835 | 31 | ERR |
| 46 | 7.4 | 14957 | 248.29 | 0.00 | 7926 | 31 | ERR |
| 48 | 6.9 | 15843 | 248.40 | 0.00 | 8006 | 31 | ERR |
| 50 | 6.4 | 16665 | 248.50 | 0.00 | 8078 | 32 | ERR |
| 52 | 5.9 | 17430 | 248.60 | 0.00 | 8141 | 32 | ERR |
| 54 | 5.5 | 18139 | 248.68 | 0.00 | 8198 | 32 | ERR |
| 56 | 5.1 | 18799 | 248.76 | 0.00 | 8250 | 32 | ERR |
| 58 | 4.7 | 19411 | 248.84 | 0.00 | 8296 | 32 | ERR |
| 60 | 4.4 | 19980 | 248.90 | 0.00 | 8338 | 33 | ERR |
| 62 | 4.1 | 20508 | 248.97 | 0.00 | 8377 | 33 | ERR |
| 64 | 3.8 | 20998 | 249.03 | 0.18 | 8411 | 33 | 100.0 |
| 66 | 3.5 | 21433 | 249.08 | 0.90 | 8441 | 33 | 99.9 |
| 68 | 3.3 | 21748 | 249.12 | 1.62 | 8463 | 33 | 99.7 |
| 70 | 3.0 | 21947 | 249.14 | 2.14 | 8477 | 33 | 99.5 |
| 72 | 2.8 | 22055 | 249.15 | 2.44 | 8484 | 33 | 99.3 |
| 74 | 2.6 | 22101 | 249.16 | 2.57 | 8487 | 33 | 99.3 |
| 76 | 2.4 | 22108 | 249.16 | 2.59 | 8487 | 33 | 99.3 |
| 78 | 2.3 | 22089 | 249.16 | 2.54 | 8486 | 33 | 99.3 |
| 80 | 2.1 | 22056 | 249.15 | 2.44 | 8484 | 33 | 99.3 |

## G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 9/12
JOB #: HALIFAX-7
DATE: 11/22/96
BY: PKS
CHKD BY:

### Halifax County Landfill - Transition Plan
### Existing Sedimentation Basin No. 2 Analysis

**Areas Draining Into Basin:**

Hydraulic Length (ft) = 1700 **(User Input)**
Fall Along Length (ft) = 100 **(User Input)**

| Drainage Area | Area (Ac.) | C | |
|---|---|---|---|
| Drainage Areas 1+4+5+6+11+12 | 7.00 | 0.35 | **(User Input)** |
| Drainage Area 18 (Wooded) | 4.17 | 0.2 | |

Total = 11.17 Acres

Avg. C = 0.29

**Peak Flow Volume:**

Time of Conc. = 7.1
Intensity (in/hr) = 6.77 **(User Input)(10 yr Storm)**
Qp (cfs) = 22.2

**Estimate Volume of Runoff:**

P6,10 (in) = 4.1 **(User Input)(6 hr, 10 yr Storm)**

Runoff Curve # (CN) = 79 **(User Input)(NC Sed. & Erosion Control Man., Fair Condition Soil Type C)**

Q* (in) = 2.04

**Set Time to Peak:**

Tp (min) = 44.7

EXISTSB2.WB1(1)

**Determine Stage-Storage Function:**

| Contour | Area (sq ft) | Incr Vol (cu ft) | Accum Vol (cu ft) | Stage (ft) | ln S | ln Z | Z est |
|---|---|---|---|---|---|---|---|
| 238 | 1782 | | 0 | 0 | | | |
| 240 | 2712 | 4494 | 4494 | 2 | 8.41 | 0.69 | 2.00 |
| 242 | 4030 | 6742 | 11236 | 4 | 9.33 | 1.39 | 4.00 |
| 244 | 5890 | 9920 | 21156 | 6 | 9.96 | 1.79 | 6.00 |
| 246 | 8680 | 14570 | 35726 | 8 | 10.48 | 2.08 | 8.00 |

***REGRESSION ANALYSIS IS NOT RUN AUTOMATICALLY!**

| Regression Output: | | |
|---|---|---|
| Constant | | 7.342846 |
| Std Err of Y Est | | 0.0759781 |
| R Squared | | 0.995165 |
| No. of Observations | | 4 |
| Degrees of Freedom | | 2 |
| X Coefficient(s) | 1.4803955646 | |
| Std Err of Coef. | 0.0729679687 | |

Ks = 1545
b = 1.48

EXISTSB2.WB1(2)

## Riser Barrel Routing - Design:

11/12

Input Data:

| | | | |
|---|---|---|---|
| | Qp (cfs) = | 22.2 | (user input) |
| | Tp (min) = | 44.7 | (user input) |
| | dT (min) = | 2 | (user input) |
| | Ks = | 1545 | |
| | b = | 1.48 | |
| | Zo (ft) = | 238 | (user input) |
| | Zinitial (ft) = | 238 | (user input) |
| Riser: | Dr (in) = | 24 | (user input) |
| | Cw = | 3.3 | (user input) |
| | Zcr (ft) = | 244 | (user input) |
| Barrel: | Db (in) = | 18 | (user input) |
| | Zi (ft) = | 238 | (user input) |
| | Cd = | 0.59 | (user input) |

Wksht. Assumes Riser Acts As A Weir.

Norm. Surf Area = 0.12 ac

Peak Outflow = 20.96 cfs

Peak Stage = 245.05 ft

| TIME (min) | INFLOW (cfs) | STORAGE (cu ft) | STAGE (ft) | OUTFLOW (cfs) | RISER (cfs) | BARREL (cfs) |
|---|---|---|---|---|---|---|
| 0 | 0.0 | 0 | 238.00 | 0.00 | na | na |
| 2 | 0.1 | 0 | 238.00 | 0.00 | 0.00 | 0.00 |
| 4 | 0.4 | 13 | 238.04 | 0.00 | 0.00 | 0.03 |
| 6 | 1.0 | 65 | 238.12 | 0.00 | 0.00 | 0.16 |
| 8 | 1.7 | 182 | 238.24 | 0.00 | 0.00 | 0.45 |
| 10 | 2.6 | 387 | 238.39 | 0.00 | 0.00 | 0.97 |
| 12 | 3.7 | 703 | 238.59 | 0.00 | 0.00 | 1.78 |
| 14 | 5.0 | 1149 | 238.82 | 0.00 | 0.00 | 2.93 |
| 16 | 6.3 | 1744 | 239.09 | 0.00 | 0.00 | 4.47 |
| 18 | 7.8 | 2501 | 239.38 | 0.00 | 0.00 | 6.43 |
| 20 | 9.3 | 3432 | 239.71 | 0.00 | 0.00 | 8.20 |
| 22 | 10.8 | 4545 | 240.07 | 0.00 | 0.00 | 9.61 |
| 24 | 12.4 | 5844 | 240.46 | 0.00 | 0.00 | 10.91 |
| 26 | 13.9 | 7330 | 240.86 | 0.00 | 0.00 | 12.14 |
| 28 | 15.4 | 9000 | 241.29 | 0.00 | 0.00 | 13.31 |
| 30 | 16.8 | 10847 | 241.73 | 0.00 | 0.00 | 14.42 |
| 32 | 18.1 | 12861 | 242.18 | 0.00 | 0.00 | 15.48 |
| 34 | 19.2 | 15029 | 242.65 | 0.00 | 0.00 | 16.50 |
| 36 | 20.2 | 17334 | 243.12 | 0.00 | 0.00 | 17.46 |
| 38 | 21.0 | 19756 | 243.59 | 0.00 | 0.00 | 18.38 |
| 40 | 21.6 | 22275 | 244.06 | 0.34 | 0.34 | 19.26 |
| 42 | 22.0 | 24827 | 244.53 | 7.90 | 7.90 | 20.08 |
| 44 | 22.2 | 26519 | 244.82 | 15.47 | 15.47 | 20.59 |
| 46 | 22.2 | 27324 | 244.96 | 19.57 | 19.57 | 20.82 |
| 48 | 21.9 | 27634 | 245.02 | 20.91 | 21.22 | 20.91 |
| 50 | 21.4 | 27754 | 245.04 | 20.94 | 21.86 | 20.94 |
| 52 | 20.8 | 27813 | 245.05 | 20.96 | 22.18 | 20.96 |
| 54 | 19.9 | 27790 | 245.04 | 20.95 | 22.06 | 20.95 |
| 56 | 18.9 | 27665 | 245.02 | 20.92 | 21.38 | 20.92 |
| 58 | 17.8 | 27423 | 244.98 | 20.09 | 20.09 | 20.85 |
| 60 | 16.8 | 27153 | 244.93 | 18.67 | 18.67 | 20.77 |
| 62 | 15.9 | 26931 | 244.89 | 17.54 | 17.54 | 20.71 |
| 64 | 15.0 | 26732 | 244.86 | 16.53 | 16.53 | 20.65 |
| 66 | 14.1 | 26546 | 244.83 | 15.61 | 15.61 | 20.59 |
| 68 | 13.3 | 26369 | 244.80 | 14.75 | 14.75 | 20.54 |
| 70 | 12.6 | 26199 | 244.77 | 13.93 | 13.93 | 20.49 |
| 72 | 11.9 | 26037 | 244.74 | 13.17 | 13.17 | 20.44 |
| 74 | 11.2 | 25881 | 244.71 | 12.45 | 12.45 | 20.40 |
| 76 | 10.6 | 25732 | 244.69 | 11.76 | 11.76 | 20.35 |
| 78 | 10.0 | 25588 | 244.66 | 11.12 | 11.12 | 20.31 |
| 80 | 9.4 | 25450 | 244.64 | 10.51 | 10.51 | 20.27 |

12/12

## Riser Barrel Routing - Settling Efficiency:

Input Data:

Particle Data:

Diam. (microns) = 50 **(user input)**
Specific Gravity = 2.65 **(user input)**

Settling Veloc. (ft/s) = 0.0064683
Reynolds No. (<0.5) = 0.086493

Efficiency Data:

Desired Efficiency (%) = 70 **(user input)**
No. of Effective Cells = 2 **(user input)**

Cs = 8.9588

| TIME (min) | INFLOW (cfs) | STORAGE (cu ft) | STAGE (ft) | OUTFLOW (cfs) | SURF. AREA (ft^2) | SET ENV. (cfs) | SET EFF. (%) |
|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 0 | 238.00 | 0.00 | 0 | na | na |
| 2 | 0.1 | 0 | 238.00 | 0.00 | 0 | 0 | ERR |
| 4 | 0.4 | 13 | 238.04 | 0.00 | 487 | 2 | ERR |
| 6 | 1.0 | 65 | 238.12 | 0.00 | 820 | 3 | ERR |
| 8 | 1.7 | 182 | 238.24 | 0.00 | 1143 | 4 | ERR |
| 10 | 2.6 | 387 | 238.39 | 0.00 | 1460 | 6 | ERR |
| 12 | 3.7 | 703 | 238.59 | 0.00 | 1771 | 7 | ERR |
| 14 | 5.0 | 1149 | 238.82 | 0.00 | 2078 | 8 | ERR |
| 16 | 6.3 | 1744 | 239.09 | 0.00 | 2379 | 9 | ERR |
| 18 | 7.8 | 2501 | 239.38 | 0.00 | 2674 | 10 | ERR |
| 20 | 9.3 | 3432 | 239.71 | 0.00 | 2963 | 12 | ERR |
| 22 | 10.8 | 4545 | 240.07 | 0.00 | 3246 | 13 | ERR |
| 24 | 12.4 | 5844 | 240.46 | 0.00 | 3522 | 14 | ERR |
| 26 | 13.9 | 7330 | 240.86 | 0.00 | 3791 | 15 | ERR |
| 28 | 15.4 | 9000 | 241.29 | 0.00 | 4052 | 16 | ERR |
| 30 | 16.8 | 10847 | 241.73 | 0.00 | 4305 | 17 | ERR |
| 32 | 18.1 | 12861 | 242.18 | 0.00 | 4550 | 18 | ERR |
| 34 | 19.2 | 15029 | 242.65 | 0.00 | 4786 | 19 | ERR |
| 36 | 20.2 | 17334 | 243.12 | 0.00 | 5012 | 20 | ERR |
| 38 | 21.0 | 19756 | 243.59 | 0.00 | 5230 | 20 | ERR |
| 40 | 21.6 | 22275 | 244.06 | 0.34 | 5437 | 21 | 100.0 |
| 42 | 22.0 | 24827 | 244.53 | 7.90 | 5632 | 22 | 90.8 |
| 44 | 22.2 | 26519 | 244.82 | 15.47 | 5754 | 23 | 79.4 |
| 46 | 22.2 | 27324 | 244.96 | 19.57 | 5810 | 23 | 74.0 |
| 48 | 21.9 | 27634 | 245.02 | 20.91 | 5831 | 23 | 72.4 |
| 50 | 21.4 | 27754 | 245.04 | 20.94 | 5840 | 23 | 72.3 |
| 52 | 20.8 | 27813 | 245.05 | 20.96 | 5844 | 23 | 72.3 |
| 54 | 19.9 | 27790 | 245.04 | 20.95 | 5842 | 23 | 72.3 |
| 56 | 18.9 | 27665 | 245.02 | 20.92 | 5834 | 23 | 72.4 |
| 58 | 17.8 | 27423 | 244.98 | 20.09 | 5817 | 23 | 73.3 |
| 60 | 16.8 | 27153 | 244.93 | 18.67 | 5798 | 23 | 75.1 |
| 62 | 15.9 | 26931 | 244.89 | 17.54 | 5783 | 23 | 76.6 |
| 64 | 15.0 | 26732 | 244.86 | 16.53 | 5769 | 23 | 77.9 |
| 66 | 14.1 | 26546 | 244.83 | 15.61 | 5756 | 23 | 79.2 |
| 68 | 13.3 | 26369 | 244.80 | 14.75 | 5743 | 22 | 80.4 |
| 70 | 12.6 | 26199 | 244.77 | 13.93 | 5731 | 22 | 81.6 |
| 72 | 11.9 | 26037 | 244.74 | 13.17 | 5720 | 22 | 82.7 |
| 74 | 11.2 | 25881 | 244.71 | 12.45 | 5709 | 22 | 83.8 |
| 76 | 10.6 | 25732 | 244.69 | 11.76 | 5698 | 22 | 84.8 |
| 78 | 10.0 | 25588 | 244.66 | 11.12 | 5688 | 22 | 85.8 |
| 80 | 9.4 | 25450 | 244.64 | 10.51 | 5678 | 22 | 86.7 |

EXISTSB2.WB1(4)

I, LEWIS O. BURR, CERTIFY THAT THIS PLAT WAS DRAWN UNDER MY SUPERVISION FROM AN ACTUAL SURVEY MADE UNDER MY SUPERVISION ON 8-94 & 4-10-95, THAT BOUNDARY DEFINITIONS FOUND IN RECORDED PAPERS DB 1081, PG 255
WERE USED AS THE PRIMARY GUIDES FOR THIS SURVEY: THAT THE BOUNDARIES NOT SURVEYED ARE CLEARLY INDICATED AS DRAWN FROM INFORMATION FOUND IN BOOK ---, PAGE ---; THAT THE RATIO OF PRECISION CALCULATED IS ONE IN 10000: THAT THIS PLAT WAS PREPARED IN ACCORDANCE WITH G.S. 47-30 AS AMENDED.
WITNESS MY ORIGINAL SIGNATURE, REGISTRATION NUMBER AND SEAL

THIS 19TH DAY OF APRIL, A.D., 1995

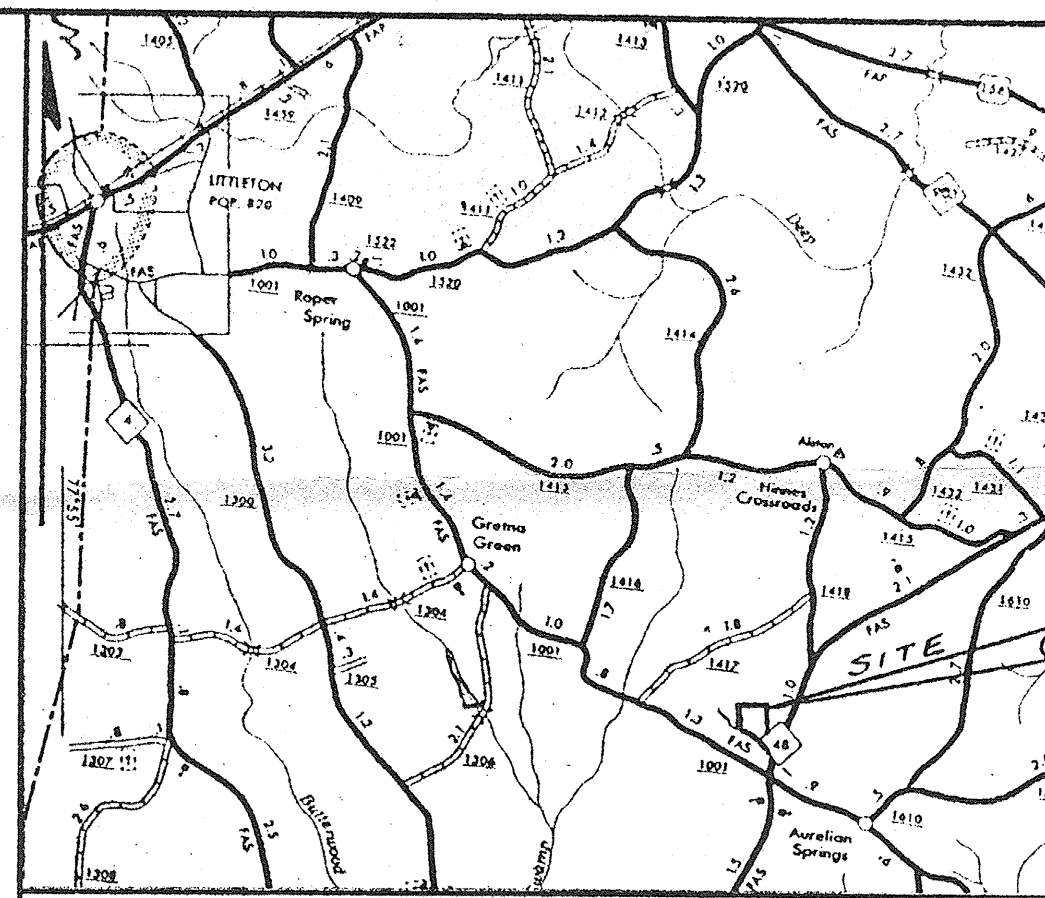
---------------------------------
SURVEYOR'S SIGNATURE REGISTRATION NUMBER

NORTH CAROLINA, HALIFAX COUNTY
I, A NOTARY PUBLIC OF THE COUNTY AND STATE AFORESAID, CERTIFY THAT LEWIS O. BURR, A REGISTERED LAND SURVEYOR, PERSONALLY APPEARED BEFORE ME THIS DAY AND ACKNOWLEDGED THE EXECUTION OF THE FOREGOING INSTRUMENT.
WITNESS MY HAND AND OFFICIAL STAMP OR SEAL

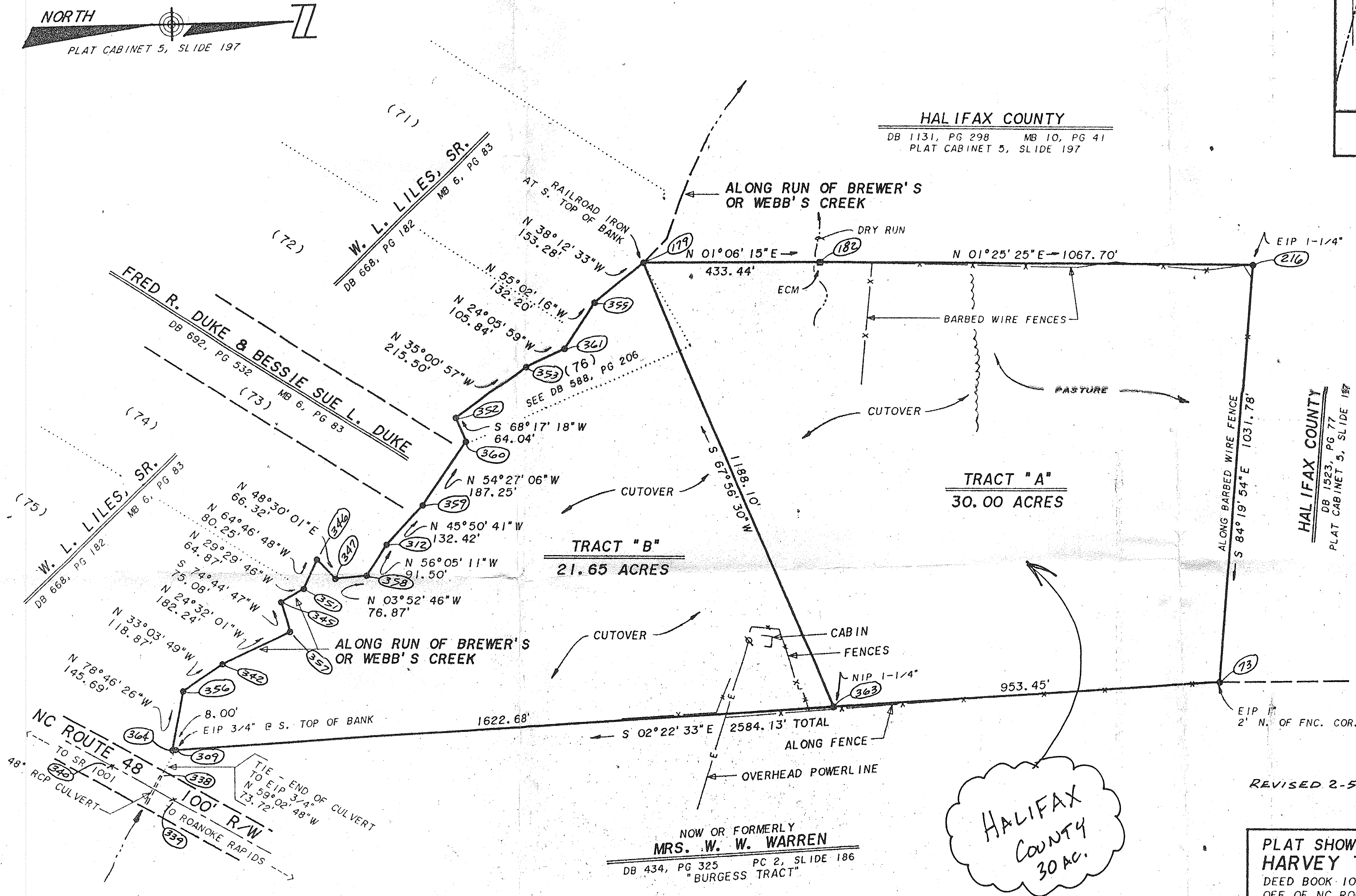
THIS 19TH DAY OF APRIL, 1995

---------------------------------
NOTARY PUBLIC

MY COMMISSION EXPIRES MARCH 5, 1996



LOCATION MAP
SCALE: NONE




NORTH CAROLINA, HALIFAX COUNTY
THE FOREGOING CERTIFICATE OF ANN BURR, NOTARY PUBLIC OF HALIFAX COUNTY, IS CERTIFIED TO BE CORRECT.
THIS ________ DAY OF ______________, 19 _____.
RECORDED ______ M. IN PLAT CABINET ______, SLIDE ______.

---------------------------------
JUDY EVANS-BARBEE, HALIFAX COUNTY REGISTER OF DEEDS

REVISED 2-5-96: ADDED POINT NUMBERS DUMP83.

I HEREBY CERTIFY THAT THE SURVEY IS OF AN EXISTING PARCEL OR PARCELS OF LAND.

---------------------------------
SURVEYOR'S SIGNATURE REGISTRATION NUMBER

200 0 200 400 600
GRAPHIC SCALE - FEET

**LEGEND:**
ECM = EXISTING CONCRETE MONUMENT
EIR = EXISTING IRON ROD
EIP = EXISTING IRON PIPE
RCP = REINFORCED CONCRETE PIPE
NIP = NEW IRON PIPE SET THIS SURVEY

PLAT SHOWING PROPERTY STANDING IN THE NAME OF
**HARVEY T. HAWKINS, JR & SELMA J. HAWKINS**
DEED BOOK 1081, PAGE 255 ** FORMERLY M. C. CRAWLEY
OFF OF NC ROUTE 48 JUST EAST OF SR 1001 @ BREWER'S CREEK

| | | |
|---|---|---|
| SCALE: 1" = 200' | APPROVED: | DRAWN BY: L.B. |
| DATE: 4-15-95 | | REVISED: 2-5-96 |

BUTTERWOOD TOWNSHIP HALIFAX COUNTY NORTH CAROLINA

BURR & ASSOCIATES, P.A.
1400 GEORGIA AVENUE
ROANOKE RAPIDS, NC 27870
(919) 537-0369

DRAWING NUMBER:
B & A 7-158


BETTY B. MAYO
CATHERINE B. CUTCHIN
DB 1502, PG 318
WILLIS J. LILES
DB 579, PG 495 FIRST ("BUTTS") TRACT
STERLING HAMILL & LOTTIE B. HAMILL
DB 650, PG 489 "FIRST TRACT"
STERLING HAMILL & LOTTIE B. HAMILL
DB 650, PG 489 "SECOND TRACT"
W. L. LILES, SR.
DB 668, PG 182, MB 6, PG 83
LEROY BUTTS & SADIE BOONE BUTTS
DB 852, PG 158
ALONG FENCE
N 06°00'07"E→2126.44'
RUN OF CREEK
ALONG RUN OF BREWER'S OR WEBB'S CREEK
THRU BEAVER POND
NORTH
PLAT CABINET 4, SLIDE 72
LOCATION MAP
SCALE: NONE
SITE
LAND AREA SUMMARY:
TRACT "A" SOUTH OF SR 1417 = 201.44 ACRES
TRACT "B" NORTH OF SR 1417 = 9.09
TOTAL LAND AREA THIS SURVEY = 210.53 ACRES
TRACT "A"
201.44 ACRES
TRACT "B"
9.09 ACRES
SR 1417 50' R/W
QUINTON MILLS & MAVIS MILLS
DB 1442, PG 540
R. W. DICKENS
DB 1507, PG 421
CHAMPION INTERNATIONAL CORP.
DB 1487, PG 51
CHAMPION INTERNATIONAL CORP.
DB 1487, PG 51
N 00°41'41"E→1191.74'
LINE OF TREES PAINTED "CHAMPION BLUE" EXTENDS 50' BEYOND PROPERTY LINE
HARVEY T. HAWKINS, JR. & SELMA J. HAWKINS
DB 1081, PG 255
ALONG FENCE
S 01°25'25"W 1067.70'
N 84°19'54"W→1031.78'
BARBED WIRE FENCE
S 00°35'39"W
S 03°36'39"W 594.84'
ALONG REMNANTS OF OLD FENCE
N 86°23'24"W 613.56'
S 06°24'47"W 889.92'
N 86°32'24"E→588.51'
S 05°55'00"E 1037.38'
REFERENCE BEARING PC 4, SLIDE 72
MRS. W. W. WARREN
DB 434, PG 325
"BURGRESS TRACT" PC 2, SL 186
THOMAS BRAXTON WARREN
DB 1128, PG 75
"MORRIS TRACT" DB 606, PG 333
THOMAS BRAXTON WARREN
DB 1128, PG 75
"MORRIS TRACT" DB 606, PG 333
TO SR 1001
TO SR 1418
I, LEWIS O. BURR, CERTIFY THAT THIS PLAT WAS DRAWN UNDER MY SUPERVISION FROM AN ACTUAL SURVEY MADE UNDER MY SUPERVISION ON 8-24-94, THAT BOUNDARY DEFINITIONS FOUND IN RECORDED PAPERS DB 1131, PG 298; DB 1501, PG 548; DB 1501, PG 551; DB 1523, PG 77 WERE USED AS THE PRIMARY GUIDES FOR THIS SURVEY; THAT THE BOUNDARIES NOT SURVEYED ARE CLEARLY INDICATED AS DRAWN FROM INFORMATION FOUND IN BOOK ---, PAGE ---; THAT THE RATIO OF PRECISION CALCULATED IS ONE IN 10000; THAT THIS PLAT WAS PREPARED IN ACCORDANCE WITH GS 47-30 AS AMENDED. WITNESS MY ORIGINAL SIGNATURE, REGISTRATION NUMBER AND SEAL THIS 14TH DAY OF OCTOBER, A.D., 1994
SURVEYOR'S SIGNATURE L-2205 REGISTRATION NUMBER
NORTH CAROLINA, HALIFAX COUNTY
I, A NOTARY PUBLIC OF THE COUNTY AND STATE AFORESAID, CERTIFY THAT LEWIS O. BURR, A REGISTERED LAND SURVEYOR, PERSONALLY APPEARED BEFORE ME THIS DAY AND ACKNOWLEDGED THE EXECUTION OF THE FOREGOING INSTRUMENT.
WITNESS MY HAND AND OFFICIAL STAMP OR SEAL THIS 14TH DAY OF OCTOBER, 1994
NOTARY PUBLIC
MY COMMISSION EXPIRES MARCH 5, 1996
LEGEND:
ECM = EXISTING CONCRETE MONUMENT
EIR = EXISTING IRON ROD
EIP = EXISTING IRON PIPE
NIP = NEW IRON PIPE SET THIS SURVEY
R/W = RIGHT OF WAY
RCP = REINFORCED CONCRETE PIPE
C/L = CHAINLINK
REFERENCES:
MAP SHOWING PROPERTY OF WILLIAM DOW BRYANT & WILLIAM A. STANSBURY; J. W. TRAYLOR & SON REGISTERED LAND SURVEYORS; APRIL 20, 1990; PLAT CABINET 4, SLIDE 72.
MAP SHOWING PROPERTY OF DENNIS A. ROSE; J. C. SHEARIN, SURVEYOR; FEBRUARY 9, 1962; MAP BOOK 10, PAGE 41.
MAP SHOWING PROPERTY OF CARRIE L. COOPER, A PORTION OF THE WEBB TRACT; SHEARIN & TRAYLOR, SURVEYORS; FEBRUARY 7, 9, 1951; MAP BOOK 6, PAGE 83.
I HEREBY CERTIFY THAT THE SURVEY IS OF AN EXISTING PARCEL OR PARCELS OF LAND.
SURVEYOR'S SIGNATURE L-2205 REGISTRATION NUMBER
200 0 200 400 600
GRAPHIC SCALE - FEET
REVISED 2-5-96: ADDED POINT NUMBERS DUMP83
PLAT SHOWING PROPERTY STANDING IN THE NAME OF
HALIFX COUNTY
DB 1131, PG 298; DB 1501, PG 548; DB 1501, PG 551; DB 1523, PG 77
SR 1417 BETWEEN SR 1001 AND SR 1418 JUST NORTH OF NC ROUTE 48
SCALE: 1" = 200'
APPROVED:
DRAWN BY: L.B.
DATE: 10-1-94
REVISED: 2-5-96
BUTTERWOOD TOWNSHIP HALIFAX COUNTY NORTH CAROLINA
BURR & ASSOCIATES, P.A.
1400 GEORGIA AVENUE
ROANOKE RAPIDS, NC 27870
(919) 537-0369
DRAWING NUMBER:
B & A 6-223