44-07

WHITE OAK SANITARY LANDFILL
HAYWOOD COUNTY,
NORTH CAROLINA

PROJECT DESIGN MANUAL

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PROJ. NO. 2913-011-01

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I

PURPOSE

I

PURPOSE

The purpose of this application is to support the Site Suitability Application approved by the State in December, 1990 and to respond to current State and Federal regulations governing the construction and operation of a Municipal Solid Waste Landfill serving Haywood County, North Carolina.

This document in hand with the "Construction Documents for the White Oak Sanitary Landfill" are intended to respond to key issues resulting from the State's review and approval of the Site Suitability Application submitted for this project. This application, in no way, is intended to superceed or reverse any information used in previous applications; rather, it is required that this application be reviewed in conjunction with the previously submitted information so that a full understanding of the project can be conveyed.

Further, this application will respond to the current State regulations as indicated in 15 NCAC 13B, Section .0504, Policy Memorandum #18, and the current EPA Subtitle "D", Section 258 federal regulations.

II

PROJECT HISTORY

II

PROJECT HISTORY

In 1990, the Haywood County Commissioners submitted to the State, a Site Suitability Application for the construction and operation of a Sanitary Landfill in the White Oak area. On December 11, 1990, the State's Division of Solid Waste Management (DSWM) issued an approval letter for that application, and outlined the requirements that would be applied to the Construction and Operation Permit Application. A copy of this letter can be found in Appendix A.

Some of the critical issues relating the abovementioned application were Wetlands, Bear Management, Groundwater and Spring Heads. The first issue, Wetlands, was resolved through obtaining a Nationwide 26 Permit from the Corp of Engineers. The bed and bank wetlands contained in the swales that traverse the proposed landfill area were delineated in the Site Suitability Application. The total area containing wetlands amounted to less than one (1) acre. Given this, Haywood County received a permit from the Corp of Engineers allowing the wetlands to be filled. The wetlands are delineated in the Construction Documents and a copy of the Permit is contained in Appendix A.

The second issue, Bear Management, presented some concern given the proposed landfill's location to the Great Smokey National Forest (a bear preserve). Haywood County went to great lengths to determine what exactly could be done to ward off bears from the landfill so as to limit personal, property and animal damage. A Bear Management Plan was submitted to the State and approved with the Site Suitability Application. Although there is not a problem with bears in the White Oak area at present, the county is proposing the protect the landfill with fencing to eliminate bear access to the site. There has been some discussion concerning the elimination of putrescible waste from the proposed landfill. While the County understands that this type of waste draws vermin to a landfill, it is almost impossible to eliminate putrescible waste from the waste stream. Therefore the County is willing to make every effort to minimize and control this type of waste at the landfill. A copy of the Bear Management Plan is contained in Appendix A.

The third issue centers around the subsurface makeup of the site. A Hydrogeological Report prepared by Law Engineering was submitted to the State for review in July of 1991 and subsequently approved in November, 1991. This report outlined the hydrogeological and geological information pertinent to the proposed landfill area contained in the entire 104 acre tract. It was then that two spring heads were determined to be located in the middle of one of the proposed landfill cells. In light of this a Spring Relief design was submitted to the State. One of the key issues that revolved around the two spring heads was the definition of surface water and groundwater and how these spring heads could be categorized. It was determined by the State Division of Environmental Management (DEM) that these two spring heads resulted from groundwater migrating through localized zones of low permeable soil of rock generally above the groundwater table. Given the fact that the recharging area serving the aquifer the spring heads are located in was to be covered by the proposed landfill liner that this aquifer would then dry up therefore eliminating the spring heads. The State approved the preliminary design for Spring Relief on October 24, 1991 and issued some requirements that would be applied to the construction plans for the landfill. A copy of this letter is contained in Appendix A. Section III of this document will respond to the issues raised in this letter.

III

PROJECT DESIGN

III

PROJECT DESIGN

Purpose:

The purpose of this Section is to provide the necessary information to support the design of the proposed landfill. This Section will dictate performances requirements, materials and construction methods as needed to fulfill the State and Federal regulations.

1.) Introduction:

The proposed White Oak Balefill is located approximately one-quarter mile west of S.R. 1338, 13 miles northeast of Waynesville, in Haywood County, North Carolina. Access to the site will be provided by the County constructing a private road off of S.R. 1338. The 104 acre site will accommodate approximately 10 acres to be used for a sanitary balefill disposal facility.

The waste proposed to be disposed at this balefill will be produced by Haywood County and all it's municipalities, except for the City of Canton, which operates it's own facility.

A geotechnical and hydrogeotechnical report was performed for the site by Law Engineering, dated July 1991 and is provided for reference in Appendix B.

2.) Site Information:

a. Legal description for calls around 103.641 acre tract for Proposed Haywood County Landfill

BEGINNING on a 14" Poplar, the common corner to Anthony W. Bramlett, et. al. deed book 285 at page 607, A. L. Bramlett, et. ux. deed book 172 at page 42 and T. N. Leatherwood deed book 92 at page 598 and runs the following calls; N10-56-07W 2309.44 feet, N31-16-14W 294.96 feet, N33-41-04W 101.24 feet, N43-59-19W 123.31 feet, NO3-21-58W 87.07 feet, N19-24-21E 60.78 feet, N29-50-18E78.79 feet, N21-07-39E 77.66 feet, N18-38-23 W 355.02 feet, N75-37-45E 347.50 feet, N63-46-50E 220.51 feet, N74-47-55E 204.53 feet, S84-57-18E 244.53 feet, S76-11-46E736.61 feet, S71-32-38E 220.21 feet, S86-36-47E 319-05 feet, S50-37-50E 539.94 feet, N31-14-55E 162.95 feet, N18-15-23E 40.01 feet, N59-29-54E 28.36 feet, N63-07-57E 36.36 feet, N37-55-32E 12.45 feet, N42-50-16E 15.43 feet, N22-16-37E 26.66 feet, N41-43-12E 21.68 feet, N 34-43-52E 171.81 feet, N24-35-00W 423.31 feet, N03-27-19W 201.59 feet, N03-05-12E 493.17 feet, N38-15-00E 185.09 feet, N34-50-59E 32.38 feet, N32-33-59E 133.32 feet, N44-35-43E 6.85 feet, N70-38-12E 10.37 feet,

N86-09-19E 170.97 feet, N80-40-56E 12.38 feet, S84-52-16E 8.07 feet, N86-51-34E 15.39 feet, N83-57-42E 14.33 feet, N89-30-56E 17.62 N87-18-18E 185 feet, N87-51-09E 404.39 feet, S77-14-08E 34.87 feet, N84-43-27E 269.97 feet, S82-14-56E 10.01 feet, N79-21-26E 23.69 feet, S79-27-10E 23.58 feet, N16-28-06W 239.12 feet, N18-07-22W 209.99 feet, N27-39-32W 19.70 feet, N23-05-55W 14.75 feet, N28-45-21W 10.25 feet, N38-47-17W 92.29 feet, N42-29-56W 216.90 N16-20-59E 74.21 feet, N05-14-59E 52.50 N02-31-37W 45.86 feet, N16-18-43E 54.20 feet, N47-31-24W 9.47 feet, N09-07-36W 45.22 feet, N27-40-36W 49.81 feet, N44-25-37W 79.23 feet, N53-23-46W 65.74 feet, N53-23-33N 135.76 feet, N79-21-28W 14.57 feet, N88-27-34W 91.41 feet, S82-24-12W 58.95 feet, S74-39-37W 35.22 feet, N10-56-07W 2309.44 feet, to the BEGINNING.

b. Responsible Individual: The proposed White Oak Balefill will be operated by Haywood County, North Carolina. Jack Horton, County Manager, will be responsible for the operation and maintenance of the balefill site. R. D. Owen will be the Site Operator at the Haywood County Balefill Site.

c. Projected Use of Land After Completion of Bale-fill: After the balefill site has reached its proposed final contours, all areas which have not been grassed previously shall be grassed. This area shall be closed to the public at all times.

d. Anticipated Lifetime of Project: The life expectancy for this Facility is approximately 5.5 years. These values were based on using a density of 1,200 lb/cy for the baled waste and anticipating that Haywood County will be disposing only approximately 140 tons/day in the balefill due to the fact that the County will be removing roughly 25% of the waste stream (Materials Recovery) prior to baling.

The volume of storage was calculated using the grid volume method. This method analyzes the elevation on a green grid and triangulates the difference between the surfaces. Grid spacing was set at 25 feet.

Cut and fill volumes were determined by the abovementioned method between the existing contours and the proposed bottom of the landfill. 6,411 grid points were analyzed and provided that 264,575 cubic yards of earth needed to be cut while only 35,540 cubic yards of fill material would be needed. Provided that cut material to fill material would be suitable, the remaining cut (229,055 cubic yards) will be stored in a stockpile area provided by the Owner.

Volume calculations were calculated between the proposed top and bottom surfaces of the balefill. The volume of fill was calculated to be 478,000 cubic yards. Based upon a 8:1 waste ratio, this provides 382,000 cubic yards for waste over the Facility.

3.) Development of the Site:

a. Methods and Sequence of Operation: This disposal facility will use the progressive trench method. A typical trench construction detail is found on page 10 of 17 in the Plans.

Disposal operations will be conducted in phases, disturbing only as much area as is required to maintain landfilling activities. As soon as possible after an area is disturbed, it will be stabilized with vegetative cover.

The construction sequence will be numerical, by phase, cell and lift numbers. A typical construction sequence for a Phase is shown on page 5 of 17 of the Plans.

The filling direction of each trench will be upslope. This direction will be utilized to help prevent stormwater from entering the leachate collection system. Berms will be used to direct the flow of surface runoff to the sediment pond. Initial access over the bottom of a new trench/cell area shall be provided by a surface of a minimum of 24 inches (thickness) of 1×10^{-2} cm/sec material. This 2' of material shall serve as a vertical drainage layer for leachate. In areas not being disturbed during the first lift of each trench, a 6 inch soil layer will be placed on top of the 24" sand layer to prevent any rain water from entering the leachate collection system. Working areas will be limited to $\pm$ 55' working faces $\pm$ 300 long. The soil layer shall be placed upstream of the working area. This layer will be removed once filling operations have reached the area where the soil is placed.

b. Waste Handling and Covering Program: The unloading of the solid waste will be confined to the smallest practicable area. Upon unloading, the waste bales will be stacked on top of each other via forklift to a maximum height of 15 feet per lift.

The baled waste will be covered at the end of each operating day with a six inch initial (daily) soil cover. Soil will not be placed on the final two rows of bales at the end of each day's operation. A protective synthetic cover will be placed over these two rows to prevent surface water from entering the waste. The cover shall be anchored with spikes through eyelets and with sandbags. At the beginning of the next day's operation, the protective cover shall be removed and the placing of bales shall be continued.

All areas left exposed with six inches of cover for a period over thirty days but not reaching final (closure) contours, must be covered with a one foot intermediate soil cover and vegetated, if the area is to be exposed during the growing season.

All initial and intermediate cover depths must be maintained until either additional waste are placed over the area or final cover is applied. A fire break will be installed every two weeks of operation. One foot of cover material will be placed as shown in the plans on sheet 12 of 17.

Upon achieving final grade in an area, final cover consisting of a 18 inch compacted soil layer with permeability of 1×10^{-7} cm/sec overlain by a 6 inch soil layer capable of supporting vegetation shall be constructed. Planting specifications may be found in the Plans on sheet 17 of 17.

c. Public Safety - Fire Protection: The County will control access to the site by providing protective fencing along the perimeter of the property and a manned gate at the entrance. The public will not be allowed to dump waste at the working area nor will they be allowed in the working area of the landfill.

The Landfill Operator will be trained and certified to operate a landfill as required by current State and Federal regulations. The Operator will be required to have access to all emergency services available in the County as the need arises on the site. The County will be required to allow the local Fire Marshal to inspect the facilities for any possible causes for a fire onsite, and the Fire Marshal will provide the necessary equipment and staff capable of fighting a landfill fire.

Spring Relief:

1.) Performance Requirements:

As indicated in the Law Engineering Report and previously in this document, there are two (2) spring heads that will be directly affected with the construction of this landfill. There are located in the Construction Documents.

The Law Engineering Report provides a flow rate for the spring heads at approximately 6.2 gallons/minute (0.0138 cfs). This measurement is indicated in the report as WP-3 (weir point no. 3). Given this, the Spring Relief system must be designed to accommodate this flow as a minimum.

Further, if contamination of the spring water were to occur, and the discharge be diverted to the leachate pond, the leachate pond would need to be designed to accommodate 8,928 gallons/day in addition to what is expected from the landfill, to provide an adequate factor of safety.

2.) Design:

The Spring Relief system proposed will consist of an excavated trench, as shown in the construction documents, filed with washed #57 river stone, an 18" perforated HDPE header pipe discharging into an 18" HDPE drain line daylighting into a swale that will convey the groundwater to the Sediment Basin. Supporting calculations and details are provided in Appendix C.

It is intended that, as the landfill liner gets constructed, the recharging area for these springs will be diminished, therefore the flow rates should drop significantly. However, the design calls for a monitoring point to be established at the Spring Relief discharge point so that contaminants can be monitored as required by NCDEM. Should some sort of contaminant be found, the drain pipe will be capped and the manhole be used as a wet well for pumping the contaminated water to the leachate pond.

The leachate pond has been designed to accommodate this flow, but considering what could be found in the field, Haywood County may need to adjust their pump and haul schedules to maintain the minimum freeboard required in the leachate pond.

COMPOSITE LINER SYSTEM:

1.) Performance Requirements:

The liner system is designed to meet current State and Federal regulations. As required by the new EPA Subtitle "D" regulations, a composite liner consisting of 24" (2 feet) of compacted soil with a permeability of 1 x 10^{-7} cm/sec with a high density polyethylene (HDPE) liner with a minimum thickness of 60 mil. A protective drainage layer must be placed on top of the HDPE liner to ensure liner quality and leachate migration.

The liner system is designed to maintain a stable slope up to 3:1 in both a saturated and dry conditions. It must also maintain it's integrity during the placement of waste in the cell. The HDPE liner's anchor trench is designed to release the liner in moments of sheer stress rather than allow the liner to be ripped or torn.

Prior to placement of the composite liner system, existing subgrade must be compacted to 95% maximum density within 2% optimum moisture content.

Grading of the subbase and clay liner base should be performed to insure that a minimum separation of four (4) feet is provided between the groundwater table and leachate.

The necessary engineering calculations supporting the leachate collection and removal system are contained in Appendix C.

2.) Site Preparation:

The site shall be cleared of trees, ground cover, debris and other material. This material shall then be disposed of properly in accordance with all federal, state and local regulations. Upon completion of the clearing operation, topsoil shall be removed and stored at the location(s) directed by the Engineer.

3.) Excavation and Sub-Base Preparation:

Bottom Grades shown on page 3 of 17 of the plans represent the top of the composite liner as detailed on sheet 11 of 17 in the Plans. Construction will begin by excavating and/or filling subbase with native soil in a particular cell/trench to an elevation 36 inches below the elevation of the top of the synthetic liner. The fill/cut areas below the composite liner will be called the "sub-base". All excess excavated material shall be stockpiled as shown on the Plans or as directed by the Owner's Engineer. All material stockpiled shall be spread to a uniform appearance with side slopes no greater than 2'H to 1'V. Stockpile soil shall not be placed within 25 feet of any excavated trench wall.

4.) Base Preparation:

The base, which will be placed directly above the subbase will consist of one foot of clean compacted native soil. The base shall be free of rocks, roots, stumps, and other debris. If any portion of the base is disturbed by rain, wind, or weather, steps shall be taken as necessary to restore the surface prior to the installation of the composite liner. At a minimum, the following construction specifications shall be adhered to:

- Placement of the base materials shall be made in multiple lifts not to exceed 6 inches per lift.
- Each lift shall be compacted to a minimum of 95% as determined by the Standard Proctor Test, ASTM-D698.
- Testing for the base material shall be as follows:

-Borrow source testing:

Test	Method	Frequency
Grain Size	ASTM D422	1,000 yd^3
Moisture Content	ASTM D2216	1,000 yd^3
Atterberg Limits	ASTM D4318	5,000 yd^3
Moisture-density	ASTM D 698	5,000 yd^3 Curve and All Changes in Material
Lab permeability (remolded samples)	US Army Corps EM 1110-2-1902	10,000 yd^3

-Base testing during construction:

Test	Method	Frequency
Density	ASTM D2922 or D2937 or D2167	10,000 ft^2/lift
Moisture Content	ASTM D2216	10,000 ft^2/lift
Undisturbed Permeability	US Army Corps EM 1110-2-1902	40,000 ft^2/lift
Moisture Content (UD sample)	ASTM D2216	40,000 ft^2/lift
Atterberg Limits	ASTM D4318	40,000 ft^2/lift

Grain Size	ASTM D422	40,000 ft^2/lift

5.) Clay Liner Installation:

The clay liner beneath the synthetic HDPE liner shall be a combination of native soils and Volclay as manufactured by American Colloid Company (See Appendix C). These soils shall be tested to insure that their permeabilities are 1 x 10^{-7} cm/sec or lower.

The clay liner shall be as a minimum twenty-four (24) inches in thickness and shall be placed directly above the base layer. The contractor shall construct a test strip to determine the required admixture of Volclay to native soils, the proper number of passes needed with a roller to achieve compaction and permeability, etc. At a minimum, the following construction specifications shall be adhered to:

- Placement of the liner materials shall be made in multiple lifts not to exceed 6 inches per lift.
- Each lift shall be compacted to a minimum of 95% as determined by the Standard Proctor Test, ASTM-D698.
- The finished layer shall be kept moist and shall not under any circumstances be allowed to dry prior to placement of the HDPE liner.
- A vertical hydraulic conductivity value of 1 x 10^{-7} cm/sec or lower shall be maintained for all clay liner materials.

- The top of the clay shall be rolled with a steel wheel roller to assure a smooth, even surface for the HDPE liner installation. If any portion of the clay liner is disturbed by weather or other causes, steps shall be taken as necessary to restore the surface prior to the installation of the remaining HDPE liner.

- Written reports and records of the testing shall be submitted to the Engineer. The Contractor shall receive written approval from the Engineer prior to installing the HDPE liner.

6.) HDPE Synthetic Liner Installation:

a. Materials: The synthetic liner shall consist of high density polyethylene (HDPE). The clay liner shall be overlain with a 60 mil HDPE liner. A smooth 60 mil liner may be used on the bottom area of the balefill, while a texture 60 mil liner will be required on the sideslopes of the balefill. The HDPE liner shall conform to, or exceed the requirements of the National Sanitation Foundation Standard Number 54(NSF-54). The textured liner shall have physical properties that are equal that of the smooth liner. Exhibit IV-1 shows the NSF-54 requirements for HDPE.

b. Field Panel Identification: A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a factory panel or a portion of roll or factory panel cut in the field. Two cases can be considered:

   . If the geomembrane is fabricated into panels in a factory panel cut in the field.

   . If the geomembrane is not fabricated into factory panels, a field panel is a roll or a portion of roll cut in the field.

   It shall be the responsibility of the Contractor to ensure that each field panel is given an "identification code" (number or letter-number) consistent with the layout plan.

TABLE 5. MATERIAL PROPERTIES

HIGH DENSITY POLYETHYLENE (HDPE)

Property	Test Method	Unsupported(U) 30	36	40	50	60	80	100
Gauge (nominal)	—	30	36	40	50	60	80	100
Thickness, mils minimum ±10%	ASTM D1593 Para 8.1.3	27	32	36	45	54	72	90
Specific Gravity (minimum)	ASTM D792 Method A	0.940	0.940	0.940	0.940	0.940	0.940	0.940
Minimum Tensile Properties (each direction)	ASTM D638							
1. Tensile Strength Yield (lb/in width)		50	60	70	90	120	140	180
2. Tensile Strength at Break (lb/in width)		90	108	120	150	180	240	300
3. Elongation at Yield (percent)		10	10	10	10	10	10	10
4. Elongation at Break (percent)		500	500	500	500	500	500	500
5. Modulus of Elasticity (lbs/sq in)		80,000	80,000	80,000	80,000	80,000	80,000	80,000
Tear Resistance (lb, minimum)	ASTM D1004 Die C	15	18	20	25	30	40	50
Low Temperature, °F	ASTM D746 Procedure B	-40	-40	-40	-40	-40	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	±3	±3	±3	±3	±3	±3	±3
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)							
1. Tensile Strength Yield		10	10	10	10	10	10	10
2. Tensile Strength at Break		10	10	10	10	10	10	10
3. Elongation at Yield		10	10	10	10	10	10	10
4. Elongation at Break		10	10	10	10	10	10	10
5. Modulus of Elasticity		10	10	10	10	10	10	10
Environmental Stress Crack (minimum, hours)	ASTM D1693 (as modified in Appendix A)	500	500	500	500	500	500	500
		Factory and Field Seam Requirements[1]						
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	45	54	63	81	108	108	135
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]
Dead Load								
Room Temperature 73°F 50% Bonded Seam Load	See Appendix A	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Elevated Temperature 158°F 25% Bonded Seam Load	See Appendix A	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Resistance to Soil Burial	ASTM D3083 (as modified in Appendix A)							
Peel Adhesion		FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]
Bonded Seam Strength (percent change maximum in original value)		-10	-10	-10	-10	-10	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further idscussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because thes materials may not be appropriate for every application. Specific information should be obtained from the manufacturer regarding installation requirements, exposure conditions, performance expectations, and experience factor.

This field panel identification code shall be as simple and logical as possible.

The Contractor shall establish a table or chart showing correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

c. Field Panel Placement:

Location: The Contractor shall verify that field panels are installed at the location indicated in the layout plan, as approved or modified.

Installation Schedule: Field panels may be installed using any one of the following schedules:

- All field panels are placed prior to field seaming (in order to protect the subgrade from erosion by rain);
- Field panels are placed one at a time and each field panel is seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
- Any combination of the above.

If all field panels are placed prior to field seaming, begin in the sump area and proceed upward and outward with "shingle" overlaps to facilitate drainage in the event of precipitation. Also proceed in the direction of prevailing winds. The Contractor is fully responsible for placement procedures.

The Engineer shall evaluate every change in the schedule proposed by the Contractor and advise him on the acceptability of the change in writing. The Contractor shall verify that the condition of the supporting soil has not changed detrimentally during installation.

The Contractor shall record the identification code, location, and date of installation of each field panel.

Weather Conditions: Geomembrane placement shall not proceed at an ambient temperature below 5°C (40°F). Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

The Contractor shall verify that the above conditions are fulfilled.

The Contractor shall inform the Engineer if the above conditions are not fulfilled.

Method of Placement: The Contractor shall verify the following:

- Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means.
- The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement.
- All personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane.
- The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.
- The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels).
- Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).
- Direct contact with the geomembrane is minimized; i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Contractor shall inform the Engineer if the above conditions are not fulfilled.

Damage: The Engineer shall inspect each panel, after placement and prior to seaming, for damage. The Engineer shall advise the Contractor which panels, or portions of panels, should be rejected, repaired, or accepted.

Damaged panels or portions of damaged panels which have been rejected shall be marked and their removal from the work area recorded by the Engineer. Repairs shall be made according to procedures described in Section IV.H.

8.) Field Seaming:

a. Seam Layout: The Contractor shall provide the Engineer with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Engineer shall review the seam layout drawing and verify that it is consistent with accepted state of practice. No panels not specifically shown on the seam layout drawing may be used without the Engineer's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 1.5 mm (5 ft.) from the toe of the slope, or areas of potential stress concentrations.

A seam numbering system compatible with the panel numbering system shall be shown on the layout drawing.

b. Requirements of Personnel: All personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests. At least one seamer shall have experience seaming a minimum of 100,000 m^2 (1,000,000 ft^2) of polyethylene geomembrane using the same type of seaming apparatus to be used to fabricate the site-specific geomembrane. The most experienced seamer, the "master seamer", shall provide direct supervision over less experienced seamers.

c. Seaming Equipment and Products: Approved processes for field seaming are extrusion welding and fusion welding. The Preferred means of seaming shall be the double fusion process.

Proposed alternate processes shall be documented and submitted to the Engineer for approval. Only an apparatus which has been specifically approved by make and model shall be used.

The Contractor shall submit all documentation listed below to the Engineer for his concurrence.

Fusion Process: The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures.

The Seamer shall log ambient, seaming apparatus, and geomembrane surface temperatures as well as seaming apparatus pressures and speed.

The Contractor shall:

- Maintain on-site the number of spare operable seaming apparatuses decided at the Pre-Construction Meeting.
- Verify that equipment used for seaming will not damage the geomembrane.
- Grind the edge of any cross seam to a smooth incline (top and bottom) prior to welding.
- Place the electric generator on a smooth base so no damage occurs to the geomembrane.
- Place a smooth insulating plate or fabric beneath the hot welding apparatus after usage.
- Protect the geomembrane from damage in heavily trafficked areas.
- Provide a movable protective layer directly below each overlap of geomembrane that is to be seamed to prevent build-up of moisture between the sheets.

Extrusion Process: The extrusion-welding apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle.

The Contractor shall provide documentation regarding the extrudate to the Engineer, and shall certify that the extrudate is compatible with the specifications, and in any event is comprised of the same resin as the geomembrane sheeting.

The Contractor shall log apparatus temperatures, extrudate temperatures, ambient temperatures, and geomembrane surface temperatures at the beginning of each seaming period, and at least once each four hours, for each extrusion apparatus used that day.

The Contractor shall:

- Maintain on-site the number of spare operable seaming apparatuses decided at the Precon-struction Meeting.
- Verify that equipment used for seaming will not damage the geomembrane.

- Purge the extruder prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel.

- Place the electric generator on a smooth base such that no damage occurs to the geomembrane.

- Place a smooth insulating plate or fabric beneath the hot welding apparatus after usage.

- Protect the geomembrane from damage in heavily trafficked areas.

d. Seam Preparation: The Contractor shall:

- Prior to seaming, clean the seam area of moisture, dust, dirt, debris of any kind, and foreign material.

- If seam overlap grinding is required, complete the process according to the Geomembrane Manufacturer's instructions within one hour of the seaming operation in a way that does not damage the geomembrane.

- Align seams are with the fewest possible number of wrinkles and "fishmouths".

e. Weather Conditions for Seaming: The required weather conditions for seaming are as follows:

- No seaming shall be attempted at an ambient temperature below 5°C (40°F) or above 40°C (104°F).

- Between ambient temperatures of 5°C (40°F) and 10°C (50°F), seaming is allowed if the geomembrane is preheated by either sun or hot air device, and if there is no excessive cooling resulting from wind.

- Above an ambient temperature of 10°C (50°F), no preheating is required.

- In all cases, the geomembrane shall be dry and protected from wind.

The Contractor shall verify that these weather conditions are fulfilled and will advise the Engineer if they are not. The Engineer shall then decide if the installation shall be stopped or postponed.

f. Overlapping and Temporary Bonding: The Contractor shall:

- Overlap the panels of geomembrane a minimum of 75 mm (3 in.) for extrusion welding and 125 mm (5 in.) for fusion welding, but in any event provide sufficient overlap to allow peel tests to be performed on the seam.

- Insure that the procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any spot welding apparatus is controlled such that the geomembrane is not damaged.

The Contractor shall log all appropriate temperatures and conditions, and shall log and report to the Engineer any non-compliances.

g. Trial Seams: Trial seams shall be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period, and at least once each four hours, for each seaming apparatus used that day. Also, each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as actual seams.

The trial seam sample shall be at least 1.0 m (3 ft.) long by 0.3 m (1 ft.) wide (after seaming) with the seam centered lengthwise. Seam overlap shall be as indicated in Section IV.G.6.

Two adjoining specimens, each 22 mm (1 in.) wide, shall be cut from the trial seam sample. The specimens shall be tested respectively in shear and peel using a field tensiometer; the seam strength in shear shall be at least 90% of typical minimum average yield and the peel strength shall be at least 60% of the typical minimum average yield of the parent material. If a specimen fails, the entire operation shall be repeated.

If the additional specimen fails, the seaming apparatus and seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams achieved.

The Engineer shall observe all trial seam procedures. The remainder of the successful trial seam sample shall be assigned a number and marked accordingly by the Contractor, who shall also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description.

The sample itself shall be cut into three pieces, one to be retained in the Owner's archives, one to be given to the Contractor, and one to be tested by the Quality Assurance Laboratory.

After completion of the above described tests, the remaining portion of the trial seam sample can be discarded. Alternatively, if agreed upon between the parties involved and documented by the Engineer in his daily report, the remaining portion of the trial seam sample can be subjected to destructive testing. If a trial seam sample fails a test conducted by the Quality Assurance Laboratory, then a destructive test seam sample shall be taken from each of the seams completed by the seamer during the shift related to the considered trial seam.

These samples shall be forwarded to the Quality Assurance Laboratory and, if they fail the tests, the procedure indicated in Section IV.H. shall apply. The conditions of this paragraph shall be considered as met for a given seam if a destructive seam test sample has already been taken.

h. General Seaming Procedure: Unless otherwise specified, the general seaming procedure used by the Contractor shall be as follows:

- For fusion welding, a movable protective layer of plastic may be required to be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded.

- If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

- Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap.

  The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 (6 in.) beyond the cut in all directions.

- If seaming operations are carried out at night, adequate illumination shall be provided at the Contractor's expense.

- Seaming shall extend to the outside edge of panels to be placed in the anchor trench.

The Contractor shall verify that the above seaming procedures are followed, and shall inform the Engineer if they are not.

i. Nondestructive Seam Continuity Testing:

a. Concept: The Contractor shall nondestructively test all field seams over their full length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. (Vacuum testing and air pressure testing are described in Sections IV.G.9.b. and IV.G.9.c. respectively.)

Continuity testing shall be carried out as the seaming work progresses, not at the completion of all field seaming.

The Engineer shall:

- Observe all continuity testing.
- Record location, date, test unit number, name of tester, and outcome of all testing.
- Inform the Contractor of any required repairs.

The Contractor shall complete any required repairs in accordance with Section IV.H.

The Engineer shall:

- Observe the repair and re-testing of the repair.
- Mark on the geomembrane that the repair has been made.
- Document the results.

The following procedures shall apply to locations where seams cannot be nondestructively tested:

- All such seams shall be cap-stripped with the same geomembrane.
- If the seam is accessible to testing equipment prior to final installation, the seam shall be nondestructively tested prior to final installation.

- If the seam cannot be tested prior to final installation, the seaming and cap-stripping operations shall be observed by the Engineer and Contractor for uniformity and completeness.

The seam number, date of observation, name of tester, and outcome of the test or observation shall be recorded by the Engineer.

Vacuum Testing: The equipment shall be comprised of the following:

- A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;
- A steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;
- A rubber pressure/vacuum hose with fittings and connections;
- An approved applicator;
- A soapy solution.

The following procedures shall be followed:

- Energize the vacuum pump and reduce the tank pressure to approximately 35 kPa (5 psi) (10 in. of Hg.) gauge.
- Wet a strip of geomembrane approximately 0.3 m by 1.2 m (12 in. by 48 in.) with the soapy solution.
- Place the box over the wetted area.
- Close the bleed valve and open the vacuum valve.
- Ensure that a leak tight seal is created.
- For a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles.

- If no bubble appears after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 75 mm (3 in.) overlap, and repeat the process.

- All areas where soap bubbles appear shall be marked and repaired in accordance with Section IV.H.

Air Pressure Testing (For Double Fusion Seam Only):

The following procedures are applicable to those processes which produce a double seam with an enclosed space.

The equipment shall be comprised of the following:

- An air pump (manual or motor driven) capable of generating and sustaining a pressure of 200 kPa (30 psi) and mounted on a cushion to protect the geomembrane;

- A rubber hose with fittings and connections:

- A sharp hollow needle, or other approved pressure feed device with a pressure gauge.

The following procedures shall be followed:

- Seal both ends of the seam to be tested.

- Insert needle or other approved pressure feed device into the tunnel created by the fusion weld.

- Insert a protective cushion between the air pump and the geomembrane.

- Energize the air pump to a pressure between 160 and 200 kPa (25 and 30 psi), close valve, and sustain pressure for approximately 5 minutes.

- If loss of pressure exceeds 15 kPa (2 psi) or does not stabilize, locate faulty area and repair in accordance with Section IV.H.

- At the conclusion of the pressure test, the end of the seam opposite the pressure gauge shall be cut. A decrease in gauge pressure must be observed or the air channel will be considered "blocked" and the test will be repeated after the blockage is corrected.

- Remove needle or other approved pressure feed device and seal.

j. Destructive Testing:

Concept: Destructive seam tests shall be performed at selected locations. The purpose of these tests is to evaluate seam strength. Seam strength testing shall be done as the seaming work progresses, not at the completion of all field seaming.

Location and Frequency: Engineer shall select locations where seam samples will be cut out for laboratory testing. Those locations shall be established as follows:

- A minimum frequency of one test location per 150 m (700 ft.) of seam length. This minimum frequency is to be determined as an average taken throughout the entire facility.

- Test locations shall be determined during seaming at the Engineer's discretion. Selection of such locations may be prompted by suspicion of excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The Contractor shall be informed in advance of the locations where the seam samples will be taken.

Sampling Procedure: Samples shall be cut by the Contractor as the seaming progresses in order to have laboratory test results before the geomembrane is covered by another material. The Engineer shall:

- Observe sample cutting.

- Assign a number to each sample, and mark it accordingly.

- Record sample location on layout drawing.

- Record reason for taking the sample at this location (e.g., statistical routine,

suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section IV.H.3. The continuity of the new seams in the repaired area shall be tested according the Section IV.G.9.b.

Size of Samples: At a given sampling location, two types of samples shall be taken by the Contractor. Each of these samples shall be 0.25 mm (1 in.) wide by 0.3 m (12 in.) long, with the seam centered parallel to the width. The distance between these two samples shall be 1.1 m (42 in.). If both samples pass the field test described in Section IV.H., a sample for laboratory testing shall be taken.

The sample for laboratory testing shall be located between the two samples for field testing. The sample for laboratory testing shall be 0.3 m (12 in.) wide by 1.1 m (42 in.) along with the seam centered lengthwise. The sample shall be cut into two parts and distributed as follows:

- one portion to the Contractor for laboratory testing;
- one portion to the Owner for archive storage;

Final determination of the sample sizes shall be made at the Pre-Construction Meeting.

Field Testing: The two 25 mm (1 in.) wide strips mentioned in the section above shall be tested in the field, by hand or tensiometer, for peel and shear respectively and shall not fail in the seam. Also, the shear and peel strength shall be at least 90% and 60%, respectively, of the typical minimum average yield strength of the parent material. If any field test samples fails to pass, then the procedures outlined in Section IV.G.10.g. shall be followed.

The Engineer shall witness all field tests and mark all samples and portions with their number. The Engineer shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressure, and pass or fail description, and attach a copy to each sample portion.

Quality Assurance Laboratory Testing: Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the Contractor in a manner which will not damage the test sample.

The Contractor will verify that packaging and shipping conditions are acceptable. The Engineer will be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetic Construction Quality Assurance Laboratory. The Contractor shall pay all costs involved in destructive test at the QA Laboratory. The Geosynthetic Construction Quality Assurance Laboratory shall be selected by the Contractor and approved in writing by Engineer.

Testing shall include "Seam Strength" [ASTM D638 with type M-1 specimen 10 mm (0.5 in.) wide tested at 50 mm (2 in.) per minute] and "Peel Adhesion" (ASTM D413 as modified in NSF Appendix A). These terms are defined in the specifications. The minimum acceptable values to be obtained in these tests are those indicated in Table 8-1, and the specifications. At least 5 specimens shall be tested for each test method. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear..).

The Geosynthetic Construction Quality Assurance Laboratory shall provide test results no more than 48 hours after they receive the samples. The Engineer shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Contractor.

Should field tensiometer testing be carried out, the following procedure should be followed: if the test passes, the sample qualifies for testing in the laboratory; if it fails, the seam should be repaired in accordance with Section IV.H.

Procedures for Destructive Test Failure: The following procedures shall apply whenever a sample fails a destructive test, whether that test conducted by the Geosynthetic Construction Quality Assurance Laboratory, or by field tensiometer. The Contractor has two options:

- The Contractor can reconstruct the seam between any two passed test locations and retest the seam destructively and non-destructively.

- The Contractor can trace the welding path to an intermediate location [at 3m (10 ft.) minimum from the point of the failed test in each direction] and take a small sample for an additional field test at each location. If these additional samples pass the test, then full laboratory samples are taken. If these laboratory samples pass the test, then the seam is reconstructed between these locations. If either samples fails, then the process is repeated to establish the zone in which the seam should be reconstructed.

All acceptable seams must be bounded by two locations from which samples passing laboratory destructive test have been taken. In cases exceeding 50 m (150 ft.) of reconstructed seam, a sample taken from the zone in which the seam has been reconstructed must pass destructive testing.

The Engineer shall document all actions taken in conjunction with destructive test failures.

8.) Defects and Repairs:

a. Identification: All seams and non-seam areas of the geomembrane shall be examined by the Engineer and the Contractor for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be broomed or washed by the Contractor if the amount of dust or mud inhibits examination.

b. Evaluation: Each suspect location both in seam and non-seam areas shall be non-destructively tested using the methods described in Section IV.G.9.c. as appropriate. Each location which fails the non-destructive testing shall be marked by the Engineer and repaired by the Contractor. Work shall not proceed with any materials which will cover locations which have been repaired until laboratory test results with passing values are available.

c. Repair Procedures: Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas.

The final decision as to the appropriate repair procedure shall be agreed upon between the Contractor and Engineer.

The procedures available include:

- Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
- Grinding and rewelding, used to repair small sections of extruded seams;
- Spot welding or seaming, used to repair small tears, pinholes, or other minor localized flaws;
- Capping, used to repair large lengths of failed seams;
- Topping, used to repair areas of inadequate seams, which have an exposed edge;
- Removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions shall be satisfied:

- Surfaces of the geomembrane which are to be repaired shall be roughened no more than one hour prior to the repair;
- All surfaces must be clean and dry at the time of the repair;
- All seaming equipment used in repairing procedures must be approved by the Engineer;
- The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the Engineer and Contractor;
- Patches or caps shall extend at least 150 mm (6 in.) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 75 mm (3 in.); and
- The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

d. Verification of Repairs: Each repair shall be numbered and logged. Each repair shall be non-destructively tested using the methods described in Section IV.G.9.c. as appropriate. Repairs which pass the non-destructive test shall be taken as an indication of an adequate repair.

Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the Engineer. Failed tests indicate that the repair shall be redone and retested until a passing test results. The Engineer shall observe all non-destructive testing of repairs and shall record the number of each repair, date, and test outcome.

e. Large Wrinkles: When seaming of the geomembrane liner is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the Engineer shall observe the geomembrane wrinkles. The Engineer shall indicate to the Contractor which wrinkles should be cut and reseamed. The seam thus produced shall be tested like any other seam.

f. Bridging: Bridging of the HDPE liner is not acceptable. Determinations of bridging shall be made during the coolest part of the day.

9.) Backfilling of Anchor Trench: The anchor trench shall be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. The anchor trench shall be backfilled and compacted by the Contractor as outlined in the specifications. Design calculations for anchor trench stability can be found in Appendix F.

Care shall be taken when backfilling the trenches to prevent any damage to the membrane.

The Engineer shall observe the backfilling operation and advise the Contractor of any problems.

10.) Liner System Acceptance: The Contractor and the Manufacturer shall retain all ownership and responsibility for the geomembrane in the lining system until acceptance by the Owner.

The geomembrane lining system shall be accepted by the Owner when:

- The installation is finished;
- Verification of the adequacy of all seams and repairs, including associated testing, is complete;
- All documentation of installation is completed including the Engineer's final report; and
- The Contractor provides the Owner with "as built" drawings of the panel layout, panel numbers and seam numbers.

Different metals may be substituted in Item 4 for testing. This may be needed to determine the generated leachate strength. After gathering enough analyses results, suitable treatment system (to be constructed on site) will be proposed for final disposal of the leachate.

6.) Inspection and Testing: Prior to the placement of waste in any cell, the leachate system for that cell shall be inspected by a registered professional engineer licensed to practice engineering in the State of North Carolina.

The engineer shall be an independent third party and shall issue a letter stating that the leachate collection system has been installed correctly, according to the design plans.

STORMWATER MANAGEMENT SYSTEM:

1.) Performance Requirements:

The site drainage design provides berms and ditches to divert stormwater run-off, from active landfill areas to the stormwater sedimentation pond.

A. Prevention of Surface Water Flow Onto Waste-Filled Areas:

Surface water passing through the landfill site shall be diverted by the use of ditches, berms and drainage swales as shown on the Plans. The waste fill areas in the Sanitary Balefill Facility are contained within a synthetic liner. Rainwater coming in contact with waste shall be handled as leachate and will gravity flow through the leachate collection system to the leachate holding structure. Rainwater not falling directly on the active working face will be handled as stormwater.

B. Stormwater Run-Off Controls

As stated above, rainwater not coming in contact with waste will be handled as stormwater. Cells with no waste will be separated from cells with waste by means of berms. These berms will prevent any stormwater from running on or off the cell that contains waste. In cells where there is no waste, the sand layer located over the leachate collection pipes will be covered by off-spec HDPE liner material. Due to the width of the sand layer, there will be an overlap of HDPE material along the center. The HDPE material will be scored into the protective drainage layer on either side of the sand layer about 6 inches to control slippage. The operator will provide sandbags along the middle overlap to keep the HDPE material from blowing off the sand layer.

In general, the following design procedures were used.

1. Stormwater runoff for designing ditches, culverts and downdrains were calculated using the Rational formula: $Q = C \times I \times A$
   where
   - Q = flow in cubic feet per second (cfs)
   - C = runoff coefficient
   - I = intensity (25 year storm) Rainfall intensity curves for the Atlanta area were used.
   - A = area in acres draining to the pond

2. Sediment ponds were designed to detain the volume of runoff waters produced from a 24-hour, 25-year storm event. A computer software package known as "Quick TR-55" by Haestad Methods was utilized to determine the volume of water produced from this particular storm event.

3. The riser pipe was designed to carry the 25 year 24 hour storm. Flow at a particular elevation is computed either by the weir or orifice equations below.

$Q = KLH^{3/2}$ (weir equation)

- Q = flow in cfs
- K = weir constant
- L = length of weir (in this case this would be the circumference of the riser pipe)
- H = hydraulic head over the weir

$Q = CA(2gH)^{0.5}$

- C = construction and energy loss coefficent
- A = area of opening
- g = acceleration due to gravity
- H = orifice head

The larger of the two flows controls.

4. The barrel pipe (RCP) through the embankment was sized according to Bernoulli's equation

$$H = 1 + Ke + \frac{29n^2L}{R^{1.33}} \frac{V^2}{2g}$$

Where:

- H = head of pipe
- Ke = entrance loss coefficient (1.0 for RCP)
- n = Manning's coefficient
- L = length of the pipe
- V = velocity in feet/sec = Q/A
- R = hydraulic radius = (wetted perimeter/area)

5. The concrete encasement required to prevent floating of the riser pipe was calculated using the following equations:

$$\text{Required volume of concrete} = \frac{(B-W)h}{58.4}$$

Where:

- h = height of riser pipe (ft)
- W = weight of riser (lb/ft)
- B = Buoyant force (lb/ft)

(Weight of submerged concrete = 87.6 lbs/ft^3)

To provide a safety factor of 1.5:

$87.6/1.5 = 58.4$ lbs/ft^3

6. The emergency spillway was sized using the weir equation:

$$Q = KLH^{3/2}$$

Where:

K = 3.10 (discharge coefficient for broad crested weirs)
L = width of weir (ft)
H = water depth over weir (ft)

Copies of calculations for all the ponds and stormwater piping are outlined under a separate document submitted with this report entitled "Erosion and Sediment Control Notebook for White Oak Sanitary Landfill, Haywood County, North Carolina.

Stormwater will be released from the ponds in such a manner that does not increase the total runoff from the site from its predeveloped condition. Sediment accumulated in the ponds will be removed when sediment levels have reached the design depths as shown on the silt gauges for the ponds. Silt gauges will be installed in all ponds as shown on the Plan of Operation.

Additional siltation and erosion control measures include:

1. Disturbing only as much area as necessary at any one time to maintain landfilling operations.
2. Seeding/mulching of all disturbed areas will commence as soon as practically possible.
3. Use of hay bales, silt fences, or equivalent devices down-gradient of disturbed areas, stockpiles, around drainage pipes inlets and outlets and at intervals along grassed waterways, until such time as permanent vegetation is established.
4. Placement of rip-rap at the outlet of all sediment pond piping, downdrains, and cross drains to aid in the prevention or erosion.

<u>Access Control:</u> Sediment ponds may be fenced with a minimum 4 foot high field fence (hog wire). Gates will be provided for equipment access for the purpose of maintenance if a fence is installed. "DANGER/NO TRESPASSING" signs should be placed at the perimeter of the facility.

DUST, LITTER AND ODOR CONTROL:

Dust control measures shall be provided as necessary to prevent creating a nuisance to adjacent landowners or to landfill employees. No oils or chemicals (other than water) shall be used to dust suppression without written approval from the North Carolina Department of Environment, Health, and Natural Resources. Minimum dust control will include a water truck for wetting of dust roads.

Blowing litter shall be controlled by fencing and policing the area daily.

Odor control measures shall be provided as necessary to prevent any nuisance to adjacent landowners. Minimum odor control measures will include regular daily cleanup of the site and a constant cover of exposed waste. Flaring of methane vents and other more aggressive odor control measures will be provided as deemed necessary by the State Inspector.

CLOSURE AND POST-CLOSURE:

1.) Performance Goals:

The design is intended to meet the requirements as specified in Subpart F, Section 258.60 of EPA Subtitle "D" Regulations.

The final cap will comprise of two (2) layers; the first layer (infiltration layer) will be eighteen (18) inches of earthen material with a permeability of 1×10^{-7} which is the equivalent of the composite liner system; the second layer (erosion layer) will be six (6) inches of earthen material capable of sustaining native plant life and provide protection from wind and water erosion.

The infiltration layer will be constructed using native soils excavated during construction mixed with the admixture Volclay similar to the methods proposed to be used with the clay layer of the composite liner. Refer to Section III.C.5 of this document for further information. The erosion layer will consist of native soils installed and permanent seeding applied and stabilized to provide adequate erosion control. Anticipated Soil Loss calculations are provided in Appendix C. Refer to Section IV.L.2-4 of this document for further information.

Since the sanitary landfill solid waste material is contained between a synthetic liner and a cap barrier soil, methane gas generated should be confined within the fill area. Gas vents shall be installed when the cap barrier soil is placed during final closure in the completed areas. Gas vents will be installed as specified on the Construction Documents. Figure VI-1 details the gas vent construction.

Monitoring of Methane Migration: Methane gas generation and migration shall be monitored on a quarterly basis using an MSA Explosimeter (or equal). The test method shall involve field testing of methane monitoring wells placed at the perimeter of the completed landfill area.

If methane is found to exceed 100% of the lower explosive limit (LEL) at the site boundary or 25% LEL in any structure, then this condition shall be reported immediately to the division.
A "NO SMOKING" sign shall also be displayed at the entrance to the landfill. "NO SMOKING" rules shall be strictly enforced on the landfill site.

Corrective Action: Should LEL's for methane gas exceed the limits described in section A above, then corrective action must be taken immediately. Corrective action shall involve but is not necessarily limited to the following:

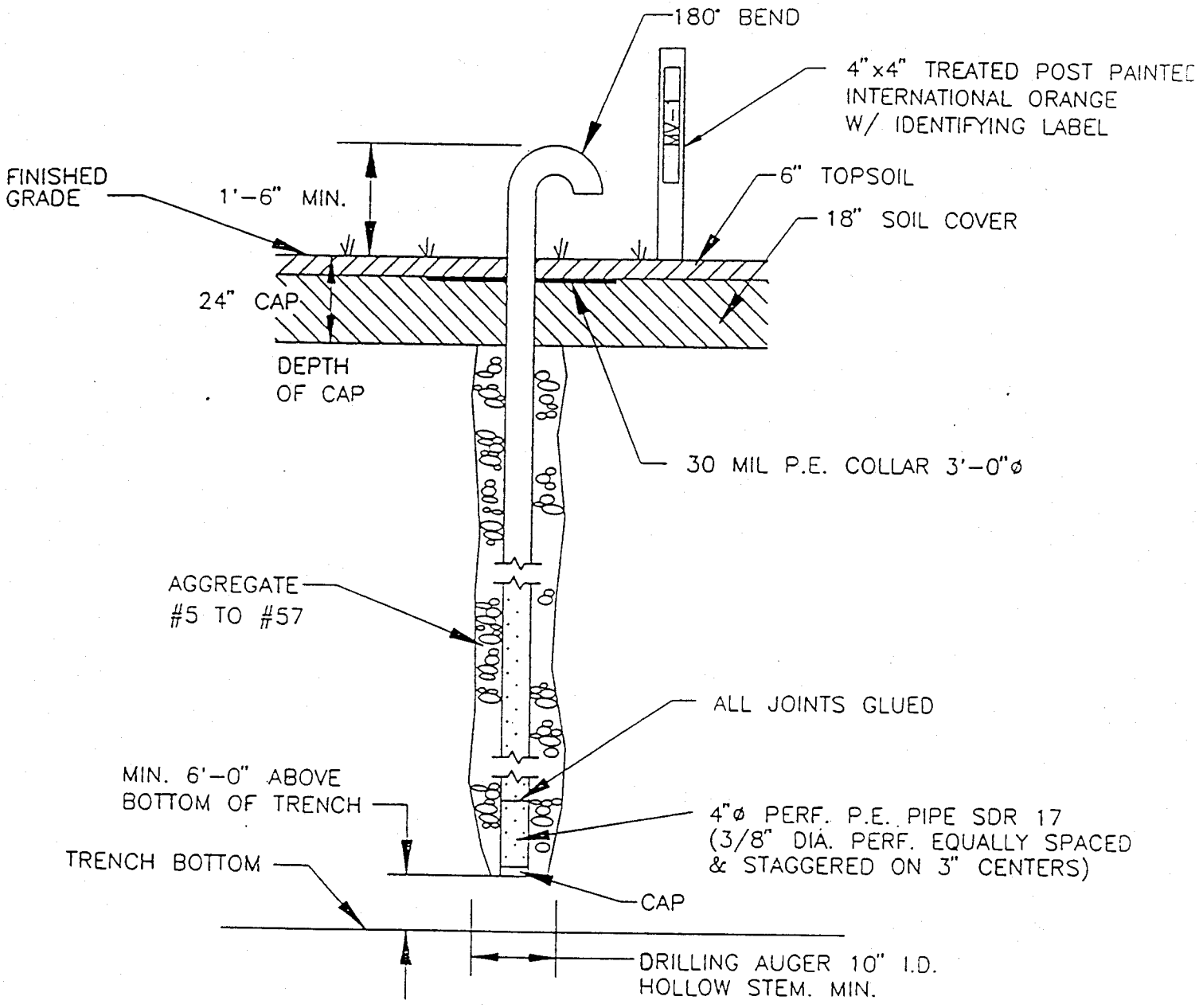
-Clearing the area of personnel and equipment
-Posting of warning signs
-Contacting an engineer to perform additional testing and recommend corrective action.

The owner will commence closure procedures no later than 30 days after the date on which the landfill receives the last known final load of wastes. Prior to closure the owner will notify the State DSWM of the status of the landfill and prepare and submit a closure plan for their review. The closure plan will include the following:

- A description of the final cap and installation procedures.
- An estimate of the area to be closed.
- An estimate of the total waste accepted by the facility.
- A schedule for completion of the closure.
- Provide test holes for confirmation of compliance for final cover.
- Any other data as required by 15A NCAC 13B Section .0510 or EPA Subtitle "D" Subpart F Section 258.60, paragraphs c-j.

Post closure care as outlined in EPA Subtitle "D" Subpart F, Section 258.61 will consist of the following:

- Maintaining the integrity of the final cap, including making repairs as required by settlement, erosion, or other means damaging the final cap.
- Maintaining the leachate collection and removal system.
- Continued monitoring of the groundwater as required by the EPA and NCDSWM.
- Continued monitoring of methane gas as required by the EPA and NCDSWM.
- Indicate who is the responsible party for post closure care.
- Indicate and maintain the planned use(s) of the property so as to ensure the integrity of the landfill systems.
- Maintain reports of the monitoring and maintenance activities during the post closure care period for submission the State DSWM at the completion of the post closure period.



GAS VENT DETAIL

N.T.S.

GROUNDWATER/SURFACE WATER MONITORING:

1.) INTRODUCTION & REQUIREMENTS:

Water quality monitoring is required by the North Carolina Solid Waste Management Division to detect and quantify contamination, as well as to measure the effectiveness of engineered disposal systems. A ground water and surface water monitoring network for this site has been designed to provide an early warning of disposal system failure. This plan will define the parameters for analysis, frequency of collection, procedures and techniques for sample collection, sample preservation and shipment, analytical procedures and chain of custody control. This plan conforms to the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities. The information listed below is based on and taken from site investigation reports completed by Law Engineering Inc., August 1991.

An application for permit for well construction should initially be submitted to:

N. C. Dept. of Environment, Health, and Natural Resources
59 Woodfin Place
Asheville, NC 28802
Attn: Groundwater Section
Phone (704) 251-6208

The North Carolina Solid Waste Management Division should also be notified of the intended design and location of the wells.

2.) Geologic Conditions/Monitoring Well Locations:

Geologic conditions for this site are described in investigation reports completed by Law Engineering., August 1991. The location and placement of monitoring wells were recommended by Law Engineering Inc.

These recommendations were followed in the preparation of this groundwater monitoring plan.

3.) Borehole Information:

See sheet 2 of 16 of the plans for the borehole information.

4.) Monitoring Well Design and Construction:

All monitoring wells shall be certified as being constructed according to this plan by a registered engineer or registered geologist.

- Drilling Methods

A variety of well drilling methods are available for the purpose of installing groundwater monitoring wells. The drilling method shall minimize the disturbance of subsurface materials and shall not cause contamination of the groundwater. Regardless of the drilling method selected, drilling equipment shall be steam cleaned before use and between borehole locations to prevent cross contamination of wells. This site will employ hollow-stem continuous auger drilling method. Other methods will be used should conditions require it.

- Monitoring Well Construction Materials

Well construction materials shall be sufficiently durable to resist chemical and physical degradation and yet not interfere with the quality of groundwater samples. Materials to be used for well casings, well screens, filter packs, and annular seals are covered in this section. Figure VII-1 is a typical detail for a groundwater monitoring well.

Well Casings and Screens

ASTM, NSR rated, Schedule 40, 2 inch PVC shall be used for the casing pipe and well screens at this site. It is understood that since PVC pipe is being selected for casing and screening material there may be the possibility that after installation PVC deteriorating compounds could be present in the groundwater. If these compounds are detected, then the Solid Waste Division must assume that the contaminants are from the sanitary landfill and not from the well casing or screen unless identical compounds are found in the upgradient wells and can not be attributed to wastes placed in the site.

Filter Pack and Annular Sealant

The materials used to construct the filter pack shall be chemically inert clean quartz sand. Fabric filters shall not be used as filter pack materials.

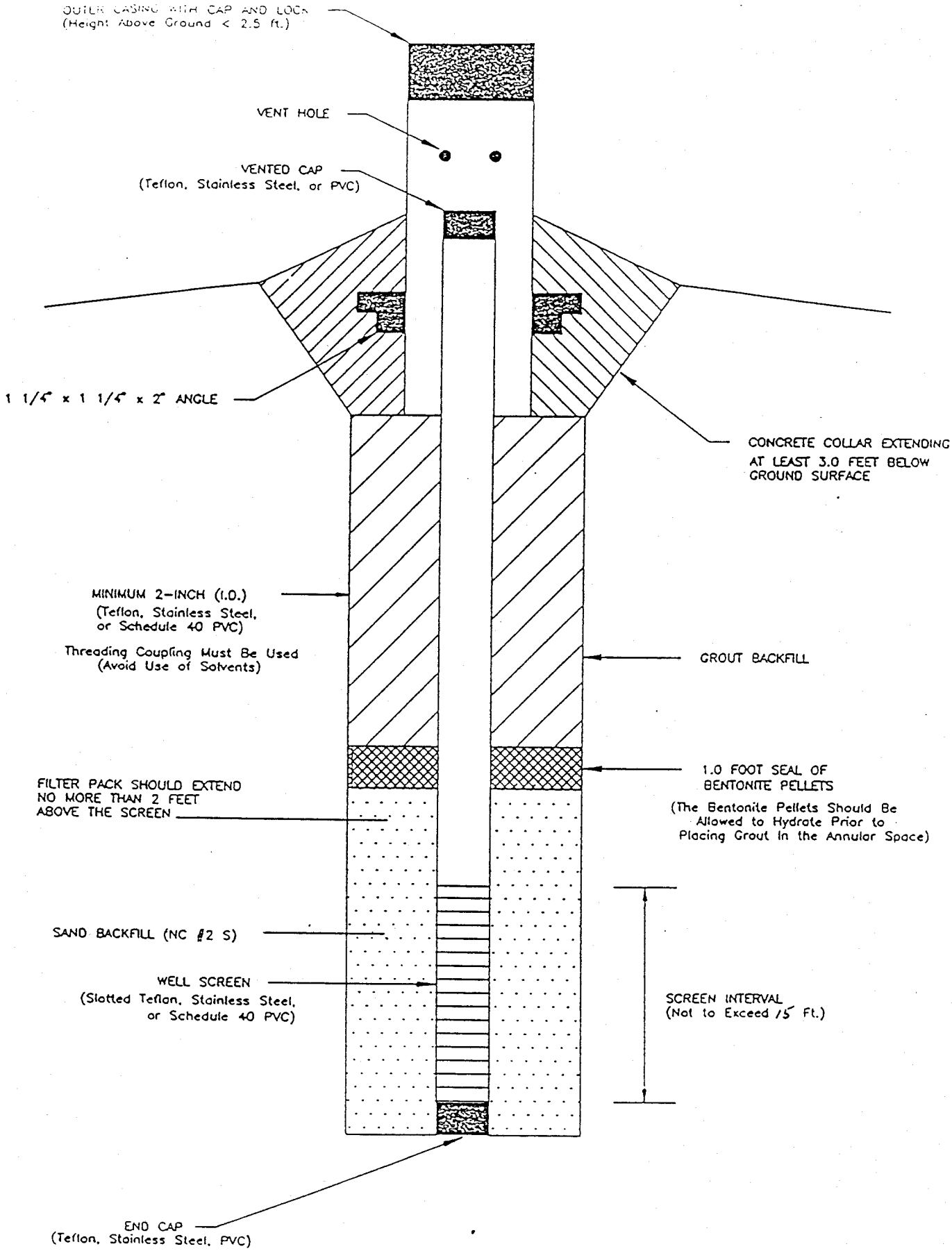


FIGURE VII-1 TYPICAL MONITORING WELL SCHEMATIC

The materials used to seal the annular space must prevent cross contamination between strata. The material shall be chemically resistant to ensure seal integrity during the life of the monitoring well and chemically inert so they do not affect the quality of the groundwater samples. A minimum of one foot of certified coarse grit sodium bentonite shall immediately overlie the filter pack. A cement and bentonite mixture, bentonite chips/pellets, or anti-shrink cement mixtures shall be used as the annular sealant in the unsaturated zone above the certified coarse grit sodium bentonite seal and below the frost line. Extending from a little below the frost line to the surface, the cap shall be composed of concrete blending into a mounded cement apron (to direct rainwater runoff away from the well) extending outward three feet from the edge of the borehole.

The untreated sodium bentonite seal shall be placed around the casing either by dropping it directly down the borehole or, if a hollow-stem auger is used, putting the bentonite between the casing and the inside of the auger stem. Both of these methods present a potential for bridging. In shallow monitoring wells, a tamping device shall be used at reduce this potential.

In deeper wells, it may be necessary to pour a small amount of formation water down the casing to wash the bentonite down the hole.

The cement-bentonite mixture shall be prepared using formation water or potable water and placed in the borehole using a tremie pipe. The tremie method ensures good sealing of the borehole from the bottom.

The remaining annular space shall be sealed with expanding cement to provide for security and an adequate surface seal. Locating the interface between the cement and bentonite-cement mixture 3 feet below the frost line serves to protect the well from damage due to frost heaving. The cement shall be placed in the borehole using the tremie method.

Figure VII-1 illustrates an appropriate protective steel cap around the well casing. A one-quarter inch vent hole provides an avenue for the escape of gas.

The protective cap guards the casing from damage and the locking cap serves as a security device to prevent well tampering.
As with drilling machinery, the well casing and screen shall be cleaned before use. Filter sands, well sealant materials, and anything else that may influence sample quality shall be free of contamination.

Screening with 0.010 inch slots shall be used unless geologic conditions discovered at the time of installation dictate a different size. The annular space between the face of the formation and the screen or slotted casing shall be filled to minimize passage of formation materials into the well. In order to ensure discrete sample horizons, the filter pack shall extend no more than two feet above the well screen as illustrated in Figure VII-1. A different filter pack material may have to be considered should geologic conditions at the time of drilling dictate the need for a different size.

Well Development

After the construction of monitoring wells is completed, natural hydraulic conductivity of the formation shall be restored and all foreign sediment removed to ensure turbidity-free groundwater samples.

A variety of techniques are available for developing a well. To be effective, they require reversals or surges in flow to avoid bridging by particles, which is common when flow is continuous in one direction. These reversals or surges can be created by using surge blocks, bailers, or pumps. Formation water shall be used for surging the well. Should a well be constructed in low yielding water-bearing formations, an outside source of water may be introduced into the well to facilitate development. In these cases, the water shall be chemically analyzed to ensure that it cannot contaminate the aquifer. If compressed air is used in the development of wells there is the possibility that trace contaminates may be introduced. Therefore, sufficient precaution shall be taken to prevent introduction of contaminants which may be cause for concern.

All equipment used to develop a well shall be steam cleaned prior to its introduction into the well.

Well Intake Design

The design and construction of the intake of the monitoring wells shall: (1) allow sufficient groundwater flow to the well for sampling; (2) minimize the passage of formation materials (turbidity) into the well; and (3) ensure sufficient structural integrity to prevent the collapse of the intake structure.

For wells completed in unconsolidated materials, the intake of a monitoring well shall consist of a screen or slotted casing with openings sized to ensure that formational material is prohibited from passing through the well during development. Screen size shall be selected to retain 90% of the filter pack and 40% of the formational material. Extraneous fine-grained material (clays and silts) that have been dislodged during drilling may be left on the screen, in the filter pack, and in the well water. These fines shall be removed from the screen and surrounding area during development. For quality-control purposes, only commercially manufactured screens or slotted casings shall be used. Field slotting of screens is unacceptable.

Documentation Of Well Design And Construction

The following information shall be required in the design and construction of wells:

- name of driller, identification of drill rig;
- date/time of construction;
- drilling method and drilling fluid * (primarily drilling mud) used:
- well location (+ 0.5 ft);
- borehole diameter and well casing diameter;
- well depth (+0.1 ft.):
- drilling and lithologic logs
- casing materials*;
- screen materials and design;
- casing and screen joint type;
- screen slot size/length;
- filter pack material*/size;
- filter pack volume;
- filter pack placement method;
- sealant materials*;
- sealant volume;
- sealant placement method;
- surface seal design/construction;
- well development procedure;
- type of protective well cap;
- ground surface elevation (+0.01 ft);

- well cap elevation (+0.01 ft.);
- top of casing elevation (+0.01 ft.); and
- detailed drawing of well (include dimensions).

*Samples of materials, adequate for leaching/sorption tests should be retained.

Well Plugging

If it becomes necessary to abandon a monitoring well, the following plugging procedures shall be used. Without proper plugging, the abandoned monitoring well will become an avenue of aquifer contamination. Plugging can also serve to inhibit water loss from artisan aquifers and to eliminate the physical hazard of an open hole. Proper plugging materials and techniques will vary according to the original well construction and the hydrogeology of the site.

The general procedure for plugging shallow monitoring wells completed in water table aquifers includes three steps.

- Removal of obstructions in the well that could interfere with the plugging operation and thorough flushing of the well to purge residual drilling fluids and other fine detritus.

- Removal of the well casing (where practical) to ensure placement of an effective seal - as a minimum when the casing is not properly grouted, the upper 20 feet of casing must be removed.

- Sealing of the well with an impermeable filler such as neat cement.

Sealant Materials

Well sealants shall be chemically inert and impermeable. Neat portland cement (with or without bentonite clay additives) and bentonite clay are acceptable sealants. General purpose (Type 1) neat portland cement is acceptable. The cement slurry is to be mixed with five to six gallons of water for each 94 pound sack of cement. The water of the cement should have a low sulfate content and a total dissolved solids content less than 2,000 parts per million. No aggregate materials are to be included in the slurry.

CAPACITIES OF WELL CASINGS

Diameter of Hole	Gallons per Lineal Foot	Sacks Cement Per Lin. Foot	Cement Set Volume
2"	0.1632	0.0199	50.2
3"	0.3672	0.0311	32.1
4"	0.6528	0.0791	12.6
5"	1.0200	0.1240	8.0
6"	1.4688	0.1785	5.6
7"	1.9992	0.2430	4.1
8"	2.6112	0.3373	3.2
10"	4.0800	0.4958	2.0
12"	5.8752	0.7140	1.4

Recommended quantities of neat portland cement needed for plugging various diameter wells are shown in the above Table. Quantities are based on the set volume, which is somewhat less than the slurry volume.

(Taken from "Plugging Abandoned Wells" by Donald K. Keech, Ground Water Age, January 1973).

The neat cement slurry shall be piped to the point of application so that the well is filled upward from the bottom. Free falling of the slurry into the well is unacceptable because the cement will become aerated with a resulting increase in permeability.

Bentonite clay additives reduce shrinking (and cracking) of the cement while the slurry is setting.

Three to five pounds of additive and 6-1/2 gallons of water shall be mixed with each 94 pound sack of cement (the clay and water are to be mixed together before cement is added to form the slurry).

Bentonite clay can be used separately as a well sealant. The clay can be dropped into the well in the form of granules, chunks, pellets, or balls. Where the potentiometric head of an aquifer causes water to rise in the well high above the level of the plug, consideration must be given to the physical form of the bentonite to be used. If a granular bentonite is added by free falling, a possibility is that the clay will hydrate and expand above the intended point of placement. A ineffective plug will result. Adding the bentonite in chunk or pellet form will prolong the effective period of wetting prior to hydration and allow

proper placement of the plug. Bentonite clay cannot be used as a sealant where organic contaminants are present in groundwater unless the bentonite is treated and documentation is present to show that it is capable of containing organic contaminants.

Shallow monitoring wells installed in unconsolidated sediments or consolidated rocks without fractures or dissolution voids are to be filled with a sealant. Backfilling of the screened or uncased section of the well (up to several feet below the casing) with clean, disinfected sand is permissible. Sand with a diameter of 0.025 inches or less (plaster sand or mortar sand) reduces cement penetration/loss. As a minimum, the upper 50 feet of deep monitoring wells shall be plugged with cement or bentonite clay.

Consolidated rocks with a high density of fractures or dissolution voids shall be filled completely with neat cement. Sand clay fill materials are not suitable because the fine grained sediments can be eroded away by groundwater flow. The use of bridging materials, such as pea gravel or larger rocks (the diameter of the bridging material should be less than 1/3 of the diameter of the well) below the casing or the placement of a plug at the base of the casing, may be necessary to retain the neat portland cement slurry in the well.

Where several confined aquifers are present in an abandoned monitoring well, impermeable seals between water bearing sections are required. Flow from artisan wells can cause problems with installation of neat portland cement. Packers or heavy plugs shall be required to inhibit water flow.

5.) Sampling & Analysis Plan:

The surface water monitoring points and groundwater monitoring wells shall be monitored for the following tests and according to the schedule below. Samples shall be taken from the locations shown on Sheet 4 of 16.

Sampling shall be completed twice during the first year of operation and then annually thereafter.

Analysis of the samples would include:

Total Metals:

1) Arsenic	2) Cadmium	3) Lead	4) Selenium
5) Copper	6) Iron	7) Zinc	8) Chromium
9) Mercury	10) Silver	11) Manganese	12) Barium

Total Inorganic Parameters for:

1) Chloride
2) Fluoride
3) Nitrate
4) Sulfates

Indicator Analysis:

The unfiltered water is tested for total inorganic parameters for:

1) Total Organic Halogens (TOX)
2) Total Organic Carbons (TOC)
3) Total Dissolved Solids (TDS)
4) Biological Oxygen Demand (BOD)
5) Chemical Oxygen Demand (COD)
6) Conductivity
7) pH

Representatives of the North Carolina Solid Waste Management Division should be present during the initial well sampling.

Increased frequency of sampling and additional parameters may be required by North Solid Waste Management Division, if deemed necessary. The initial sampling shall serve as background data.

At the time of sampling, water level elevations shall be measured to determine if horizontal and vertical flow gradients have changed since initial site characterization. A change in hydrologic conditions may necessitate modification to the design of the groundwater monitoring system.

Field measurements shall include depth to standing water and total depth of the well to the bottom of the intake screen structure. The measurements shall be taken to 0.1 foot. Each well will have a referenced point from which its water level measurement is taken. The reference point shall be established relation to a permanent bench mark and the survey shall also note the well location.

The water standing in a well prior to sampling may not be representative of in-situ groundwater quality. Therefore, the standing water shall be removed (purged) so that water which is representative of the formation can enter the well.

The procedure for well evacuation shall depend on the yield of the well. When evacuating low yield wells, the wells shall be evacuated to dryness once. If a well cannot be bailed dry, then the amount of water equivalent to three to five well volumes shall be evacuated.

Purging equipment may include Teflon bladder pumps or Teflon stainless steel bailers. The well should recharge fully before sampling.

When purging equipment must be reused, it shall be cleaned with a nonphosphate detergent mixed with deionized water followed by rinsing with deionized or distilled water. Clean latex gloves shall be worn by the sampling personnel. A clean plastic sheet shall be placed adjacent to or around the well in order to prevent purging equipment and lines from coming in contact with the ground, which in turn could introduce contaminants to the well. The plastic sheet and gloves shall be discarded between wells.

Extraction of well-water samples require the use of equipment and sample handling in the field that greatly increases the potential for inadvertent sample contamination. Field sampling error greatly exceeds laboratory error. The traces of chemicals being monitored can be lost to the air by agitation or vaporization. They can pass into and out of the water with temperature and pH changes. They can decompose when allowed to stand in the sun. Contamination from the ground surface can pass to hands, to the bottle and then to the sample. Cleanliness and attention to detail will hold these errors to a minimum.

Once a sampling technique has been established it shall be repeated for all subsequent sampling. Sampling equipment that may be used at this facility is as follows:

1. Teflon or stainless steel (316) sampling bailers shall be used. The bailer line should consist of either 1) teflon coated wire 2) single strand stainless steel 3) monofilament line or 4) nylon rope. The line shall not be reused for subsequent sampling.

2. If possible dedicated samplers should be used for each well. This eliminates cross-contamination, and allows thorough cleaning in the laboratory before sampling. If a dedicated sampler is not available the device must be cleaned between wells. Bailer cleaning procedures are outlined in the Sampling Procedure section on this page. If a bailer shows insoluble contamination, field cleaning is not recommended.

Sampling equipment should be constructed of inert material. Equipment with neoprene fittings, PVC bailers, tygon tubing, silicone rubber bladders, neoprene impellers, polyethylene, and viton are not acceptable.

6.) Sampling Handling and Preservation:

- Total Metals: If turbid, the well water sample may temporarily (not more than 24 hours) be placed on ice to allow soil particles to settle. Clear water may then be decanted and poured into an appropriate sampling container acidified with HNO_3. If decanting is to be performed, the initial sample container should be clean Teflon or Polyethylene filled to the top without headspace.

- All sample bottles shall be filled to the top, capped with a Teflon seal, and be placed on ice immediately after sampling. On arrival at the laboratory they are transferred to a refrigerator.

- Table 1 is a list of preservatives and holding times. Conductance and pH shall be performed immediately after collection if possible. The calibration and procedure shall be recorded and continued at each sampling project. If a sample is returned to the laboratory, it shall be tested immediately on arrival and this alternate procedure shall be recorded and repeated at each sampling project.

- Sample delivery to the laboratory shall be in the shortest possible time after collection. If delay is incurred this shall be entered in the field log book along with the increment.

- Blanks: A distilled water blank shall be carried to the field and put through the entire sampling procedure. This will be done a minimum of one time for every 10 samples. If positives are found, this will alert the collector to field sampling error. (See Quality Assurance)

TABLE 1

Preservation Procedures and Holding Times

Parameter	Recommended Container	Preservative Indicators of Ground water Contamination	Holding Time	Volume Required For One Analysis
Sulfate	P,G	Cool 4°C	28 days	*
TDS	P,G	Cool 4°C	7 days	*
COD	P,G	Cool 4°C H_2SO_4 to pH 2	28 days	*
BOD	P,G	Cool 4°C	48 hours	*
pH	T,P,G	Field Determined	None	*
Conductivity	T,P,G	Field Determined	None	
TOC	G,amber, T-lined cap (no headspace)	Cool 4°C HCL to pH 2	28 days	*
TOX	T,P G,amber, T-lined septa or caps (no headspace)	Cool 4°C, add 1 ml of 1.1M sodium sulfite	7 days	*
Chloride	T,P,G	4°C	28 days	*
Arsenic Barium Cadmium Chromium Copper Iron Lead Manganese Mercury Selenium Silver Zinc	T,P	Total Metals Field Acidifed to pH 2 with HNO_3	6 months	*
Fluoride	T,P	Cool 4°C	28 days	*
Nitrate\ Nitrite	T,P,G	4°C/H_2SO_4 to pH 2	14 days	*

* Lab specific, contact lab performing analysis prior to sampling

P = polyethylene
G = glass
T = Fluorocarbon resins (Teflon, PTFE, FEP, etc.)

7.) Chain of Custody:

Custody and protection of samples is an important legal consideration. As few people as possible should handle the samples. The sampler is personally responsible for collected samples, and shall be able to attest to the integrity of samples until transfer. If the samples are placed in a vehicle, it shall be kept locked. Any ice chest shall be locked or located in a place which is locked, and having access only by responsible officials.

A chain-of-custody form shall be used to document the handling of samples from the moment of collection until testing. The ID number of each sampling point shall be entered along with a word description of the sample. Note that several bottles collected for different parameters will have the same ID number if they come from one sampling point.

The Chain-of-Custody form shall contain the facility name,date of sampling and name of the collector. Each transfer of custody is recorded with an appropriate signature, date and time.

If the samples are to be shipped they must be sealed. A bill of lading must be secured.

8.) Analytical Procedures:

The laboratory performing the analyses shall specify a method (EPA Manual SW-846, EPA 600/4-79-020, or an EPA approved method).

Records of groundwater analyses shall include the methods used (by number), the extraction date, and date of actual analysis. Data from samples that are not analyzed within recommended holding times shall be considered suspect. Any deviation from an EPA approved method shall be adequately tested to ensure that the quality of the results meets the performance specifications (e.g. detection limit, sensitivity, precision, accuracy) of the reference method. A planned deviation shall be justified and submitted for approval by the North Carolina Solid Waste Management Division prior to use.

9.) Quality Assurance/Quality Control:

It is the responsibility of The City of High Point to ensure the reliability of the analytical data being gathered during the monitoring program.

A field blank shall be taken at least once for every 10 samples. Distilled water is taken to the site, and handled like a sample. It is poured into a bailer, or extracted using the same pumping equipment and sample bottles are filled using identical technique.

Analysis of the blank alerts the sampler to technical error. The blank test results are not used to correct the sample results, but are reported as-is. If the contaminant levels in the blank are within an order of magnitude of the ground-water sample results, the wells shall be resampled.

In selecting a laboratory to conduct analyses of groundwater samples it shall be Haywood County's responsibility to ensure that the laboratory of choice is exercising a proper QA/QC program as described in the S & A plan. The approved EPA test methods contain within them the requirement to run a spiked sample to determine percent recovery. This shall be a part of the lab report. Additional quality control such as method blanks and duplicates are also described in the test method and shall be included in the laboratory work agreement. The laboratory QA program shall be a part of this Plan. Quality assurance procedures are time consuming and increase the cost of testing, but the facility shall be regulated based on the results and it is to the County's advantage to employ the best qualified laboratory.

Any field instruments that Haywood County will use shall be calibrated prior to field use and recalibrated in the field before measuring each sample.

10.) Analysis of Results:

In order to determine whether the groundwater is receiving contamination from the site it is necessary to compare the test results with the background test results. Several inherent variabilities must be considered:

- The sampling technique will vary somewhat from event to event even under ideal conditions.
- The aquifer will contain a certain quality of elements.
- The laboratory test itself can vary slightly.

A method must be used that shows significant deviation beyond the inherent deviation. A statistical analysis using the Student's t-test is presently approved by EPA for this purpose and will be used for this site.

11.) Reporting Results:

All results shall be reported to:

Department of Environment, Health, and Natural Resources
Solid Waste Management Division
Attention: Solid Waste Hydrogeologist
P. O. Box 27687
Raleigh, North Carolina 27611

12.) Monitoring Well Sampling Procedure:

The greatest source of inadvertent sample contamination is through incorrect handling by field personnel. The levels of concern are minute, as compared to a waste sample, and extreme care is needed. This will usually slow down the speed of sample collection, but the reliability of test results is increased proportionally.

Water standing in a well may not be a true representation of water quality in the aquifer. Changes in temperature and pressure, contact with air, and prolonged contact with well casing materials can all affect the chemical quality of the water. Therefore, before sampling, the well must be evacuated (purged).

13.) Well Evacuation Procedure:

Any item coming in contact with the inside of the well casing or the well water shall be kept in a clean container and handled only with gloved hands. Always start with the least contaminated well.

For wells with rapid recovery, which cannot be evacuated, 3 to 5 well volumes will be removed. This reflects the present technology in which the goal is to remove standing water without diluting any potential plume by drawing in pure water.

- Assemble Equipment
    - Place a plastic sheet, such as a painter's drop cloth around the well as a work area. Unlock protective well casing.
    - Bring steel measuring tape and electric sounder to the plastic sheet. The sounder probe and tape have been precleaned in the lab and wrapped in foil. Unwrap without touching them.
    - Put on new gloves. Unlock and remove well cap. Place it top-down on a corner of the plastic sheet.
- Calculate the volume of water to be evacuated:
    a. Use the electric sounder ("m-scope") to measure the distance from top of the casing to top of water.
    b. Use the steel tape to measure the distance from top of casing to the bottom of the well or use total depth data provided by company.
    - Subtract #1 from #2 to obtain the height (h) of the volume of water in the well.

- Multiply h times the appropriate conversion factor to obtain the volume of water in the well in gallons.

  (1). For a 2-inch inside diameter well, h x 0.1623 = Volume (gal)
  (2). For a 4-inch inside diameter well, h x 0.6 = Volume (gal)

- Evacuate at least 3 x well volume (gal) to obtain a representative sample.

- Clean the steel measuring tape and electric sounder probe by rinsing with 10% Nitric Acid followed by distilled water. Wrap in foil for use on the next well. If isopropyl alcohol is used, be sure to allow all apparatus to dry thoroughly before proceeding to next well. Do not use methanol if it is a suspected contaminant.

- Evacuate the Well

  - Bring 2 dishpans and a measuring container to the plastic sheet and line one dishpan with aluminum foil.

  - Bring the bailer, which has been precleaned in the laboratory and wrapped in foil, to the plastic sheet. Unwrap it without touching the bailer.

  - Bring the roll of bailer cord to the sheet. This roll has also been covered with foil and keep it clean. Place it in the unlined dishpan and unwrap it without handling the rope.

  - At this point both bailer-handler and helper should put on a new pair of gloves.

  - The end of the bailer rope is tied to the top of the bailer. Use foil where needed to assure that the rope does not touch any item while in use.

  - The bailer is lifted and lowered carefully into the well until it is submerged.

  - The bailer is raised in a hand over hand manner and the rope is allowed to fall into the polyethylene dishpan lined with foil.

  - Pour groundwater from bailer into the measuring container. Repeat bailing procedure until a 3 x volume (gal) (see 2d and e) has been evacuated. If the bailer touches the container, line the lip with aluminum foil.

- If the well goes dry before 3 volumes obtained, then sample when the well has recovered sufficiently to provide a sample volume. Some wells require 24 hours for recovery settling.

- Save the evacuated water in the measuring container for proper disposal. Do not pour on the ground next to the well.

- The rope is untied from the bailer and the portion used is cut off for discard.

- The used gloves, the used rope, the bailer foil, dishpan foil and the plastic sheet are rolled up and discarded in the large trash bag provided. Proceed with sampling procedure or if well requires a recovery period before sampling, replace well cap and lock protective casing. In general, allow 24 hours for well water stabilization. Where recharge is rapid and water is clear of sediment, this waiting period may be shortened.

14.) Sampling Procedure:

- Bailed Samples:

  - Place a plastic sheet such as a painter's drop cloth, around the well as a work area, to prevent sample bottle contact with the ground. Unlock the protective well casing.

  - Bring 2 dishpans to the sheet and line one with aluminum foil.

  - Arrange sample bottles on the sheet. Place waste water container in vicinity of well.

  - Bring the bailer, which has been precleaned in the laboratory and wrapped in foil to the plastic sheet. Unwrap it without touching the bailer.

  - Bring the roll of bailer cord to the sheet. This spool has also been covered generously with foil to keep it clean. Place it in the unlined dishpan and unwrap it without handling the rope. Selection of inert rope is important. new nylon rope is available from several manufacturers.

  - Unlock and remove the well cap. Place it top-down on a corner of the plastic sheet.

  - At this point bailer-handler and helper should put on a new pair of gloves.

- The end of the bailer rope is tied to the top of the bailer. The rope must not touch anything but the clean aluminum foil. Use foil where needed.

- The bailer is lifted and lowered carefully into the well until it is submerged.

- The helper will unscrew the appropriate sample caps and place them top down on the plastic sheet without touching the interiors or dislodging any teflon discs inside the caps.

- The bailer is raised in a hand over hand manner and the rope is allowed to fall into the polyethylene dishpan lined with foil. The first bailer-full is discarded into the waste container.

- The samples are poured into the bottles without bubbles, and are filled to the top without headspace. The helper can hold the bottle and be responsible for recapping without touching the interior of the cap, and screwing down tightly. It is not good practice to leave sample in the sun. They should be placed in the ice chest as soon as possible.

- The organic samples are the most delicate and should be collected first. A sample for volatile analysis must be filled so that the vial has meniscus. The cap is slid over it and closed so that no bubble can be seen when the sample vial is upended. The volatile samples are usually collected in three 1-liter bottles without preservative and these should be collected next, also without headspace. If a sample is to be collected for total metals it should be collected right after the volatile samples in order to minimize the sediment requiring removal. Preserved samples should be collected, taking great care that the acids and salts in the bottles do not contact the helper's gloves, and thus, pass to other caps and bottles. Do not allow the bailer to touch any sample bottles, or allow any rope end or gloved fingers to contact the sample well water while pouring.

- All remaining sample bottles should now be carried to the ice chest where they are labeled, placed in zip-loc bags, and iced down.

- The labels can be pre-filled out leaving less work and time delay at the site. The label must have:

  - Name of facility
  - Date of sampling and time
  - Sampler's name
  - Parameter to be sampled for
  - Type of preservative added to sample
  - Sample description (monitoring well ID)

  Additionally, mark each sample bottle with an identification number using red glass-marking crayon which is resistant to water. If possible, bottle caps are good places to add an I.D. This is a precaution in case labels get wet or come off during transport.

- The well cap is replaced. Lock the protective well casing.

- The rope is untied from the bailer and all used rope is discarded.

- The used gloves, the used rope, the bailer foil, dishpan foil and the plastic sheet are folded up and discarded in the large trash bag provided.

- Proceed to the next well and repeat.

  Note: It is good practice to take an extra set of sample bottles to the field in case of breakage or accidental contamination.

- Bailer Cleaning

The best procedure is one bailer for one well. However, when this is not possible a single bailer may be cleaned between wells as follows: (Use of any other solvents will interfere with test results).

Teflon Bailer

a. Phosphate-free soap and tap water wash
b. Tap water rinse
c. 10% nitric or 10% hydrochloric acid rinse
d. Deionized or distilled water rinse
e. Isopropyl alcohol rinse
f. Air dry
g. Wrap with aluminum foil shiny side out to prevent contamination before use.

- Split Samples

  In order to keep sample handling to a minimum the parallel splitter procedure should be used.

  Parallel Split:

  - The two sample bottles for a given test are lined and caps removed.
  - One bailer-full is poured into one bottle, and the next bailer-full is poured into the other bottles.
  - The two sample bottles for another test are then lined up, and filled as in 2.
  - This procedure is continued until all test bottles for a given well are filled for both parties.

IV

CONSTRUCTION SPECIFICATIONS

A

NOTICE TO BIDDERS

A pre-bid conference will be held on _____, _____1992 in the Conference Room located on the second floor of the Municipal Office Building at _____ p.m. Sealed proposals will be received by _____, Haywood County, North Carolina in the _____ located _____ _____until____p.m. _____,1992, at which time they will be opened and read for the furnishing of the following:

BID #_____ - White Oak Landfill Design and Permit for Haywood County, North Carolina

General Contractors are notified that "An Act to Regulate the Practice of General Contractors, Section 87-1 thru 15", ratified by the General Assembly of North Carolina, on March 10, 1925, and as subsequently amended will be observed in receiving and awarding general contracts.

The successful bidder will be required to post a performance bond and a payment bond for one hundred percent (100%) of the amount of his contract.

Contract Documents, including Drawings and Technical Specifications, are on file at _____ _____ _____.

Copies of the proposed form and Plans may be obtained by depositing One Hundred ($100.00) Dollars with _____ for each set so obtained. Each such deposit will be refunded to bona fide bidders and suppliers if the proposal form and plans are returned in good condition within ten (10) days after bid opening. Copies of Haywood County Standard Specifications and details may be purchased from _____ for Fifty ($50.00) Dollars for each copy.

All hand carried Bids are to be presented to the Purchasing Agent in his/her office or at the time of the bid opening in the Conference Room on the third floor. Proposals are to be marked "Bid # _____ - White Oak Landfill Design and Permit for Haywood County, North Carolina, not to be opened until _____ p.m., _____, _____, 1992.

Bidders who mail their proposals shall address them as follows:

Cash, bid bond, certified check or cashier's check on a bank insured by the Federal Deposit Insurance Corporation made payable to _____ in the amount of five percent (5%) of the total bid must accompany all proposals in order to guarantee compliance with the provisions of the proposal.

The City reserves the right to reject any and all bids, as may in the judgement of the _____ serve its best interest and the County further reserves the right to waive irregularities and informalities in any bid submitted.

Bids may be held by the _____ for a period not to exceed sixty (60) days from the date of the opening for bids.

Jack Horton, County Manager

(Copy of Advertisement)

"Equal Opportunity Employer, Male/Female/Handicapped"

BID ESTIMATE

ITEM NO.	APPROX. QUAN.	UNIT	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
1.		S.F.	60 Mil HDPE Liner Installed	$	$
2a.		S.F.	12" Clay Base w/Perm. $1x10^{-7}$/Sec	$	$
2b.		S.F.	24" Clay Base for Leachate Pond $1x10^{-3}$	$	$
3a.		C.Y.	Clean, Natural, Quartz, Silica Sand	$	$
3b.		C.Y.	Clean Natural Soil $1x10^{-5}$/On-Site	$	$
4.		L.F.	Leachate Underdrain w/6" P.P.	$	$
5.		L.F.	6" Non-Perforated HDPE Pipe	$	$
6.		L.F.	Anchor Trench (App. 36,720 S.F.)	$	$
7.		V.F.	60" Manhole with Pipe and Fittings	$	$
8.			Each 60" Manhole Frames and Covers	$	$
9.		L.F.	30" AC-CMP Pipe	$	$
10.		L.F.	42" AC-CMP Pipe	$	$
11.		C.Y.	Class II Bedding	$	$
12.		L.F.	Placement of All Weather Access Road ± 22 Ft. Wide	$	$

B

PROPOSAL

FOR

WHITE OAK LANDFILL DESIGN AND PERMIT

FOR

HAYWOOD COUNTY, NORTH CAROLINA

Place: _____
_____
_____

Date: _____
Time: _____

Proposal of _____ (hereinafter called "Bidder") a corporation organized and existing under the laws of the State of _____ a partnership, or an individual doing business as _____.

TO:
(hereinafter called OWNER)

Gentlemen:

The Bidder, in compliance with your Invitation for Bids for the White Oak Landfill Design and Permit for Haywood County, North Carolina, having examined the Plans and Specifications with related Contract Documents and the site of the work, and being familiar with all of the conditions surrounding the construction of the proposed project including the availability of materials and labor, hereby proposes to furnish all labor, materials and supplies and to construct the project in accordance with the contract documents, within the time set forth therein, and at the price stated below. This price is to cover all expense incurred in performing the work required under the contract documents of which this PROPOSAL is a part.

The Bidder hereby agrees to commence work under this contract on or before a date to be specified in a written "Work Order" of the Owner and to fully complete the work as stipulated in Section IX, Supplemental General Conditions.

Bidder further agrees to pay liquidated damages, as stipulated in Section IX, Supplemental General Conditions.

Bidder acknowledges receipt of the following addenda:

1.) Addendum No. 1 - _____

ITEM NO.	APPROX. QUAN.	UNIT	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
13.		Each	Leachate Cleanout Assembly	$	$
14		L.F.	18" Non-Perforated Flexible Temporary Drain	$	$
15.		L.F.	12" Non-Perforated Flexible Temporary Drain	$	$
16.		Each	4"x4" Bench Mark	$	$
17.		Acre	Fertilizer & Permanent Grassing	$	$
18.		Acre	Temporary Grassing	$	$
19.		L.F.	Silt Fence	$	$
20.		S.F.	Class "B" Rip-Rap	$	$
21.		Each	6" HDPE Pipe Penetration Through Liner	$	$
22.		Each	6" Pipe Outlet to Leachate Pond With Penetration, Concrete & Other Materials	$	$
23.		L.S.	Mobilization/Demobilization for Groundwater Monitoring Well	$	$
24.		V.F.	Drilling for Groundwater Monitoring Wells	$	$
25.		V.F.	Casing 2" Diameter	$	$
26.		V.F.	Well Screens 2" Diameter	$	$

ITEM NO.	APPROX. QUAN.	UNIT	DESCRIPTION	UNIT PRICE	TOTAL AMOUNT
27.		Each	Monitoring Well Construction	$_____	$_____
28.		Each	Report of Well Records	$_____	$_____
29.		Each	Surface Water Monitoring Marker	$_____	$_____
30.		Each	Groundwater Monitoring Marker	$_____	$_____
31.		Each	HDPE Manhole Cover	$_____	$_____
32.		V.F.	HDPE Manhole	$_____	$_____
33.		Each	5' Diameter - 8" Thick Concrete Slab for Ballast	$_____	$_____
34.		C.Y.	Additional Excavation for Trenches	$_____	$_____
35.		C.Y.	Backfill Dewatering Trenches	$_____	$_____
			TOTAL BASE BID	**$**_____	

No Sales Tax is to be included in Bid Price. Any Sales Tax applicable will be added when payment is made.

ADDITIONAL WORK IF ORDERED BY THE ENGINEER:

1. Contractor shall remove and dispose of unsuitable material on-site and haul and install select backfill materials as directed by the Engineer for a unit price of $_____ per cubic yard.

2. Contractor shall provide all labor and materials for solid rock excavation and disposal on-site as directed by the Engineer for the unit price as follows:

   Rip Rock $_____ per cubic yard
   Trench Rock $_____ per cubic yard

The unit and lump sum prices shown shall include all labor, materials, bailing, shoring removal, overhead, profit, insurance, etc., to cover the finished work of the several kinds called for.

Bidder agrees that this bid shall be good and may not be withdrawn for a period of 60 days after the scheduled closing time for receiving bids.

The Bidder understands that the Owner reserves the right to reject any or all bids and to waive any informalities in the bidding.

The Bidder hereby agrees to commence work under this Contract with adequate forces and equipment, on a date to be specified in a written work order of the Engineer, and to fully complete the work within 90 consecutive calendar days from and including said date.

The Bidder further agrees that, in case of failure on his part to execute the Contract Agreement and bonds within fifteen (15) days after notification of Award of Contract, the Bid Bond or Certified Check accompanying his bid and the monies payable thereon, shall be paid into the funds of the Owner as liquidated damages for such failure, otherwise the check or bid bond accompanying this Proposal shall be returned to the Bidder according to the provisions of the "Instructions to Bidders".

PROPOSED LIST OF SUB-CONTRACTORS

To insure and promote proper construction standards, all sub-contractors, and their assigned tasks, shall be listed and approved before the Bid will be accepted. Once Bids are accepted, any change in this listing will require prior approval by the Owner. If there is a change of the sub-contractors, resulting in a reduction in the total cost of construction, the Owner shall be awarded the net reduction at the time of approval of the new sub-contractor.

SUB-CONTRACTING FIRM	LICENSE NUMBER AND CLASSIFICATION	ASSIGNED TASKS

PRIME CONTRACTOR_____

OFFICER'S SIGNATURE_____

TITLE_____

DATE_____

Attached hereto is a _____ for the sum of

_____ Dollars ($_____)
according to the conditions of the "Instructions to Bidders".

SEAL (if bid is by Corp.)

_____
Bidder

_____
By

_____
Title

_____
Address of Bidder

_____
Telephone Number

C

BID BOND

KNOW ALL MEN BY THESE PRESENTS, that we, the undersigned,

_____ as Principal, and

_____ as Surety, are hereby

held and firmly bound unto Haywood County, North Carolina as Owners in the penal sum of _____ for the payment of which, well and truly to be made, we hereby jointly and severally bind ourselves, and our heirs, executors, administrators, successors and assigns.

Signed, this _____ day of _____, 19___.

The condition of the above obligation is such that whereas the Principal has submitted to _____ a certain bid, attached hereto and hereby made a part hereof to enter into contract in writing, for the _____, White Oak Landfill Design and Permit for Haywood County, North Carolina.

NOW THEREFORE,

(a) If said Bid shall be rejected or in the alternate,

(b) If said Bid shall be accepted and the Principal shall execute and deliver a Contract in the Form of Contract attached hereto (properly completed in accordance with said Bid) and shall furnish a Bond for his faithful performance of said Contract, and for the payment of persons performing labor and furnishing materials in connection therewith, and shall in all other respects perform the agreement created by the acceptance of said Bid, then this obligation shall be void, otherwise the same shall remain in force and effect; it being expressly understood and agreed that the liability of the Surety for any and all claims hereunder shall, in no event, exceed the penal amount of this obligation as herein stated.

The Surety, for value received, hereby stipulates and agrees that the obligation of said Surety and its BOND shall be in no way impaired or affected by any extension of the time within which the Owner may accept such Bid; and said Surety does hereby waive notice of any such extension.

IN WITNESS WHEREOF, the Principal and the Surety have hereunto set their hands and seals, and such of them as are corporations have caused their corporate seals to be hereto affixed and these presents to be signed by their proper officers, the day and year set forth above.

_____(L.S.)
PRINCIPAL

_____
SURETY

_____
BY

D

CONTRACT FOR SITE PREPARATION

THIS CONTRACT made this _____ Day of _____

19____ by and between _____

(A corporation organized and existing under the laws of the State of N.C.) hereinafter called the Contractor and Haywood County, North Carolina, hereafter called the Local Public Agency.

WITNESSETH, that the Contractor and the Local Public Agency for the consideration stated herein mutually agree as follows:

ARTICLE 1 - Statement of Work. The Contractor shall furnish all supervision, technical personnel, labor, materials, tools, equipment, and services, including utility and transportation services, and perform and complete all work required for the construction of the improvements embraced in the Site Preparation, namely: _____ _____, White Oak Landfill for Haywood County, North Carolina, and required supplemental work for their Improvement, Contract Number , all in strict accordance with the Contract Documents for Site Preparations, including all Addenda, thereto.

Addenda, thereto, Numbered 1) As shown on Sheet 2 of 4 of the Construction Drawings, Dated December 1, 1991 And_____Dated_____, all as prepared by the Central Engineering Department of the City of High Point, North carolina, herein referred to as the Engineer.

Article 2 - The Contract Price. The Local Public Agency will pay the Contractor for the performance of the contract in current funds for the total quantities of work performed at the unit prices stipulated in the bid of several respective items of work completed, subject to additions and deductions as provided in the Section - CHANGES IN THE WORK under GENERAL SPECIFICATIONS AND CONDITIONS.

Article 3 - Contracts. The executed contract documents shall consist of the following:

a. This Agreement
b. Addenda
c. Invitation for Bids
d. Instructions to Bidders
e. Signed Copy of Bid
f. General Specifications and conditions
g. Project Special Provisions
h. Special Conditions
i. Technical Specifications
j. Projects (as listed in Project Special Provisions)

This Agreement, together with other documents enumerated in this ARTICLE 3, which said other documents are as fully a part of the Contract as if hereto attached, or herein repeated, forms the Contract between the parties hereto.

In the event that any provision in any component part of this contract conflicts with any provisions of any other component part, the provision of the component part first enumerated in this ARTICLE 3 shall govern, except at otherwise specifically stated.

IN WITNESS WHEREOF, the parties hereto have caused this AGREEMENT to be executed in ___ original copies on the day and year first above written.

Attest:

_____ _____
(Contractor)

_____ BY: _____

_____ TITLE: _____

_____
(Street)

_____
(City)

HAYWOOD COUNTY, NORTH CAROLINA
(Local Public Agency)

_____ BY: MAYOR _____

COUNTY CLERK _____ TITLE _____

(Print or type the names underneath all signatures)

Certification

I, _____, certify that I am the _____ of the corporation named as Contractor herein; that _____ who signed this Agreement on behalf of the Contractor, was then _____ of said corporation; that said Agreement was duly signed for and in behalf of said corporation by authority of its governing body, and is within the scope of its corporate powers.

_____ Corporate

_____ Seal

Performance And Payment Bond (Or Bonds)

Following the Form of Agreement, insert the approved form of statutory Surety Bond or Bonds to insure the performance of the Contract and payment of labor and materials. In addition to the corporate signature of the surety company(ies) on the Bond(s), each bond should be countersigned by the surety company's attorney-in-fact, authorized to act within the state in which the project is situated.

E

PERFORMANCE BOND

STATE OF _____

COUNTY OF _____

KNOW ALL MEN BY THESE PRESENTS: That we, _____

_____

Hereinafter called the "Surety" are held and firmly bound unto Haywood County, North Carolina (Hereinafter called the "Owner"), in the penal sum of _____

_____

($_____) Dollars for payment of which we bind ourselves, our heirs, executors, administrator, successors, and assigns for the faithful performance of a certain written contract dated the _____ Day of _____, 19____, entered into between the Principal and the _____, for _____

_____

a copy of which said contract is incorporated herein by reference and is made a part hereof as if fully copied herein.

NOW THEREFORE, The condition of this obligation is such that if the Principal shall faithfully perform the terms and conditions of the Contract in all respects on _____ Part, and shall fully pay all obligations incurred in connection with the Performance of such on account of labor and equipment used in connection therewith, and all such other obligations of every form, nature, and character, and shall save harmless the Owner from all and any liability of every nature, kind, and character which may be incurred in connection with the performance of fulfillment of such contract or other such liability resulting from negligence or otherwise on the part of such principal, and further shall save harmless the Owner from all costs and damage which may be suffered by reason of the failure to fully and complete perform said contract and shall fully reimburse and repay the Owner for all expenditures of every kind, character, and description which may be incurred by the Owner in making good any and every default which may exist on the Part of the Principal in connection with the Performance of said Contract; and further that the Principal shall pay all lawful claims of all persons, firms, partnerships, or corporations for all labor performed and materials furnished in connection with the performance of the contract, and that the failure so to do with such persons, firms, partnerships, or corporations shall give them a direct right of action against the Principal and Surety under this obligation, and provided, however, that if any alterations or additions which may be made under the Contract, or in the work to be done under it, or the giving by the Owner of any extension of time for the performance of the Contract, or any other forbearance on the Part of either the Owner or

the Principal shall not in any way release the Principal and Surety, or either of them, their heirs, executors, administrators, successors, or assigns from their liability hereunder.

Notice to the surety of any such alterations, extensions, or forbearance being expressly waive. This obligation shall remain in full force and effect until the performance of all covenants, terms, and conditions herein stipulated and after such performance, it shall become null and void.

IN TESTIMONY HEREOF witness the hands and seals of the Parties hereto on this _____ Day of _____, 19____.

Execute in _____ Counter-Parts.

_____

BY_____

WITNESS:

_____BY_____

_____BY_____

F

APPROVAL BY COUNTY ATTORNEY

Approved as to form and legality:

_____ Date:_____
, County Attorney

APPROVAL BY FINANCE OFFICER

This instrument has been preaudited in the manner required by the local Government Budget and Fiscal Control Act.

_____ Date:_____

G

CERTIFICATION OF NONSEGREGATED FACILITIES

The Bidder certifies that he does not maintain or provide for his employees any segregated facilities at any of his establishments, and that he does not permit his employees to perform their services at any location, under his control, where segregated facilities are maintained. The Bidder agrees that a breach of this certification will be a violation of the Equal Opportunity clause in any contract resulting from acceptance of this bid. As used in this certification, the term "segregated facilities" means any waiting rooms, work areas, restrooms and washrooms, restaurants and other eating areas, timeclocks, locker rooms, and other storage or dressing areas, parking lots, drinking fountains, recreation or entertainment areas, transportation, and housing facilities provided for employees which are segregated by explicit directive or are in fact segregated on the basis of race, color, religion, or national origin, because of habit, local custom, or otherwise. The Bidder agrees that (except where he has obtained identical certification from proposed subcontractors for specific time periods) he will obtain identical certifications from proposed subcontractors prior to the award of subcontracts exceeding $10,000 which are not exempt from the provisions of the Equal Opportunity clause, and that he will retain such certifications in his files.

Note: The penalty for making false statements in offers is prescribed in 18 U.S.C. & 1001.

Date _____, 19___ _____
(Name of Bidder)

Official Address

_____ BY:_____

_____ Title:_____

_____

H

GENERAL CONDITIONS

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The Contractor shall certify that installation has proceeded in accordance with the Specifications and Contract Documents for this project except as noted to the Engineer.

LEACHATE COLLECTION & REMOVAL SYSTEM:

1.) Performance Requirements:

The leachate system is designed to maintain less than 1 foot (30 cm) depth of leachate over the composite liner. Leachate volumns generated while the landfill is open were used to design the piping system and storage facility to maintain a conservative design.

The leachate storage facility is designed to provide thirty (30) days of storage as required when treatment of the leachate is being provided by a local Wastewater Treatment Facility. Also, a minimum of two (2) feet of freeboard is provided as a measure of safety.

The leachate piping system is designed to adequately support live and dead loads expected in the construction and operation of a sanitary landfill. The manufacturer of the piping material used has provided Test Data that supports the use of HDPE piping to convey the leachate to the storage facility.

The protective drainage layer over the HDPE liner is intended to have two primary functions. The first is to protect the HDPE liner from damage during construction and operation. The second function is to convey the leachate from the active areas to the collection system so that the leachate can be drained to the storage facility for treatment. Using the HELP model, it is imperative that this layer have the necessary geotechnical properties to ensure the depth of leachate on top of the liner does not exceed one (1) foot.

The necessary engineering calculations supporting the leachate collection and removal system are contained in Appendix C.

2.) Construction Materials:

a. Pipe and Fittings: The pipe supplied under this specification shall be high performance, high molecular weight, high density polyethylene pipe equal to Drisco-pipe 1000 as manufactured by Phillips Driscopipe, Inc., Dallas, Texas and shall conform to ASTM D 1248 (Type III, Class C, Category 5, P34). Minimum cell classification values shall be 345434C as referenced in ASTM D 3350 - 1981a. The fittings supplied under this specification shall be molded from a polyethylene compound having a cell classification equal to or exceeding the compound used in the pipe or shall be manufactured using a polyethylene compound having a cell classification equal to or exceeding the cell classification of the pipe supplied under this specification shall be of the same manufacture as the pipe being supplied.

Perforated Leachate collection Pipe: Straight high density polyethylene pipe shall be used for perforated leachate piping. All leachate collection pipes shall be 6 inch diameter perforated HDPE pipe.

Non-Perforated Leachate collection Pipe: Straight high density polyethylene pipe shall be used for and solid leachate piping.

All leachate header pipes shall be 6 inch diameter solid HDPE pipe. All leachate header pipes shall have butt fused joints.

Physical Properties of Pipe Compound:

- Density: The density shall be no less than 0.941-0.955 gms/cm^3 as referenced in ASTM D1505.

- Melt Flow: Melt Flow shall be no greater than 0.4 gms/10 min. when tested in accordance with ASTM D 1238 - Condition E.

- Flex Modulus: Flexural Modulus shall be 110,000 to less than 180,000 psi as referenced in ASTM D 790.

- Tensile Strength at Yield: Tensile strength shall be 3,000 to less than 3,500 psi as referenced in ASTM D 638.

- ESCR: Environmental Stress Crack Resistance shall be in excess of 1,000 hours with zero failures when tested in accordance with ASTM D 1693 - Condition C.

- Hydrostatic Design Basis shall be 1,600 psi as 23°C when tested in accordance with ASTM D 2837.

Rejection: Polyethylene pipe and fittings may be rejected for failure to meet any of the requirements of this specifications.

Pipe Dimensions: Pipe supplied under this specification shall have a nominal IPS (Iron Pipe Size) OD unless otherwise specified. The SDR (Standard Dimension Ratio) of the pipe supplied shall be SDR21.

b. Geotextile Fabric:

Materials: The geotextile fabric shall be a Trevira Type 1120, as manufactured by Hoechst Celanese Corporation, or an approved equal. The geotextile shall have the following minimum physical properties:

Fabric Property	Unit	Test Method	Value
Fabric Weight	oz/yd^2	ASTM D-3776	6.0
Thickness, t	mils	ASTM D-1777	95
Grab Strength	lbs	ASTM D-4632	230/180
Grab Elongation	%	ASTM D-4632	65/75
Trapezoid Tear Strength	lbs	ASTM D-4533	80/75
Puncture Resistance (5/16" hemispherical tip)	lbs	ASTM D-3787	100
Mullen Burst Strength	psi	ASTM D-3786	345
Water Flow Rate	gpm/ft^2	ASTM D-4491	180
Permeability	cm/sec	ASTM D-4491	0.59
AOS (Mod to 10 min)	Sieve Size	ASTM D-4751	70-100
Roll Widths, Minimum	ft		15
Roll Length, Minimum	ft		300

c. Stone Filter: The stone filter shall be smooth, well rounded, washed river gravel that meets the gradation specifications for #57 stone.

d. Protective Drainage Layer: The drainage layer is granualar material placed on top of the liner to allow leachate to drain to the leachate collection pipes located within the drainage layer. A 50' swath of Fine Silica Sand shall be placed along the centerline of each trench (i.e. centerline of leachate collection pipe). The Sand shall be wrapped along the bottom and sides with Trevira No. 1120 Geotextile Fabric or equal, leaving the top exposed. The depth of the sand is 2'. Outside the plan view limits of sand, the drainage layer may be a "finer granular material", as specified below:

- Slope Stability--The material must have a slope stability factor of safety of at least 3 under the following conditions; saturated, uncompacted, resting on HDPE textured sheet at a slope of 3:1, material thickness of 2'.

- Permeability--The compacted permeability must be greater than 10^{-5} cm/sec.

- Acceptance--The material must be acceptable to the Engineer, Owner, and the North Carolina Department of Environment, Health and Natural Resources for its intended application.

e. - Ballast Material--The ballast material in the leachate pond shall be concrete slabs which are 5' in diameter and 8" thick. A sheet of Trevira Type 1145 or approved equal shall be placed between the slab and liner to protect the liner.

- Placement--The drainage layer is to be placed in 6" lifts to a depth of 2' with the first layer left uncompacted to preclude damage to the HDPE liner. Subsequent 6" lifts are to be compacted to a stable condition.

- Access--Only articulating rubber tired equipment is to be used in placing the drainage material. Smooth stell wheel roller may be used for compaction. Tracked vehicles, tamping foot, and grid type rollers are prohibited.

- Protection--The Contractor shall protect newly graded/compacted areas from traffic and erosion. Keep free of trash and debris.

- Maintenance--The Contractor shall repair and reestablish grades in settled eroded and rutted areas to specify tolerances.

- Areas--The Contractor shall, where completed compacted areas are disturbed by subsequent construction operations or adverse weather, reshape, and compact to required density prior to further construction.

f. Sand: The sand drainage layer shall be a clean, quartz silica natural sand or blend of natural sands that have a minimum permeability of 1×10^{-2}cm/sec.

g. Geonet: A lateral drainage layer shall be a Polynet PN-3000 composite made by Fluid Systems, Inc., with a hydraulic conductivity of 1 cm/sec or an approved equal. The Polynet PN-3000 shall have a non-woven geotextile fabric heat-laminated to one side. The geotextile fabric shall be a Trevira Type 1120, as manufactured by Hoechst Celanese Corporation, or an approved equal. The geotextile acts as a filter, allowing fluids to enter the composite while preventing soil fines from entering the open spaces in the net and clogging the flow of liquids.

3.) Construction Methods

a. Leachate collection pipes: The leachate collection lines will be oriented as shown in the plans. The perforated leachate collection lines are placed into the bottom

center of collection trenches. Lined areas where leachate collection pipes are to be placed shall be double lined for a minimum width of 11 feet with the HDPE liner as shown in the plans. A 6.0 oz. per square yard of geotextile fabric shall be placed on top of the double lined area for additional cushioning and protection to the liner. This additional liner shall be extrusion welded to the existing liner. The minimum 6 inch diameter perforated HDPE pipe shall then be laid true and on grade as shown on the plan of operation. A layer of washed, well rounded river gravel (meeting #57 gradation requirements) shall be placed over the collection pipe. The stone will then be wrapped with he fabric and fastened as shown in the plans. Perforated leachate collection line will be equipped with a cleanout to provide access to the line.

- Handling of Pipe: Pipe shall be stored on clean, level ground to prevent undue scratching or gouging of the pipe. If the pipe must be stacked for storage, such stacking should be done in accordance with the pipe manufacturer's recommendations. The handling of the pipe should be done in such a manner that it is not damaged by dragging over sharp objects or cut by chokers or lifting equipment.

- Repair of Damaged Sections: Segments of pipe having cuts or gouges in excess of 10% of the wall thickness of the pipe should be cut out and removed. The undamaged portions of the pipe shall be rejoined using the butt fusion joining method.

- Pipe Joining: Sections of polyethylene pipe should be joined into continuous lengths on the job site above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements, alignment, and fusion pressures.

- Handling of Fused Pipe: Fused segments of pipe shall be handled so as to avoid damage to the pipe. When lifting fused sections of pipe, chains or cable type chokers shall be prohibited. Nylon slings are required. Spreader bars shall be used when lifting long fused sections. Care shall be exercised to avoid cutting or gouging the pipe.

- Testing for Non-Perforated HDPE Pipe: When a length of pipe approved by the Engineer is ready for testing, the following procedures shall be used.

  Preparation: Provide a test pump, an accurate meter, and all other accessories required to make the test. Provide and remove all temporary bulkheads, plugs, and flanges required to perform the pressure test.

  Test Pressure and Leakage: Test the pipe line at ±15 psi. Sustain the pressure for 2 hours. The pressure shall not drop by more than 2 psi during this period.

  If leaks are detected, locate, repair, and retest. If results are not totally satisfactory, the Engineer may require testing for a longer period of time.

b. Trenching and Backfill:

- Trench Construction: The trench and trench bottom shall be constructed in accordance with ASTM D 2321 - Section 7.

- Embedment Material: Embedment materials shall be Class I materials as defined by ASTM D 2321 - Section 6. The use of Class II, Class III, Class IV and Class V materials for embedment is prohibited.

- Bedding: Bedding of the pipe shall be performed in accordance with ASTM D 2321 - Section 8. Compaction rates shall be as specified in ASTM D 2321.

- Haunching and Initial Backfill: Haunching and initial backfill shall be as specified in ASTM D 2321 - Section 9 using Class I, Class II, or Class III materials. Materials used and compaction rates shall be as specified.

- Special Conditions: ASTM D 2321 - Section 11.2, Minimum Cover for Load Application, Section 11.3, Use of Compaction Equipment, and Section 11.4, Removal of Trench Protection apply.

c. Precast Sewer Manholes:

- Manholes shall be constructed at the locations shown on the plans. Manholes shall be to the depth shown on the plans. Details of manholes are shown on the plans and construction shall be in accordance with these details.

- Where polyethylene pipes enter and exit a manhole, the hole shall be sealed with grout and a neoprene rubber boot.

- After the manhole construction has been completed to the proper elevation, the cast iron manhole frame shall be set in a full bed of mortar and adjusted to the elevation established by the Plans.

d. Geonet: The leachate collection system is completed by installing a HDPE drainage net directly above the synthetic liner. The geonet will not extend up the sideslopes of the balefill.

e. Sand layer: A 24" thick sand layer will be placed above the drainage net, in a fifty (50) foot swath centered along the leachate collection lines. The sand drainage layer shall be a clean, quartz silica natural sand or blend of natural sands that have a minimum permeability of 1 x 10^{-2}cm/sec.

f. Protective Drainage Layer: The Contractor shall verify that this material's soil placement is consistent with state of the art procedures such as:

- Placement of soils on the geomembrane shall not proceed at an ambient temperature below 5°C (40°F) nor above 40°C (104°F).

- Placement of soils on the geomembrane shall be done in a manner that minimizes wrinkles in the liner. If large wrinkles are formed, the Contractor shall cut and reseam the wrinkled area.

- Equipment used for placing soil shall not be driven directly on the geomembrane.

- A minimum thickness of two (2) feet of soil is required between rubber-tired vehicles and the geomembrane.

- In heavily trafficked areas such as access ramps, soil thickness shall be at least 3 ft. (0.9m).

The Contractor shall:

- Measure soil thickness and verify that the required thicknesses are maintained.

- Verify that final thicknesses are consistent with design.

- Verify that placement of soil was done in such a manner that geomembrane damage is unlikely.

The Contractor shall inform the Engineer if the above conditions are not fulfilled.

g. Leachate Impoundments: A Leachate Impoundment shall be used for the collection and storage of leachate. Upon completion of the leachate impoundment, and prior to it being put in use, a registered professional engineer licensed to practice engineering in the State of North Carolina shall issue a letter to the North Carolina Solid Waste Management Division stating that the facility has been constructed according to the construction plans and specifications.

- The leachate pond shall have a 60 mil HDPE synthetic liner along with 12 inches of clay with a permeability of 1×10^{-8} cm/sec. It will by sized to handle a 30 day storage. Design calculations for the leachate pond may be found in Appendix C of this report.

4.) Measures to Prevent Clogging: The following measures shall be taken to prevent clogging in the leachate collection system:

a. The liner installation provides 2% minimum slope on the lateral drainage layer above the liner to promote leachate drainage.

b. Lateral drainage layer consists of a geonet with a minimum hydraulic conductivity of 1 cm/sec below sand with minimum hydraulic conductivity of 1×10^{-2} cm/sec.

c. A leachate cleanout assembly is provided upstream of each collector line to pressure wash the lines if needed.

d. The area 6 inches outside of the perforated collection pipes shall be an aggregate filter pack. This filter pack will consist of a 6 inch layer of washed, well rounded river gravel that meets gradation specifications for a #57 stone. This aggregate filter is designed to help prevent clogging of perforations and silting of the pipe itself. Any silting that occurs can be removed by pressure washing.

The above design to prevent clogging is based in part on information from the book Avoiding Failure of Leachate Collection and Cap Drainage Systems by Jeffrey Bass, Archur D. Little, Inc. Cambridge, Massachusetts, 1986.

5.) Leachate Quantities: To minimize leachate generation, this landfill contains design features which consist of:

a. a relatively impervious cap over the completed areas,

b. intermediate and final cover slopes of 2 percent or more,

c. multiple solid waste layers,

d. good grass cover, and

e. diversion of surface run-off around the facility.

An estimate of leachate peak flow has been made using the Hydrologic Evaluation of Landfill Performance (HELP) model developed for the EPA Municipal Environmental Research Laboratory by the Corps of Engineers Waterways Experiment Station at Vicksburg, Mississippi. The program models the effects of precipitation, surface storage, run-off, infiltration, percolation, evaporation, soil moisture storage, and lateral drainage on this specific landfill design.

Computer runs were made for a typical leachate holding facility serving a typical phase of development to determine leachate quantities.

To estimate the quantity of leachate to be generated, the daily peak value of leachate volume estimated by the program for the 10 acre site was determined. This value was converted into units of gallons/acre. It was then multiplied by the total number of acres that will be lined within the site. This will be the projected quantity of leachate that will be generated by the whole site. Calculations and the HELP model run can by found in Appendix C.

5.) Leachate Handling and Treatment: Initially leachate will be collected and transported to the Waynesville Wastewater Treatment Plant. Samples from the Leachate Pond will be analyzed on a semi-annual basis. The following parameters shall be tested:

1. Biochemical Oxygen Demand
2. Chemical Oxygen Demand
3. Total Nitrogen
4. Heavy Metals: Arsenic, Barium, Lead, Zinc Magnesium
5. Total Dissolved Solids
6. pH
7. Specific Conductance

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GENERAL CONDITIONS

ARTICLE 1--DEFINITIONS

Wherever used in these General Conditions or in the other Contract Documents the following terms have the meanings indicated which are applicable to both the singular and plural thereof:

Addenda - Written or graphic instruments issued prior to the opening of Bids which clarify, correct or change the bidding documents or the Contract Documents.

Agreement - The written agreement between OWNER and CONTRACTOR covering the Work to be performed; other Contract Documents are attached to the Agreement and made a part thereof as provided therein.

Application for Payment - The form accepted by ENGINEER which is to be used by CONTRACTOR in requesting progress or final payments and which is to include such supporting documentation as is required by the Contract Documents.

Bid - The offer or proposal of the bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

Bonds - Bid, performance and payment bonds and other instruments of security.

Change Order - A document recommended by ENGINEER, which is signed by CONTRACTOR and OWNER and authorizes an addition, deletion or revision in the Work, or an adjustment in the Contract Price or the Contract Time, issued on or after the Effective Date of the Agreement.

Contract Documents - The Agreement, Addenda (which pertain to the Contract Documents), CONTRACTOR's Bid (including documentation accompanying the Bid and any post-Bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Agreement, the Bonds, these General Conditions, the Supplementary Conditions, the Specifications and the Drawings as the same are more specifically identified in the Agreement, together with all amendments, modifications and supplements issued pursuant to paragraphs 3.4 and 3.5 on or after the Effective Date of the Agreement.

Contract Price - The moneys payable by OWNER to CONTRACTOR under the Contract Documents as stated in the Agreement (subject to the provisions of paragraph 11.9.1 in the case of Unit Price Work).

Contract Time - The number of days (computed as provided in paragraph 17.2) or the date stated in the Agreement for

the completion of the Work.

CONTRACTOR - The person, firm or corporation with whom OWNER has entered into the Agreement.

Defective - An adjective which when modifying the word Work refers to Work that is unsatisfactory, faulty or deficient, or does not conform to the Contract Documents, or does not meet the requirements of any inspection, reference standard, test or approval referred to in the Contract Documents, or has been damaged prior to ENGINEER's recommendation of final payment (unless responsibility for the protection thereof has been assumed by OWNER at Substantial Completion in accordance with paragraph 14.8 or 14.10).

Drawings - The drawings which show the character and scope of the Work to be performed and which have been prepared or approved by ENGINEER and are referred to in the Contract Documents.

Effective Date of the Agreement - The date indicated in the Agreement on which it becomes effective, but if no such date is indicated it means the date on which the Agreement is signed and delivered by the last of the two parties to sign and deliver.

ENGINEER - The person, firm or corporation named as such in the Agreement.

Field Order - A written order issued by ENGINEER which orders minor changes in the Work in accordance with paragraph 9.5 but which does not involve a change in the Contract Price or the Contract Time.

* General Requirements - Sections of Division 1 of the Specifications.

Laws and Regulations; Laws or Regulations - Laws, rules, regulations, ordinances, codes and/or orders.

Notice of Award - The written notice by OWNER to the apparent successful bidder stating that upon compliance by the apparent successful bidder with the conditions precedent enumerated therein, within the time specified, OWNER will sign and deliver the Agreement.

Notice to Proceed - A written notice given by OWNER to CONTRACTOR (with a copy to ENGINEER) fixing the date on which the Contract Time will commence to run and on which CONTRACTOR shall start to perform CONTRACTOR'S obligations under the Contract Documents.

OWNER - The public body or authority, corporation, association, firm or person with whom CONTRACTOR has entered into the Agreement and for whom the Work is to be provided.

Partial Utilization - Placing a portion of the Work in service for the purpose for which it is intended (or a related purpose) before reaching Substantial Completion for all the Work.

Project - The total construction of which the Work to be provided under the Contract Documents may be the whole, or a part as indicated elsewhere in the Contract Documents.

Resident Project Representative - The authorized representative of ENGINEER who is assigned to the site or any part thereof.

Shop Drawings - All drawings, diagrams, illustrations, schedules and other data which are specifically prepared by or for CONTRACTOR to illustrate some portion of the Work and all illustrations, brochures, standard schedules, performance charts, instructions, diagrams and other information prepared by a Supplier and submitted by CONTRACTOR to illustrate material or equipment for some portion of the Work.

Specifications - Those portions of the Contract Documents consisting of written technical descriptions of materials, equipment, construction systems, standards and workmanship as applied to the Work and certain administrative details applicable thereto.

Subcontractor - An individual, firm or corporation having a direct contract with CONTRACTOR or with any other Subcontractor for the performance of a part of the Work at the site.

Substantial Completion - The Work (or a specified part thereof) has progressed to the point where, in the opinion of ENGINEER as evidenced by ENGINEER's definitive certificate of Substantial Completion, it is sufficiently complete, in accordance with the Contract Documents, so that the Work (or specified part) can be utilized for the purposes for which it is intended; or if there be no such certificate issued, when final payment is due in accordance with paragraph 14.13. The terms "substantially complete" and "substantially completed" as applied to any Work refer to Substantial Completion thereof.

Supplementary Conditions - The part of the Contract Documents which amends or supplements these General Conditions.

Supplier - A manufacturer, fabricator, supplier, distributor, materialman or vendor.

Underground Facilities - All pipelines, conduits, ducts, cables, wires, manholes, vaults, tanks, tunnels or other such facilities or attachments, and any encasements containing such

facilities which have been installed underground to furnish any of the following services or materials: electricity, gases, steam, liquid petroleum products, telephone or other communications, cable television, sewage and drainage removal, traffic or other control systems or water.

Unit Price Work - Work to be paid for on the basis of unit prices.

Work - The entire completed construction or the various separately identifiable parts thereof required to be furnished under the Contract Documents. Work is the result of performing services, furnishing labor and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.

Work Directive Change - A written directive to CONTRACTOR, issued on or after the Effective Date of the Agreement and signed by OWNER and recommended by ENGINEER, ordering an addition, deletion or revision in the Work, or responding to differing or unforeseen physical conditions under which the Work is to be performed as provided in paragraph 4.2 or 4.3 or to emergencies under paragraph 6.22. A Work Directive Change may not change the Contract Price or the Contract Time, but is evidence that the parties expect that the change directed or documented by a Work Directive Change will be incorporated in a subsequently issued Change Order following negotiations by the parties as to its effect, if any, on the Contract Price or Contract Time as provided in paragraph 10.2.

Written Amendment - A written amendment of the Contract Documents, signed by OWNER and CONTRACTOR on or after the Effective Date of the Agreement and normally dealing with the non-engineering or nontechnical rather than strictly Work-related aspects of the Contract Documents.

ARTICLE 2 - PRELIMINARY MATTERS

Delivery of Bonds:

2.1 When CONTRACTOR delivers the executed Agreements to OWNER, CONTRACTOR shall also deliver to OWNER such Bonds as CONTRACTOR may be required to furnish in accordance with paragraph 5.1

Copies of Documents:

2.2 ENGINEER shall furnish to CONTRACTOR up to six copies (unless otherwise specified in the Supplementary Conditions) of the Contract Documents as are reasonably necessary for the execution of the Work. Additional copies will be furnished, upon request, at the cost of reproduction.

Commencement of Contract Time; Notice to Proceed:

2.3 The Contract Time will commence to run on the date indicated in the Notice to Proceed. A Notice to Proceed may be given at any time within thirty days after the Effective Date of the Agreement. In no event will the Contract Time commence to run later than the thirtieth day after the Effective Date of the Agreement.

Starting the Project:

2.4 CONTRACTOR shall start to perform the Work on the date when the Contract Time commences to run, but no Work shall be done at the site prior to the date on which the Contract Time commences to run.

Before Starting Construction:

2.5 Before undertaking each part of the Work, CONTRACTOR shall carefully study and compare the Contract Documents and check and verify pertinent figures shown thereon and all applicable field measurements. CONTRACTOR shall promptly report in writing to ENGINEER any conflict, error or discrepancy which CONTRACTOR may discover and shall obtain a written interpretation or clarification from ENGINEER before preceding with any Work affected thereby; however, CONTRACTOR shall not be liable to OWNER or ENGINEER for failure to report any conflict, error or discrepancy in the Contract Documents, unless CONTRACTOR had actual knowledge thereof or should reasonably have known thereof.

2.6 Within ten days after the Effective Date of the Agreement (unless otherwise specified in the General Requirements), CONTRACTOR shall submit to ENGINEER for review:

2.6.1 an estimated progress schedule indicating the starting and completion dates of the various stages of the Work;

2.6.2 a preliminary schedule of Shop Drawing submissions; and

2.6.3 a preliminary schedule of values for all of the Work which will include quantities and prices of items aggregating the Contract Price and will subdivide the Work into component parts in sufficient detail to serve as the basis for progress payments during construction. Such prices will include an appropriate amount of overhead and profit applicable to each item of Work which will be confirmed in writing by CONTRACTOR at the time of submission.

2.7 Before any Work at the site is started, CONTRACTOR shall deliver to OWNER, with a copy to ENGINEER, certificates (and other evidence of insurance requested by OWNER) which CONTRACTOR is required

to purchase and maintain in accordance with paragraphs 5.1 and 5.2, and OWNER shall deliver to CONTRACTOR certificates (and other evidence of insurance requested by CONTRACTOR) which OWNER is required to purchase and maintain in accordance with paragraphs 5.4 and 5.5.

Preconstruction Conference:

2.8 Within twenty days after the Effective Date of the Agreement, but before CONTRACTOR starts the Work at the site, a conference attended by CONTRACTOR, ENGINEER and others as appropriate will be held to discuss the schedules referred to in paragraph 2.6, to discuss procedures for handling Shop Drawings and other submittals and for processing Applications for Payment, and to establish a working understanding among the parties as to the Work.

Finalizing Schedules:

2.9 At least ten days before submission of the first Application for Payment, CONTRACTOR, ENGINEER and others as appropriate will finalize the schedules submitted in accordance with paragraph 2.6. The finalized progress schedule will be acceptable to ENGINEER as providing an orderly progression of the Work to completion within the Contract Time, but such acceptance will neither impose on ENGINEER responsibility for the progress or scheduling of the Work nor relieve CONTRACTOR from full responsibility therefor. The finalized schedule of Shop Drawing submissions will be acceptable to ENGINEER as providing a workable arrangement for processing the submissions. The finalized schedule of values will be acceptable to ENGINEER as to form and substance.

ARTICLE 3 - CONTRACT DOCUMENTS: INTENT, AMENDING, REUSE

Intent:

3.1 The Contract Documents comprise the entire agreement between OWNER and CONTRACTOR concerning the Work. The Contract Documents are complementary; what is called for by one is as binding as if called for by all. The Contract Documents will be construed in accordance with the law of the place of the Project.

3.2 It is the intent of the Contract Documents to describe a functionally complete Project (or part thereof) to be constructed in accordance with the Contract Documents. Any Work, materials or equipment that may reasonably be inferred from the Contract Documents as being required to produce the intended result will be supplied whether or not specifically called for. When words which have a wellknown technical or trade

meaning are used to describe Work, materials or equipment, such words shall be interpreted in accordance with that meaning. Reference to standard specifications, manuals or codes of any technical society, organization or association, or to the Laws or Regulations of any governmental authority, whether such reference be specific or by implication, shall mean the latest standard specification, manual, code or Laws or Regulations in effect at the time of opening of Bids (or, on the Effective Date of the Agreement if there were no Bids), except as may be otherwise specifically stated. However, no provision of any referenced standard specification, manual or code (whether or not specifically incorporated by reference in the Contract Documents) shall be effective to change the duties and responsibilities of OWNER, CONTRACTOR or ENGINEER, or any of their consultants, agents or employees from those set forth in the Contract Documents, nor shall it be effective to assign to ENGINEER, or any of ENGINEER's consultants, agents or employees, any duty or authority to supervise or direct the furnishing or performance of the Work or any duty or authority to undertake responsibility contrary to the provisions of paragraph 9.15 or 9.16. Clarifications and interpretations of the Contract Documents shall be issued by ENGINEER as provided in paragraph 9.4.

3.3 If, during the performance of the Work, CONTRACTOR finds a conflict, error or discrepancy in the Contract Documents, CONTRACTOR shall so report to ENGINEER in writing at once and before proceeding with the Work affected thereby shall obtain a written interpretation or clarification from ENGINEER; however, CONTRACTOR shall not be liable to OWNER or ENGINEER for failure to report any conflict, error or discrepancy in the Contract Documents unless CONTRACTOR had actual knowledge thereof or should reasonably have known thereof.

Amending and Supplementing Contract Documents:

3.4 The Contract Documents may be amended to provide for additions, deletions and revisions in the Work or to modify the terms and conditions thereof in one or more of the following ways:

3.4.1 a formal Written Amendment,

3.4.2 a Change Order (pursuant to paragraph 10.4), or

3.4.3 a Work Directive Change (pursuant to paragraph 10.1).

As indicated in paragraph 11.2 and 12.1, Contract Price and Contract Time may only be changed by a Change Order or a Written Amendment.

3.5 In addition, the requirements of the Contract Documents may be supplemented, and minor variations and deviations in the Work may be authorized, in one or more of the following ways:

3.5.1 a Field Order (pursuant to paragraph 9.5),

3.5.2 ENGINEER's review of a Shop Drawings or sample (pursuant to paragraphs 6.26 and 6.27), or

3.5.3 ENGINEER's written interpretation or clarification (pursuant to paragraph 9.4).

Reuse of Documents:

3.6 Neither CONTRACTOR nor any Subcontractor or Supplier or other person or organization performing or furnishing any of the Work under a direct or indirect contract with OWNER shall have or acquire any title to or ownership rights in any of the Drawings, Specifications or other documents (or copies of any thereof) prepared by or bearing the seal of ENGINEER; and they shall not reuse any of them on extensions of the Project or any other project without written consent of OWNER and ENGINEER and specific written verification or adaptation by ENGINEER.

ARTICLE 4 - AVAILABILITY OF LANDS; PHYSICAL CONDITIONS; REFERENCE POINTS

Availability of Lands:

4.1 OWNER shall furnish, as indicated in the Contract Documents, the lands upon which the Work is to be performed, rights-of-way and easements for access thereto, and such other lands which are designated for the use of CONTRACTOR. Easements for permanent structures or permanent changes in existing facilities will be obtained and paid for by OWNER, unless otherwise provided in the Contract Documents. If CONTRACTOR believes that any delay in OWNER's furnishing these lands, rights-of-way or easements entitles CONTRACTOR to an extension of the Contract Time, CONTRACTOR may make a claim therefor as provided in Article 12. CONTRACTOR shall provide for all additional lands and access thereto that may be required for temporary construction facilities or storage of materials and equipment.

Physical Conditions:

4.2.1 Explorations and Reports: Reference is made to the Supplementary Conditions for identification of those reports of explorations and tests of subsurface conditions at the site that have been utilized by

ENGINEER in preparation of the Contract Documents. CONTRACTOR may rely upon the accuracy of the technical data contained in such reports, but not upon nontechnical data, interpretations or opinions contained therein or for the completeness thereof for CONTRACTOR's purposes. Except as indicated in the immediately preceding sentence and in paragraph 4.2.6, CONTRACTOR shall have full responsibility with respect to subsurface conditions at the site.

4.2.2 Existing Structures: Reference is made to the Supplementary Conditions for identification of those drawings of physical conditions in or relating to existing surface and subsurface structures (except Underground Facilities referred to in paragraph 4.3) which are at or contiguous to the site that have been utilized by ENGINEER in preparation of the Contract Documents. CONTRACTOR may rely upon the accuracy of the technical data contained in such drawings, but not for the completeness thereof for CONTRACTOR's purposes. Except as indicated in the immediately preceding sentence and in paragraph 4.2.6, CONTRACTOR shall have full responsibility with respect to physical conditions in or relating to such structures.

4.2.3 Report of Differing Conditions: If CONTRACTOR believes that:

4.2.3.1 any technical data on which CONTRACTOR is entitled to rely as provided in paragraphs 4.2.1 and 4.2.2 is inaccurate, or

4.2.3.2 any physical condition uncovered or revealed at the site differs materially from that indicated, reflected or referred to in the Contract Documents,

CONTRACTOR shall, promptly after becoming aware thereof and before performing any Work in connection therewith (except in an emergency as permitted by paragraph 6.22), notify OWNER and ENGINEER in writing about the inaccuracy or difference.

4.2.4 ENGINEER's Review: ENGINEER will promptly review the pertinent conditions, determine the necessity of obtaining additional explorations or tests with respect thereto and advise OWNER in writing (with a copy to CONTRACTOR) of ENGINEER's finding and conclusions.

4.2.5 Possible Document Change: If ENGINEER concludes that there is a material error in the Contract Documents or that because of newly discovered conditions a change in the Contract Documents is

required, a Work Directive Change or a Change Order will be issued as provided in Article 10 to reflect and document the consequences of the inaccuracy or difference.

4.2.6 Possible Price and Time Adjustments: In each such case, an increase or decrease in the Contract Price or an extension or shortening of the Contract Time, or any combination thereof, will be allowable to the extent that these are attributable to any such inaccuracy or difference. If OWNER and CONTRACTOR are unable to agree as to the amount or length thereof, a claim may be made therefor as provided in Articles 11 and 12.

Physical Conditions - Underground Facilities:

4.3.1 Shown or Indicated: The information and data shown or indicated in the Contract Documents with respect to existing Underground Facilities at or contiguous to the site is based on information and data furnished to OWNER or ENGINEER by the owners of such Underground Facilities or by others. Unless it is otherwise expressly provided in the Supplementary Conditions:

4.3.1.1 OWNER and ENGINEER shall not be responsible for the accuracy or completeness of any such information or data; and,

4.3.1.2 CONTRACTOR shall have full responsibility for reviewing and checking all such information and data, for locating all Underground Facilities shown or indicated in the Contract Documents, for coordination of the Work with the owners of such Underground Facilities during construction, for the safety and protection thereof as provided in paragraph 6.20 and repairing any damage thereto resulting from the Work, the cost of all of which will be considered as having been included in the Contract Price.

4.3.2 Not Shown or Indicated: If an Underground Facility is uncovered or revealed at or contiguous to the site which was not shown or indicated in the Contract Documents and which CONTRACTOR could not reasonably have been expected to be aware of, CONTRACTOR shall, promptly after becoming aware thereof and before performing any Work affected thereby (except in an emergency as permitted by paragraph 6.22), identify the owner of such Underground Facility and give written notice thereof to that owner and to OWNER and ENGINEER. ENGINEER will promptly review the Underground Facility to determine the extent to which the Contract Documents should be modified

to reflect and document the consequences of the existence of the Underground Facility, and the Contract Documents will be amended or supplemented to the extent necessary. During such time, CONTRACTOR shall be responsible for the safety and protection of such Underground Facility as provided in paragraph 6.20. CONTRACTOR shall be allowed an increase in the Contract Price or an extension of the Contract Time, or both, to the extent that they are attributable to the existence of any Underground Facility that was not shown or indicated in the Contract Documents and which CONTRACTOR could not reasonably have been expected to be aware of. If the parties are unable to agree as to the amount or length thereof, CONTRACTOR may make a claim therefor as provided in Articles 11 and 12.

Reference Points:

4.4 OWNER shall provide engineering surveys to establish reference points for construction which in ENGINEER's judgment are necessary to enable CONTRACTOR to proceed with the Work. CONTRACTOR shall be responsible for laying out the Work (unless otherwise specified in the General Requirements), shall protect and reserve the established reference points and shall make no changes or relocations without the prior written approval of OWNER. CONTRACTOR shall report to ENGINEER whenever any reference point is lost or destroyed or requires relocation because of necessary changes in grades or locations, and shall be responsible for the accurate replacement or relocation of such reference points by professionally qualified personnel.

ARTICLE 5 - BONDS AND INSURANCE

Performance and Other Bonds:

5.1 CONTRACTOR shall furnish performance and payments Bonds, each in an amount at least equal to the Contract Price as security for the faithful performance and payment of all CONTRACOTR'S obligations under the Contract Documents. These Bonds shall remain in effect at least until one year after the date when final payment becomes due, except as otherwise provided by Law or Regulation or by the Contract Documents. CONTRACTOR shall also furnish such other Bonds as are required by the Supplementary Conditions. All Bonds shall be in the form prescribed by Law or Regulation or by the Contract Documents and be executed by such sureties as are named in the current of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as

published in Circular 570 (ammended) by the Audit Staff Bureau of Accounts, U.S. Treasury Department. All Bonds signed by an agent must be accompanied by a certified copy of the authority to act.

5.2 If the surety on any Bond furnished by CONTRACTOR is declared a bankrupt or becomes insolvent or its right to do business is terminated in any state where any part of the Project is located or its ceases to meet the requirements of paragraph 5.3, CONTRACTOR shall within five days thereafter substitute another Bond and Surety, both of which must be acceptable to OWNER.

Contractor's Liability Insurance:

5.3 CONTRACTOR shall purchase and maintain such comprehensive general liability and other insurance as is appropriate for the Work being performed and furnished and as will provide protection from claims set forth below which may arise out of or result from CONTRACTOR's performance and furnishing of the Work and CONTRACTOR's other obligations under the Contract Documents, whether it is to be performed or furnished by CONTRACTOR, by any subcontractor, by anyone directly or indirectly employed by any of them to perform or furnish any of the Work, or by anyone for whose acts any of them may be liable:

5.3.1 Claims under workers' or workmen's compensation, disability benefits and other similar employee benefit acts;

5.3.2 Claims for damages because of bodily injury, occupational sickness or disease, or death of CONTRACTOR's employees;

5.3.3 Claims for damages because of bodily injury, sick-ness or disease, or death of any person other than CONTRACTOR's employees;

5.3.4 Claims for damages insured by personal injury liability coverage which are sustained (a) by any person as a result of an offense directly or indirectly related to the employment of such person by CONTRACTOR, or (b) by any other person for any other reason;

5.3.5 Claims for damages, other than to the Work itself, because of injury to or destruction of tangible property wherever located, including loss of use resulting therefrom;

5.3.6 Claims arising out of operation of Laws or Regulations for damages because of bodily injury or death of any person or for damage to property; and

5.3.7 Claims for damages because of bodily injury or death of any person or property damage arising out

of the ownership, maintenance or use of any motor vehicle.

The insurance required by this paragraph 5.3 shall include the specific coverages and be written for not less than the limits of liability and coverages provided in the Supplementary Conditions, or required by law, whichever is greater. The comprehensive general liability insurance shall include completed operations insurance. All of the policies of insurance so required to be purchased and maintained (or the certificates or other evidence thereof) shall contain a provision or endorsement that the coverage afforded will not be cancelled, materially changed or renewal refused until at least thirty days' prior written notice has been given to OWNER and ENGINEER by certified mail. All such insurance shall remain in effect until final payment and at all times thereafter when CONTRACTOR may be correcting, removing or replacing defective Work in accordance with paragraph 13.12. In addition, CONTRACTOR shall maintain such completed operations insurance for at least two years after final payment and furnish OWNER with evidence of continuation of such insurance at final payment and one year thereafter.

Contractual Liability Insurance:

5.4 The comprehensive general liability insurance required by paragraph 5.3 will include contractual liability insurance applicable to CONTRACTOR's obligations under paragraphs 6.30 and 6.31.

Owner's Liability Insurance:

5.5 OWNER shall be responsible for purchasing and maintaining OWNER's own liability insurance and, at OWNER's option, may purchase and maintain such insurance as will protect OWNER against claims which may arise from operations under the Contract Documents.

Property Insurance:

5.6 Unless otherwise provided in the Supplementary Conditions, OWNER shall purchase and maintain property insurance upon the Work at the site to the full insurable value thereof (subject to such deductible amounts as may be provided in the Supplementary Conditions or required by Laws and Regulations). This insurance shall include the interest of OWNER, CONTRACTOR, Subcontractor, ENGINEER and ENGINEER's consultants in the Work, all of whom shall be listed as insureds or additional insured parties, shall insure against the perils of fire and extended coverage and shall include "all risk" insurance for physical loss and damage

including theft, vandalism and malicious mischief, collapse and water damge, and such other perils a may be provided inthe Supplementary Conditions, and shall include damges, losses and expenses arising out of or resulting from any insured loss or incurred inthe repair of replacement of any insured property (including but not limited to fees and charges of engineers, architects, attorneys and other professionals). If not covered under the "all risk" insurance or otherwise provided inthe Supplementary Conditions, CONTRACTOR shall purchase and maintain similar property insurance on portions of the Work stored on and off the site or in transit when such portions of the Work are to be included in an Application for Payment.

Waiver of Rights:

5.4

5.4.1 OWNER and CONTRACTOR waive all rights against each other for all losses and damages caused by any of the perils covered by the policies of insurance and any other property insurance applicable to the Work, and also waive all such rights against the Subcontractors, ENGINEER, ENGINEER's consultants and all other parties named as insureds in such policies for losses and damages so caused. As required by paragraph 6.11, each subcontract between CONTRACTOR and a Subcontractor will contain similar waiver provisions by the Subcontractor in favor of OWNER, CONTRACTOR, ENGINEER, ENGINEER's consultants and all other parties named as insureds. None of the above waivers shall extend to the rights that any of the insured parties may have to the proceeds of insurance held by OWNER as trustee or otherwise payable any policy so issued.

5.4.2 OWNER and CONTRACTOR intend that any policies provided shall protect all of the parties insured and provide primary coverage for all losses and damages caused by the perils covered thereby. Accordingly, all such policies shall contain provisions to the effect that in the event of payment of any loss or damage the insurer will have no rights of recovery against any of the parties named as insureds or additional insureds, and if the insurers require separate waiver forms to be signed by ENGINEER or ENGINEER's consultant OWNER will obtain the same, and if such waiver forms are required of any Subcontractor, CONTRACTOR will obtain the same.

Receipt and Application of Proceeds:

5.5 Any insured loss under the policies of insurance required will be adjusted with

OWNER and made payable to OWNER as trustee for the insureds, as their interests may appear, subject to the requirements of any applicable mortgage clause and of paragraph 5.6. OWNER shall deposit in a separate account any money so received, and shall distribute it in accordance with such agreement as the parties in interest may reach. If no other special agreement is reached the damaged Work shall be repaired or replaced, the moneys so received applied on account thereof and the Work and the cost thereof covered by an appropriate Change Order or Written Amendment.

5.6 OWNER as trustee shall have power to adjust and settle any loss with the insurers unless one of the parties in interest shall object in writing within fifteen days after the occurrence of loss to OWNER's exercise of this power. If such objection be made, OWNER as trustee shall make settlement with the insurers in accordance with such agreement as the parties in interest may reach. If required in writing by any party in interest, OWNER as trustee shall, upon the occurrence of an insured loss, give bond for the proper performance of such duties.

Acceptance of Insurance:

5.7 If OWNER has any objection to the coverage afforded by or other provisions of the insurance required to be purchased and maintained by CONTRACTOR in accordance with paragraphs 5.1 and 5.2 on the basis of its not complying with the Contract Documents, OWNER shall notify CONTRACTOR in writing thereof within ten days of the date of delivery of such certificates to OWNER in accordance with paragraph 2.7. If CONTRACTOR has any objection to the coverage afforded by or other provisions of the policies of insurance required to be purchased and maintained by OWNER on the basis of their not complying with the Contract Documents, CONTRACTOR shall notify OWNER in writing thereof within ten days of the date of delivery of such certificates to CONTRACTOR in accordance with paragraph 2.7. OWNER and CONTRACTOR shall each provide to the other such additional information in respect of insurance provided by each as the other may reasonably request. Failure by OWNER or CONTRACTOR to give any such notice of objection within the time provided shall constitute acceptance of such insurance purchased by the other as complying with the Contract Documents.

Partial Utilization - Property Insurance:

5.8 If OWNER finds it necessary to occupy or use a portion or portions of the Work prior to Substantial Completion of all the Work, such use or occupancy may be

accomplished in accordance with paragraph 14.10; provided that no such use or occupancy shall commence before the insurers providing the property insurance have acknowledged notice thereof and in writing effected the changes in coverage necessitated thereby. The insurers providing the property insurance shall consent by endorsement on the policy or policies, but the property insurance shall not be cancelled or lapse on account of any such partial use or occupancy.

ARTICLE 6 - CONTRACTOR'S RESPONSIBILITIES

Supervision and Superintendence:

6.1 CONTRACTOR shall supervise and direct the Work competently and efficiently, devoting such attention thereto and applying such skills and expertise as may be necessary to perform the Work in accordance with the Contract Documents. CONTRACTOR shall be solely responsible for the means, methods, techniques, sequences and procedures of construction, but CONTRACTOR shall not be responsible for the negligence of others in the design or selection of a specific means, method, technique, sequence or procedure of construction which is indicated in and required by the Contract Documents. CONTRACTOR shall be responsible to see that the finished Work complies accurately with the Contract Documents.

6.2 CONTRACTOR shall keep on the Work at all times during its progress a competent resident superintendent, who shall not be replaced without written notice to OWNER and ENGINEER except under extraordinary circumstances. The superintendent will be CONTRACTOR's representative at the site and shall have authority to act on behalf of CONTRACTOR. All communications given to the superintendent shall be as binding as if given to CONTRACTOR.

Labor, Materials and Equipment:

6.3 CONTRACTOR shall provide competent, suitable qualified personnel to survey and lay out the Work and perform construction as required by the Contract Documents. CONTRACTOR shall at all times maintain good discipline and order at the site.

6.4 Unless otherwise specified in the General Requirements, CONTRACTOR shall furnish and assume full responsibility for all materials, equipment, labor, transportation, construction equipment and machinery, tools, appliances, fuel, power, light, heat, telephone, water, sanitary facilities,

temporary facilities and all other facilities and incidentals necessary for the furnishing, performance, testing, start-up and completion of the Work.

6.5 All materials and equipment shall be of good quality and new, except as otherwise provided in the Contract Documents. If required by ENGINEER, CONTRACTOR shall furnish satisfactory evidence (including reports of required tests) as to the kind and quality of materials and equipment. All materials and equipment shall be applied, installed, connected, erected, used, cleaned and conditioned in accordance with the instructions of the applicable Supplier except as otherwise provided in the Contract Documents; but no provision of any such instructions will be effective to assign to ENGINEER, or any of ENGINEER's consultants, agents or employees, any duty or authority to supervise or direct the furnishing or performance of the Work or any duty or authority to undertake responsibility contrary to the provisions of paragraph 9.15 to 9.16.

Adjusting Progress Schedule:

6.6 CONTRACTOR shall submit to ENGINEER for acceptance (to the extent indicated in paragraph 2.9) adjustments in the progress schedule to reflect the impact thereon of new developments; these will conform generally to the progress schedule then in effect and additionally will comply with any provisions of the General Requirements applicable thereto.

Substitutes or "Or-Equal" Items:

6.7.1 Whenever materials or equipment are specified or described in the Contract Documents by using the name of a proprietary item or the name of a particular Supplier the naming of the item is intended to establish the type, function and quality required. Unless the name is followed by words indicating that no substitution is permitted, materials or equipment of other Suppliers may be accepted by ENGINEER if sufficient information is submitted by CONTRACTOR to allow ENGINEER to determine that the material or equipment proposed is equivalent or equal to that named. The procedure for review by ENGINEER will include the following as supplemented in the General Requirements. Requests for review of substitute items of material and equipment will not be accepted by ENGINEER from anyone other than CONTRACTOR. If CONTRACTOR wishes to furnish or use a substitute item of material or equipment, CONTRACTOR shall make written application to ENGINEER for acceptance thereof, certifying that the

proposed substitute will perform adequately the functions and achieve the results called for by the general design, be similar and of equal substance to that specified and be suited to the same use as that specified. The application will state that the evaluation and acceptance of the proposed substitute will not prejudice CONTRACTOR's achievement of Substantial Completion on time, whether or not acceptance of the substitute for use in the Work will require a change in any of the Contract Documents (or in the provisions of any other direct contract with OWNER for work on the Project) to adapt the design to the proposed substitute and whether or not incorporation or use of the substitute in connection with the Work is subject to payment of any license fee or royalty. All variations of the proposed substitute from that specified will be identified in the application and available maintenance, repair and replacement service will be indicated. The application will also contain an itemized estimate of all costs that will result directly or indirectly from acceptance of such substitute, including costs of redesign and claims of other contractors affected by the resulting change, all of which shall be considered by ENGINEER in evaluating the proposed substitute. ENGINEER may require CONTRACTOR to furnish at CONTRACTOR's expense additional data about the proposed substitute.

6.7.2 If a specific means, method, technique, sequence or procedure of construction is indicated in or required by the Contract Documents, CONTRACTOR may furnish or utilize a substitute means, method, sequence, technique or procedure of construction acceptable to ENGINEER, if CONTRACTOR submits sufficient information to allow ENGINEER to determine that the substitute proposed is equivalent to that indicated or required by the Contract Documents. The procedure for review by ENGINEER will be similar to that provided in paragraph 6.7.1 as applied by ENGINEER and as may be supplemented in the General Requirements.

6.7.3 ENGINEER will be allowed a reasonable time within which to evaluate each proposed substitute. ENGINEER will be the sole judge of acceptability, and no substitute will be ordered, installed or utilized without ENGINEER's prior written acceptance which will be evidenced by either a Change Order or a reviewed Shop Drawing. OWNER may require CONTRACTOR to furnish at CONTRACTOR's expense a special performance guarantee or other surety with respect to

any substitute. ENGINEER will record time required by ENGINEER and ENGINEER's consultants in evaluating substitutions proposed by CONTRACTOR and in making changes in the Contract Documents occasioned thereby. Whether or not ENGINEER accepts a proposed substitute, CONTRACTOR shall reimburse OWNER for the charges of ENGINEER and ENGINEER's consultants for evaluating each proposed substitute.

Concerning Subcontractors, Suppliers and Others:

6.8.1 CONTRACTOR shall not employ any Subcontractor, Supplier or other person or organization (including those acceptable to OWNER and ENGINEER as indicated in paragraph 6.8.2), whether initially or as a substitute, against whom OWNER or ENGINEER may have reasonable objection. CONTRACTOR shall not be required to employ any Subcontractor, Supplier or other person or organization to furnish or perform any of the Work against whom CONTRACTOR has reasonable objection.

6.8.2 If the Supplementary Conditions require the identity of certain Subcontractors, Suppliers or other persons or organizations (including those who are to furnish the principal items of materials and equipment) to be submitted to OWNER in advance of the specified date prior to the Effective Date of the Agreement for acceptance by OWNER and ENGINEER and if CONTRACTOR has submitted a list thereof in accordance with the Supplementary Conditions, OWNER's or ENGINEER's acceptance (either in writing or by failing to make written objection thereto by the date indicated for acceptance or objection in the bidding documents or the Contract Documents) of any such Subcontractor, Supplier or other person or organization so identified may be revoked on the basis of reasonable objection after due investigation, in which case CONTRACTOR shall submit an acceptable substitute, the Contract Price will be increased by the difference in the cost occasioned by such substitution and an appropriate Change Order will be issued or Written Amendment signed. No acceptance by OWNER or ENGINEER of any such Subcontractor, Supplier or other person or organization shall constitute a waiver of any right of OWNER or ENGINEER to reject defective Work.

6.9 CONTRACTOR shall be fully responsible to OWNER and ENGINEER for all acts and omissions of the Subcontractors, Suppliers and other persons and organizations performing or

furnishing any of the Work under a direct or indirect contract with CONTRACTOR just as CONTRACTOR is responsible for CONTRACTOR's own acts and omissions. Nothing in the Contract Documents shall create any contractual relationship between OWNER or ENGINEER and any such Subcontractor, Supplier or other person or organization, nor shall it create any obligation on the part of OWNER or ENGINEER to pay or to see to the payment of any moneys due any such Subcontractor, Supplier or other person or organization except as may otherwise be required by Laws and Regulations.

6.10 The divisions and sections of the Specifications and the identifications of any Drawings shall not control CONTRACTOR in dividing the Work among Subcontractors or Suppliers or delineating the Work to be performed by any specific trade.

6.11 All Work performed for CONTRACTOR by a Subcontractor will be pursuant to an appropriate agreement between CONTRACTOR and the Subcontractor which specifically binds the Subcontractor to the applicable terms and conditions of the Contract Documents for the benefit of OWNER and ENGINEER and contains waiver provisions as required by paragraph 5.8. CONTRACTOR shall pay each Subcontractor a just share of any insurance moneys received by CONTRACTOR on account of losses under policies issued pursuant to paragraph 5.4 and 5.5.

Patent Fees and Royalties:

6.12 CONTRACTOR shall pay all license fees and royalties and assume all costs incident to the use in the performance of the Work or the incorporation in the Work of any invention, design, process, product or device which is the subject of patent rights or copyrights held by others. If a particular invention, design, process, product or device is specified in the Contract Documents for use in the performance of the Work and if to the actual knowledge of OWNER or ENGINEER its use is subject to patent rights or copyrights calling for the payment of any license fee or royalty to others, the existence of such rights shall be disclosed by OWNER in the Contract Documents. CONTRACTOR shall indemnify and hold harmless OWNER and ENGINEER and anyone directly or indirectly employed by either of them from and against all claims, damages, losses and expenses (including attorneys' fees and court and arbitration costs) arising out of any infringement of patent rights or copyrights incident to the use in the performance of the Work or resulting from the incorporation in the Work of any invention, design, process, product or device not specified in the Contract

Documents, and shall defend all such claims in connection with any alleged infringement of such rights.

Permits:

6.13 Unless otherwise provided in the Supplementary Conditions, CONTRACTOR shall obtain and pay for all construction permits and licenses. OWNER shall assist CONTRACTOR, when necessary, in obtaining such permits and licenses. CONTRACTOR shall pay all governmental charges and inspection fees necessary for the prosecution of the Work, which are applicable at the time of opening of Bids, or if there are no Bids on the Effective Date of the Agreement. CONTRACTOR shall pay all charges of utility owners for connections to the Work, and OWNER shall pay all charges of such utility owners for capital costs related thereto.

Laws and Regulations:

6.14.1 CONTRACTOR shall give all notices and comply with all Laws and Regulations applicable to furnishing and performance of the Work. Except where otherwise expressly required by applicable Laws and Regulations, neither OWNER nor ENGINEER shall be responsible for monitoring CONTRACTOR's compliance with any Laws or Regulations.

6.14.2 If CONTRACTOR observes that the Specifications or Drawings are at variance with any Laws or Regulations, CONTRACTOR shall give ENGINEER prompt written notice thereof, and any necessary changes will be authorized by one of the methods indicated in paragraph 3.4. If CONTRACTOR performs any Work knowing or having reason to know that it is contrary to such Laws or Regulations, and without such notice to ENGINEER, CONTRACTOR shall bear all costs arising therefrom; however, it shall not be CONTRACTOR's primary responsibility to make certain that the Specifications and Drawings are in accordance with such Laws and Regulations.

Taxes:

6.15 CONTRACTOR shall pay all sales, consumer, use and other similar taxes required to be paid by CONTRACTOR in accordance with the Laws and Regulations of the place of the Project which are applicable during the performance of the Work.

Uses of Premises:

6.16 CONTRACTOR shall confine construction equipment, the storage of materials and equipment and the operations of workers to the Project site and land and areas identified in and permitted by the Contract Documents and other land and areas permitted by Laws and

Regulations, rights-of-way, permits and easements, and shall not unreasonably encumber the premises with construction equipment or other materials or equipment. CONTRACTOR shall assume full responsibility for any damage to any such land or area, or to the owner or occupant thereof or of any land or areas contiguous thereto, resulting from the performance of the Work. Should any claim be made against OWNER or ENGINEER by any such owner or occupant because of the performance of the Work, CONTRACTOR shall promptly attempt to settle with such other party by agreement or otherwise resolve the claim by arbitration or at law. CONTRACTOR shall, to the fullest extent permitted by Laws and Regulations, indemnify and hold OWNER and ENGINEER harmless from and against all claims, damages, losses and expenses (including, but not limited to, fees of engineers, architects, attorneys and other professionals and court and arbitration costs) arising directly, indirectly or consequentially out of any action, legal or equitable, brought by any such other party against OWNER or ENGINEER to the extent based on a claim arising out of CONTRACTOR's performance of the Work.

6.17 During the progress of the Work, CONTRACTOR shall keep the premises free from accumulations of waste materials, rubbish and other debris resulting from the Work. At the completion of the Work CONTRACTOR shall remove all waste materials, rubbish and debris from and about the premises as well as all tools, appliances, construction equipment and machinery, and surplus materials, and shall leave the site clean and ready for occupancy by OWNER. CONTRACTOR shall restore to original condition all property not designated for alteration by the Contract Documents.

6.18 CONTRACTOR shall not load nor permit any part of any structure to be loaded in any manner that will endanger the structure, nor shall CONTRACTOR subject any part of the Work or adjacent property to stresses or pressures that will endanger it.

Record Documents:

6.19 CONTRACTOR shall maintain in a safe place at the site one record copy of all Drawings, Specifications, Addenda, Written Amendments, Change Orders, Work Directive Changes, Field Orders and written interpretations and clarifications (issued pursuant to paragraph 9.4) in good order and annotated to show all changes made during construction. These record documents together with all approved samples and a counterpart of all reviewed Shop Drawings will be available to ENGINEER for

reference. Upon completion of the Work, these record documents, samples and Shop Drawings will be delivered to ENGINEER for OWNER.

Safety and Protection:

6.20 CONTRACTOR shall be responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the Work. CONTRACTOR shall take all necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury or loss to:

6.20.1 all employees on the Work and other persons and organizations who may be affected thereby;

6.20.2 all the Work and materials and equipment to be incorporated therein, whether in storage on or off the site; and

6.20.3 other property at the site or adjacent thereto, including trees, shrubs, lawns, walks, pavements, roadways, structures, utilities and Underground Facilities not designated for removal, relocation or replacement in the course of construction.

CONTRACTOR shall comply with all applicable Laws and Regulations of any public body having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss; and shall erect and maintain all necessary safeguards for such safety and protection. CONTRACTOR shall notify owners of adjacent property and of Underground Facilities and utility owners when prosecution of the Work may affect them, and shall cooperate with them in the protection, removal, relocation and replacement of their property. All damage, injury or loss to any property referred to in paragraph 6.20.2 or 6.20.3 caused, directly or indirectly, in whole or in part, by CONTRACTOR, any Subcontractor, Supplier or any other person or organization directly or indirectly employed by any of them to perform or furnish any of the Work or anyone for whose acts any of them may be liable, shall be remedied by CONTRACTOR (except damage or loss attributable to the fault of Drawings or Specifications or to the acts or omissions of OWNER or ENGINEER or anyone employed by either of them or anyone for whose acts either of them may be liable, and not attributable, directly or indirectly, in whole or in part, to the fault or negligence of CONTRACTOR). CONTRACTOR's duties and responsibilities for the safety and protection of the Work shall continue until such time as all the Work is completed and ENGINEER has issued a notice to OWNER and CONTRACTOR in accordance with paragraph 14.13 that the Work is acceptable (except as otherwise expressly provided

in connection with Substantial Completion).

6.21 CONTRACTOR shall designate a responsible representative at the site whose duty shall be the prevention of accidents. This person shall be CONTRACTOR's superintendent unless otherwise designated in writing by CONTRACTOR to OWNER.

Emergencies:

6.22 In emergencies affecting the safety or protection of persons or the Work or property at the site or adjacent thereto, CONTRACTOR, without special instruction or authorization from ENGINEER or OWNER, is obligated to act to prevent threatened damage, injury or loss. CONTRACTOR shall give ENGINEER prompt written notice if CONTRACTOR believes that any significant changes in the Work or variations from the Contract Documents have been caused thereby. If ENGINEER determines that a change in the Contract Documents is required because of the action taken in response to an emergency, a Work Directive Change or Change Order will be issued to document the consequences of the changes or variations.

Shop Drawings and Samples:

6.23 After checking and verifying all field measurements and after complying with applicable procedures specified in the General Requirements, CONTRACTOR shall submit to ENGINEER for review in accordance with the accepted schedule of Shop Drawing submissions (see paragraph 2.9), or for other appropriate action if so indicated in the Supplementary Conditions, three copies plus the number of copies required by the CONTRACTOR (unless otherwise specified in the General Requirements) of all Shop Drawings, which will bear a stamp or specific written indication that CONTRACTOR has satisfied CONTRACTOR's responsibilities under the Contract Documents with respect to the review of the submission. All submissions will be identified as ENGINEER may require. The data shown on the Shop Drawings will be complete with respect to quantities, dimensions, specified performance and design criteria, materials and similar data to enable ENGINEER to review the information as required.

6.24 CONTRACTOR shall also submit to ENGINEER for review with such promptness as to cause no delay in Work, all samples required by the Contract Documents. All samples will have been checked by and accompanied by a specific written indication that CONTRACTOR has satisfied CONTRACTOR's responsibilities under the Contract Documents with respect to the review of the submission and will be identified clearly as to

material, Supplier, pertinent data such as catalog numbers and the use for which intended.

6.25.1 Before submission of each Shop Drawing or sample CONTRACTOR shall have determined and verified all quantities, dimensions, specified performance criteria, installation requirements, materials, catalog numbers and similar data with respect thereto and review or coordinated each Shop Drawing or sample with other Shop Drawings and samples and with the requirements of the Work and the Contract Documents.

6.25.2 At the time of each submission, CONTRACTOR shall give ENGINEER specific written notice of each variation that the Shop Drawings or samples may have from the requirements of the Contract Documents, and, in addition, shall cause a specific notation to be made on each Shop Drawing submitted to ENGINEER for review of each such variation.

6.26 ENGINEER will review with reasonable promptness Shop Drawings and samples, but ENGINEER's review will be only for conformance with the design concept of the Project and for compliance with the information given in the Contract Documents and shall not extend to means, methods, techniques, sequences or procedures of construction (except where a specific means, method, technique, sequence or procedure of construction is indicated in or required by the Contract Documents) or to safety precautions or programs incident thereto. The review of a separate item as such will not indicate approval of the assembly in which the item functions. CONTRACTOR shall make corrections required by ENGINEER, and shall return the required number of corrected copies of Shop Drawings and submit as required new samples for review. CONTRACTOR shall direct specific attention in writing to revisions other than the corrections called for by ENGINEER on previous submittals.

6.27 ENGINEER's review of Shop Drawings or samples shall not relieve CONTRACTOR from responsibility for any variation from the requirements of the Contract Documents unless CONTRACTOR has in writing called ENGINEER's attention to each such variation at the time of submission as required by paragraph 6.25.2 and ENGINEER has given written approval of each such variation by a specific written notation thereof incorporated in or accompanying the Shop Drawing or sample approval; nor will any review by ENGINEER relieve CONTRACTOR from responsibility for errors or omissions in the Shop Drawings or from responsibility for having complied with the provisions of paragraph 6.25.1.

6.28 Where a Shop Drawing or sample is required by the Specifications, any related Work performed prior to ENGINEER's review of the pertinent submission will be the sole expense and responsibility of CONTRACTOR.

Continuing the Work:

6.29 CONTRACTOR shall carry on the Work and adhere to the progress schedule during all disputes or disagreements with OWNER. No Work shall be delayed or postponed pending resolution of any disputes or disagreements, except as permitted by paragraph 15.5 or as Contractor and OWNER may otherwise agree in writing.

Indemnification:

6.30 To the extent permitted by law, the CONTRACTOR shall indemnify and hold harmless OWNER, ENGINEER, ENGINEER'S consultants and agents and employees of any of them from and against all claims, damages and expenses, including but not limited to attorneys' fees, arising out of or resulting from performance of the Work, provided that such claim, damage, loss or expense is attributable to bodily injury, sickness, disease or death, or to injury to or destruction of tangible property (other than the Work itself) including loss of use resulting therefrom, but only to the extent caused in whole or in part by negligent acts or omissions of the Contractor, a Subcontractor, anyone directly or indirectly employed by them or anyone for whose acts they may be liable. Such obligation shall not be construed to negate, abridge, or reduce other rights or obligations of indemnity which would otherwise exist as to a party or person described in this Paragraph 6.30.

6.31 In any and all claims against OWNER or ENGINEER or any of their consultants, agents or employees by any employee of CONTRACTOR, any Subcontractor, any person or organization directly or indirectly employed by any of them to perform or furnish any of the Work or anyone for whose acts any of them may be liable, the indemnification obligation under paragraph 6.30 shall not be limited in any way by any limitation on the amount or type of damages, compensation or benefits payable by or for CONTRACTOR or any such Subcontractor or other person or organization under workers' or workmen's compensation acts, disability benefit acts or other employee benefit acts.

6.32 The obligations of CONTRACTOR under paragraph 6.30 shall not extend to the liability of ENGINEER, ENGINEER's consultants, agents or employees arising out of the preparation or approval of maps, drawings, opinions, reports, surveys, Change Orders, designs or specifications.

ARTICLE 7 - OTHER WORK

Related Work at Site:

7.1 OWNER may perform other work related to the Project at the site by OWNER's own forces, have other work performed by utility owners or let other direct contracts therefor which shall contain General Conditions similar to these. If the fact that such other work is to be performed was not noted in the Contract Documents, written notice thereof will be given to CONTRACTOR prior to starting any such other work; and, if CONTRACTOR believes that such performance will involve additional expense to CONTRACTOR or requires additional time and the parties are unable to agree as to the extent thereof, CONTRACTOR may make a claim therefor as provided in Articles 11 and 12.

7.2 CONTRACTOR shall afford each utility owner and other contractor who is a party to such a direct contract (or OWNER, if OWNER is performing the additional work with OWNER's employees) proper and safe access to the site and a reasonable opportunity for the introduction and storage of materials and equipment and the execution of such work, and shall properly connect and coordinate the Work with theirs. CONTRACTOR shall do all cutting, fitting and patching of the Work that may be required to make its several parts come together properly and integrate with such other work. CONTRACTOR shall not endanger any work of others by cutting, excavating or otherwise altering their work and will only cut or alter their work with the written consent of ENGINEER and the others whose work will be affected. The duties and responsibilities of CONTRACTOR under this paragraph are for the benefit of such utility owners and other contractors to the extent that there are comparable provisions for the benefit of CONTRACTOR in said direct contracts between OWNER and such utility owners and other contractors.

7.3 If any part of the CONTRACTOR's Work depends for proper execution or results upon the work of any such other contractor or utility owner (or OWNER), CONTRACTOR shall inspect and promptly report to ENGINEER in writing any delays, defects or deficiencies in such work that render it unavailable or unsuitable for such proper execution and results. CONTRACTOR's failure so to report will constitute an acceptance of the other work as fit and proper for integration with CONTRACTOR's Work except for latent or nonapparent defects and deficiencies in the other work.

Coordination:

7.4 If OWNER contracts with

others for the performance of other work on the Project at the site, the person or organization who will have authority and responsibility for coordination of the activities among the various prime contractors will be identified in the Supplementary Conditions, and the specific matters to be covered by such authority and responsibility will be itemized, and the extent of such authority and responsibilities will be provided, in the Supplementary Conditions. Unless otherwise provided in the Supplementary Conditions, neither OWNER nor ENGINEER shall have any authority or responsibility in respect of such coordination.

ARTICLE 8 - OWNER'S RESPONSIBILITIES

8.1 OWNER shall issue all communications to CONTRACTOR through ENGINEER.

8.2 In case of termination of the employment of ENGINEER, OWNER shall appoint an engineer against whom CONTRACTOR makes no reasonable objection, whose status under the Contract Documents shall be that of the former ENGINEER. Any dispute in connection with such appointment shall be subject to arbitration.

8.3 OWNER shall furnish the data required of OWNER under the Contract Documents promptly and shall make payments to CONTRACTOR promptly after they are due as provided in paragraphs 14.4 and 14.13.

8.4 OWNER's duties in respect of providing lands and easements and providing engineering surveys to establish reference points are set forth in paragraphs 4.1 and 4.4. Paragraph 4.2 refers to OWNER's identifying and making available to CONTRACTOR copies of reports of explorations and tests of subsurface conditions at the site and in existing structures which have been utilized by ENGINEER in preparing the Drawings and Specifications.

8.5 OWNER's responsibilities in respect of purchasing and maintaining liability and property insurance are set forth in paragraphs 5.3 through 5.6.

8.6 OWNER is obligated to execute Change Orders as indicated in paragraph 10.4.

8.7 OWNER's responsibility in respect of certain inspections, tests and approvals is set forth in paragraph 13.4.

8.8 In connection with OWNER's right to stop Work or suspend Work, see paragraphs 13.10 and 15.1. Paragraph 15.2 deals with OWNER's right to terminate services of CONTRACTOR under certain circumstances.

ARTICLE 9 - ENGINEER'S STATUS DURING CONSTRUCTION

Owner's Representative:

9.1 ENGINEER will be OWNER's representative during the construction period. The duties and responsibilities and the limitations of authority of ENGINEER as OWNER's representative during construction are set forth in the Contract Documents and shall not be extended without written consent of OWNER and ENGINEER.

Visits to Site:

9.2 ENGINEER will make visits to the site at intervals appropriate to the various stages of construction to observe the progress and quality of the executed Work and to determine, in general, if the Work is proceeding in accordance with the Contract Documents. ENGINEER will not be required to make exhaustive or continuous on-site inspections to check the quality or quantity of the Work. ENGINEER's efforts will be directed toward providing for OWNER a greater degree of confidence that the completed Work will conform to the Contract Documents. On the basis of such visits and on-site observations as an experienced and qualified design professional, ENGINEER will keep OWNER informed of the progress of the Work and will endeavor to guard OWNER against defects and deficiencies in the Work.

Project Representation:

9.3 If OWNER and ENGINEER agree, ENGINEER will furnish a Resident Project Representative to assist ENGINEER in observing the performance of the Work. The duties, responsibilities and limitations of authority of any such Resident Project Representative and assistants will be as provided in the Supplementary Conditions. If Owner designates another agent to represent OWNER at the site who is not ENGINEER's agent or employee, the duties, responsibilities and limitations of authority of such other person will be as provided in the Supplementary Conditions.

Clarifications and Interpretations:

9.4 ENGINEER will issue with reasonable promptness such written clarifications or interpretations of the requirements of the Contract Documents (in the form of Drawings or otherwise) as ENGINEER may determine necessary, which shall be consistent with or reasonably inferable from the overall intent of the Contract Documents. If CONTRACTOR believes that a written clarification or interpretation justifies an increase in the Contract Price or an extension of the Contract Time and the parties

are unable to agree to the amount or extent thereof, CONTRACTOR may make a claim therefor as provided in Article 11 or Article 12.

Authorized Variations in Work:

9.5 ENGINEER may authorize minor variations in the Work from the requirements of the Contract Documents which do not involve an adjustment in the Contract Price or the Contract Time and are consistent with the overall intent of the Contract Documents. These may be accomplished by a Field Order and will be binding on OWNER, and also on CONTRACTOR who shall perform the Work involved promptly. If CONTRACTOR believes that a Field Order justifies an increase in the Contract Price or an extension of the Contract Time and the parties are unable to agree as to the amount or extent thereof, CONTRACTOR may make a claim therefor as provided in Article 11 or 12.

Rejecting Defective Work:

9.6 ENGINEER will have authority to disapprove or reject Work which ENGINEER believes to be defective, and will also have authority to require special inspection or testing of the Work as provided in paragraph 13.9, whether or not the Work is fabricated, installed or completed.

Shop Drawings, Change Orders and Payments:

9.7 In connection with ENGINEER's responsibility for Shop Drawings and samples, see paragraph 6.23 through 6.29 inclusive.

9.8 In connection with ENGINEER's responsibilities as to Change Orders, see Articles 10, 11 and 12.

9.9 In connection with ENGINEER's responsibilities in respect of Application for Payment, see Article 14.

Determinations for Unit Prices:

9.10 ENGINEER will determine the actual quantities and classifications of Unit Price Work performed by CONTRACTOR. ENGINEER will review with CONTRACTOR ENGINEER's preliminary determinations on such matters before rendering a written decision thereon (by recommendation of an Application for Payment or otherwise). ENGINEER's written decisions thereon will be final and binding upon OWNER and CONTRACTOR, unless, within ten days after the date of any such decision, either OWNER or CONTRACTOR delivers to the other party to the Agreement and to ENGINEER written notice of intention to appeal from such a decision.

Decisions on Disputes:

9.11 ENGINEER will be the

initial interpreter of the requirements of the Contract Documents and judge of the acceptability of the Work thereunder. Claims, disputes and other matters relating to the acceptability of the Work or the interpretation of the requirements of the Contract Documents pertaining to the performance and furnishing of the Work and claims under Articles 11 and 12 in respect of changes in the Contract Price or Contract Time will be referred initially to ENGINEER in writing with a request for a formal decision in accordance with this paragraph, which ENGINEER will render in writing within a reasonable time. Written notice of each such claim, dispute and other matter will be delivered by the claimant to ENGINEER and the other party to the Agreement promptly (but in no event later than thirty days) after the occurrence of the event giving rise thereto, and written supporting data will be submitted to ENGINEER and the other party within sixty days after such occurrence unless ENGINEER allows an additional period of time to ascertain more accurate data in support of the claim.

9.12 When functioning as interpreter and judge under paragraphs 9.10 and 9.11, ENGINEER will not show partiality to OWNER or CONTRACTOR and will not be liable in connection with any interpretation or decision rendered in good faith in such capacity. The rendering of a decision by ENGINEER pursuant to paragraphs 9.10 and 9.11 with respect to any such claim, dispute or other matter (except any which have been waived by the making or acceptance of final payment as provided in paragraph 14.16) will be a condition precedent to any exercise by OWNER or CONTRACTOR of such rights or remedies as either may otherwise have under the Contract Documents or by Laws or Regulations in respect of any such claim, dispute or other matter.

Limitations on ENGINEER's Responsibilities:

9.13 Neither ENGINEER's authority to act under this Article 9 or elsewhere in the Contract Documents nor any decision made by ENGINEER in good faith either to exercise or not exercise such authority shall give rise to any duty or responsibility of ENGINEER to CONTRACTOR, any Subcontractor, any Supplier, or any other person or organization performing any of the Work, or to any surety for any of them.

9.14 Whenever in the Contract Documents the terms "as ordered", "as directed", "as required", "as allowed", "as approved" or terms of like effect or import are used, or the adjectives "reasonable", "suitable", "acceptable", "proper" or "satisfactory" or adjectives of like effect or import are used to describe a requirement, direction, review

or judgment of ENGINEER as to the Work, it is intended that such requirement, direction, review or judgment will be solely to evaluate the Work for compliance with the Contract Documents (unless there is a specific statement indicating otherwise). The use of any such term or adjective shall not be effective to assign to ENGINEER any duty or authority to supervise or direct the furnishing or performance of the Work or any duty or authority to undertake responsibility contrary to the provisions of paragraph 9.15 or 9.16.

9.15 ENGINEER will not be responsible for CONTRACTOR's means, methods, techniques, sequences or procedures of construction, or the safety precautions and programs incident thereto, and ENGINEER will not be responsible for CONTRACTOR's failure to perform or furnish the Work in accordance with the Contract Documents.

9.16 ENGINEER will not be responsible for the acts or omissions of CONTRACTOR or of any Subcontractor, any Supplier, or of any other person or organization performing or furnishing any of the Work.

ARTICLE 10 - CHANGES IN THE WORK

10.1 Without invalidating the Agreement and without notice to any surety, OWNER may, at any time or from time to time, order additions, deletions or revisions in the Work; these will be authorized by a Written Amendment, a Change Order, or a Work Directive Change. Upon receipt of any such document, CONTRACTOR shall promptly proceed with the Work involved which will be performed under the applicable conditions of the Contract Documents (except as otherwise specifically provided).

10.2 If OWNER and CONTRACTOR are unable to agree as to the extent, if any, of an increase or decrease in the Contract Price or an extension or shortening of the Contract Time that should be allowed as a result of a Work Directive Change, a claim may be made therefor as provided in Article 11 or Article 12.

10.3 CONTRACTOR shall not be entitled to an increase in the Contract Price or an extension of the Contract Time with respect to any Work performed that is not required by the Contract Documents as amended, modified and supplemented as provided in paragraphs 3.4 and 3.5, except in the case of an emergency as provided in paragraph 6.22 and except in the case of uncovering Work as provided in paragraph 13.9.

10.4 OWNER and CONTRACTOR shall execute appropriate Change Orders (or Written Amendments) covering:

10.4.1 changes in the Work which are ordered by OWNER pursuant to paragraph 10.1, are required because of acceptance of defective Work under paragraph 13.13 or correcting defective Work under paragraph 13.14, or are agreed to by the parties;

10.4.2 changes in the Contract Price or Contract Time which are agreed to by the parties; and

10.4.3 changes in the Contract Price or Contract time which embody the substance of any written decision rendered by ENGINEER pursuant to paragraph 9.11;

provided that, in lieu of executing any such Change Order, an appeal may be taken from any such decision in accordance with the provisions of the Contract Documents and applicable Laws and Regulations, but during any such appeal, CONTRACTOR shall carry on the Work and adhere to the progress schedule as provided in paragraph 6.29.

10.5 If notice of any change affecting the general scope of the Work or the provisions of the Contract Documents (including, but not limited to, Contract Price or Contract Time) is required by the provisions of any Bond to be given to a surety, the giving of any such notice will be CONTRACTOR's responsibility, and the amount of each applicable Bond will be adjusted accordingly.

ARTICLE 11 - CHANGE OF CONTRACT PRICE

11.1 The Contract Price constitutes the total compensation (subject to authorized adjustments) payable to CONTRACTOR for performing the Work. All duties, responsibilities and obligations assigned to or undertaken by CONTRACTOR shall be at his expense without change in the Contract Price.

11.2 The Contract Price may only be changed by a Change Order or by a Written Amendment. Any claim for an increase or decrease in the Contract Price shall be based on written notice delivered by the party making the claim to the other party and to ENGINEER promptly (but in no event later than thirty days) after the occurrence of the event giving rise to the claim and stating the general nature of the claim. Notice of the amount of the claim with supporting data shall be delivered within sixty days after such occurrence (unless ENGINEER allows an additional period of time to ascertain more accurate data in support of the claim) and shall be accompanied by claimant's written statement that the amount claimed covers all known amounts (direct, indirect and consequential) to which the claimant is entitled

as a result of the occurrence of said event. All claims for adjustment in the Contract Price shall be determined by ENGINEER in accordance with paragraph 9.11 if OWNER and CONTRACTOR cannot otherwise agree on the amount involved. No claim for an adjustment in the Contract Price will be valid if not submitted in accordance with this paragraph 11.2.

11.3 The value of any Work covered by a Change Order or of any claim for an increase or decrease in the Contract Price shall be determined in one of the following ways:

11.3.1 Where the Work involved is covered by unit prices contained in the Contract Documents, by application of unit prices to the quantities of the items involved (subject to the provisions of paragraph 11.9.1 through 11.9.3 inclusive).

11.3.2 By mutual acceptance of a lump sum (which may include an allowance for overhead and profit not necessarily in accordance with paragraph 11.6.2.1).

11.3.3 On the basis of the Cost of the Work (determined as provided in paragraphs 11.4 and 11.5) plus a CONTRACTOR's Fee for overhead and profit (determined as provided in paragraphs 11.6 and 11.7).

Cost of the Work:

11.4 The term Cost of the Work means the sum of all costs necessarily incurred and paid by CONTRACTOR in the proper performance of the Work. Except as otherwise may be agreed to in writing by OWNER, such costs shall be in amounts no higher than those prevailing in the locality of the Project, shall include only the following items and shall not include any of the costs itemized in paragraph 11.5:

11.4.1 Payroll costs for employees in the direct employ of CONTRACTOR in the performance of the Work under schedules of job classifications agreed upon by OWNER and CONTRACTOR. Payroll costs for employees not employed full time on the Work shall be apportioned on the basis of their time spent on the Work. Payroll costs shall include, but not be limited to, salaries and wages plus the cost of fringe benefits which shall include social security contributions, unemployment, excise and payroll taxes, workers' or workmen's compensation, health and retirement benefits, bonuses, sick leave, vacation and holiday pay applicable thereto. Such employees shall include superintendents and foremen at the site. The expenses of performing Work after regular working hours, on Saturday, Sunday or legal

holidays, shall be included in the above.

11.4.2 Cost of all materials and equipment furnished and incorporated in the Work, including costs of transportation and storage thereof, and Suppliers' field services required in connection therewith. All cash discounts shall accrue to CONTRACTOR unless OWNER deposits funds with CONTRACTOR with which to make payments, in which case the cash discounts shall accrue to OWNER. All trade discounts, rebates and refunds and all returns from sale of surplus materials and equipment shall accrue to OWNER, and CONTRACTOR shall make provisions so that they may be obtained.

11.4.3 Payments made by CONTRACTOR to the Subcontractors for Work performed by Subcontractors. If required by OWNER, CONTRACTOR shall obtain competitive bids from Subcontractors acceptable to CONTRACTOR and shall deliver such bids to OWNER who will then determine, with the advice of ENGINEER, which bids will be accepted. If a subcontract provides that the Subcontractor is to be paid on the basis of Cost of the Work Plus a Fee, the Subcontractor's Cost of the Work shall be determined in the same manner as CONTRACTOR's Cost of the Work. All subcontracts shall be subject to the other provisions of the Contract Documents insofar as applicable.

11.4.4 Costs of special consultants (including but not limited to engineers, architects, testing laboratories, surveyors, attorneys and accountants) employed for services specifically related to the Work.

11.4.5 Supplemental costs including the following:

11.4.5.1 The proportion of necessary transportation, travel and subsistence expenses of CONTRACTOR's employees incurred in discharge of duties connected with the Work.

11.4.5.2 Cost, including transportation and maintenance, of all materials, supplies, equipment, machinery, appliances, office and temporary facilities at the site and hand tools not owned by the workers, which are consumed in the performance of the Work, and cost less market value of such items used but not consumed which remain the property of CONTRACTOR.

11.4.5.3 Rentals of all construction equipment and machinery and the parts thereof whether rented from CONTRACTOR or others in accordance with rental agreements approved by OWNER

with the advice of ENGINEER, and the costs of transportation, loading, unload-ing, installation, dismantling and removal thereof-all in accordance with terms of said rental agreements. The rental of any such equipment, machinery or parts shall cease when the use thereof is no longer necessary for the Work.

11.4.5.4 Sales, consumer, use or similar taxes related to the Work, and for which CONTRACTOR is liable, imposed by Laws and Regulations.

11.4.5.5 Deposits lost for cause other than negligence of CONTRACTOR, any Subcontractor or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, and royalty payments and fees for permits and licenses.

11.4.5.6 Losses and damages (and related expenses), not compensated by insurance or otherwise, to the Work or otherwise sustained by CONTRACTOR in connection with the performance and furnishing of the Work (except losses and damages within the deductible amounts of property insurance established by OWNER in accordance with paragraph 5.7), provided they have resulted from causes other than the negligence of CONTRACTOR, and Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable. Such losses shall include settlements made with the written consent and approval of OWNER. No such losses, damages and expenses shall be included in the Cost of the Work for the purpose of determining CONTRACTOR's Fee. If, however, any such loss or damage requires reconstruction and CONTRACTOR is placed in charge thereof, CONTRACTOR shall be paid for services a fee proportionate to that stated in paragraph 11.6.2.

11.4.5.7 The cost of utilities, fuel and sanitary facilities at the site.

11.4.5.8 Minor expenses such as telegrams, long distance telephone calls, telephone service at the site, expressage and similar petty cash items in connection with the Work.

11.4.5.9 Cost of premiums for additional Bonds and insurance required because of changes in the Work and premiums for property insurance coverage within the limits of the deductible amounts established by OWNER in accordance with paragraph 5.7.

11.5 The term Cost of the Work shall not include any of the following:

11.5.1 Payroll costs and other compensation of CONTRACTOR's officers, executives, principals (of partnership and sole proprietorships), general managers, engineers, architects, estimators, attorneys, auditors, accountants, purchasing and contracting agents, expeditors, timekeepers, clerks and other personnel employed by CONTRACTOR whether at the site or in CONTRACTOR's principal or a branch office for general administration of the Work and not specifically included in the agreed upon schedule of job classifications referred to in paragraph 11.4.1 or specifically covered by paragraph 11.4.4 - all of which are to be considered administrative costs covered by the CONTRACTOR's Fee.

11.5.2 Expenses of CONTRACTOR's principal and branch offices other than CONTRACTOR's office at the site.

11.5.3 Any part of CONTRACTOR's capital expenses, including interest on CONTRACTOR's capital employed for the Work and charges against CONTRACTOR for delinquent payments.

11.5.4 Cost of premiums for all Bonds and for all insurance whether or not CONTRACTOR is required by the Contract Documents to purchase and maintain the same (except for the cost of premiums covered by subparagraph 11.4.5.9 above).

11.5.5 Costs due to the negligence of CONTRACTOR, any Subcontractor, or anyone directly or indirectly employed by any of them or for whose acts any of them may be liable, including but not limited to, the correction of defective Work, disposal of materials or equipment wrongly supplied and making good any damage to property.

11.5.6 Other overhead or general expense costs of any kind and the costs of any item not specifically and expressly included in paragraph 11.4.

CONTRACTOR's Fee:

11.6 The CONTRACTOR's Fee allowed to CONTRACTOR for overhead and profit shall be determined as follows:

11.6.1 a mutually acceptable fixed fee; or if none can be agreed upon.

11.6.2 a fee based on the following percentages of the various portions of the Cost of the Work:

11.6.2.1 for costs incurred under paragraphs 11.4.1 and 11.4.2, the CONTRACTOR's Fee shall be fifteen percent;

11.6.2.2 for costs incurred under paragraph 11.4.3, the

CONTRACTOR's Fee shall be five percent; and if a subcontract is on the basis of Cost of the Work Plus a Fee, the maximum allowable to CONTRACTOR on account of overhead and profit of all Subcontractors shall be fifteen percent;

11.6.2.3 no fee shall be payable on the basis of costs itemized under paragraphs 11.4.4, 11.4.5 and 11.5;

11.6.2.4 the amount of credit to be allowed by CONTRACTOR to OWNER for any such change which results in a net decrease in cost will be the amount of the actual net decrease plus a deduction in CONTRACTOR's Fee by an amount equal to ten percent of the net decrease; and

11.6.2.5 when both additions and credits are involved in any one change, the adjustment in CONTRACTOR's Fee shall be computed on the basis of the net change in accordance with paragraphs 11.6.2.1 through 11.6.2.4, inclusive.

11.7 Whenever the cost of any Work is to be determined pursuant to paragraph 11.4 or 11.5, CONTRACTOR will submit in form acceptable to ENGINEER an itemized cost breakdown together with supporting data.

Cash Allowances:

11.8 It is understood that CONTRACTOR has included in the Contract Price all allowances so named in the Contract Documents and shall cause the Work so covered to be done by such Subcontractors or Suppliers and for such sums within the limit of the allowances as may be acceptable to ENGINEER. CONTRACTOR agrees that:

11.8.1 The allowances include the cost to CONTRACTOR (less any applicable trade discounts) of materials and equipment required by the allowances to be delivered at the site, and all applicable taxes; and

11.8.2 CONTRACTOR's costs for unloading and handling on the site, labor, installation costs, overhead, profit and other expenses contemplated for the allowances have been included in the Contract Price and not in the allowances. No demand for additional payment on account of any thereof will be valid.

Prior to final payment, an appropriate Change Order will be issued as recommended by ENGINEER to reflect actual amounts due CONTRACTOR on account of Work covered by allowances, and the Contract Price shall be correspondingly adjusted.

Unit Price Work:

11.9.1 Where the Contract

Documents provide that all or part of the Work is to be Unit Price Work, initially the Contract Price will be deemed to include for all Unit Price Work an amount equal to the sum of the established unit prices for each separately identified item of Unit Price Work times the estimated quantity of each item as indicated in the Proposal. The estimated quantities of items of Unit Price Work are not guaranteed and are solely for the purpose of comparison of Bids and determining an initial Contract Price. Determinations of the actual quantities and classifications of Unit Price Work performed by CONTRACTOR will be made by ENGINEER in accordance with Paragraph 9.10.

11.9.2 Each unit price will be deemed to include an amount considered by CONTRACTOR to be adequate to cover CONTRACTOR's overhead and profit for each separately identified item.

11.9.3 Where the quantity of any item of Unit Price Work performed by CONTRACTOR differs by more than twenty-five percent from the estimated quantity of such item indicated in the Proposal and there is no corresponding adjustment with respect to any other item of Work and if CONTRACTOR believes that CONTRACTOR has incurred additional expense as a result thereof, CONTRACTOR may make a claim for an increase in the Contract Price in accordance with Article 11 if the parties are unable to agree as to the amount of any such increase.

ARTICLE 12 - CHANGE OF CONTRACT TIME

12.1 The Contract Time may be changed only by a Change Order or a Written Amendment. Any claim for an extension or shortening of the Contract Time shall be based on written notice delivered by the party making the claim to the other party and to ENGINEER promptly (but in no event later than thirty days) after the occurrence of the event giving risk to the claim and stating the general nature of the claim. Notice of the extent of the claim with supporting data shall be delivered within sixty days after such occurrence (unless ENGINEER allows an additional period of time to ascertain more accurate data in support of the claim) and shall be accompanied by the claimant's written statement that the adjustment claimed is the entire adjustment to which the claimant has reason to believe it is entitled as a result of the occurrence of said event. All claims for adjustment in the Contract Time shall be determined by ENGINEER in accordance with paragraph 9.11 if OWNER and CONTRACTOR cannot

otherwise agree. No claim for an adjustment in the Contract Time will be valid if not submitted in accordance with the requirements of this paragraph 12.1.

12.2 The Contract Time will be extended in an amount equal to time lost due to delays beyond the control of CONTRACTOR if a claim is made therefor as provided in paragraph 12.1. Such delays shall include, but not be limited to, acts of neglect by OWNER or others performing additional work as contemplated by Article 7, or to fires, floods, labor disputes, epidemics, abnormal weather conditions or acts of God.

12.3 All time limits stated in the Contract Documents are of the essence of the Agreement. The provisions of this Article 12 shall not exclude recovery for damages (including but not limited to fees and charges of engineers, architects, attorneys and other professionals and court and arbitration costs) for delay by either party.

ARTICLE 13 - WARRANTY AND GUARANTEE; TESTS AND INSPECTIONS; CORRECTION, REMOVAL OR ACCEPTANCE OF DEFECTIVE WORK

Warranty and Guarantee:

13.1 CONTRACTOR warrants and guarantees to OWNER and ENGINEER that all Work will be in accordance with the Contract Documents and will not be defective. Prompt notice of all defects shall be given to CONTRACTOR. All defective Work, whether or not in place, may be rejected, corrected or accepted as provided in this Article 13.

Access to Work:

13.2 ENGINEER and ENGINEER's representatives, other representatives of OWNER, testing agencies and governmental agencies with jurisdictional interests will have access to the Work at reasonable times for their observation, inspecting and testing. CONTRACTOR shall provide proper and safe conditions for such access.

Tests and Inspections:

13.3 CONTRACTOR shall give ENGINEER timely notice of readiness of the Work for all required inspections, tests or approvals.

13.4 If Laws or Regulations of any public body having jurisdiction require any Work (or part thereof) to specifically be inspected, tested or approved, CONTRACTOR shall assume full responsibility therefor, pay all costs in connection therewith and furnish ENGINEER the required certificates of inspection, testing or approval. CONTRACTOR shall also be responsible for and

shall pay all costs in connection with any inspection or testing required in connection with OWNER's or ENGINEER's acceptance of a Supplier of materials or equipment submitted for approval prior to CONTRACTOR's purchase thereof for incorporation in the Work. The cost of all inspections, tests and approvals in addition to the above which are required by the Contract Documents shall be paid by OWNER (unless otherwise specified).

13.5 All inspections, tests or approvals other than those required by Laws or Regulations of any public body having jurisdiction shall be performed by organizations acceptable to OWNER and CONTRACTOR (or by ENGINEER if so specified).

13.6 If any Work (including the work of others) that is to be inspected, tested or approved is covered without written concurrence of ENGINEER, it must, if requested by ENGINEER, be uncovered for observation. Such uncovering shall be at CONTRACTOR's expense unless CONTRACTOR has given ENGINEER timely notice of CONTRACTOR's intention to cover the same and ENGINEER has not acted with reasonable promptness in response to such notice.

13.7 Neither observations by ENGINEER nor inspections, tests or approvals by others shall relieve CONTRACTOR from CONTRACTOR's obligations to perform the Work in accordance with the Contract Documents.

Uncovering Work:

13.8 If any Work is covered contrary to the written request of ENGINEER, it must, if requested by ENGINEER, be uncovered for ENGINEER's observation and replaced at CONTRACTOR's expense.

13.9 If ENGINEER considers it necessary or advisable that covered Work be observed by ENGINEER or inspected or tested by others, CONTRACTOR, at ENGINEER's request, shall uncover, expose or otherwise make available for observation, inspection or testing as ENGINEER may require, that portion of the Work in question, furnishing all necessary labor, material and equipment. If it is found that such Work is defective, CONTRACTOR shall bear all direct, indirect and consequential costs of such uncovering, exposure, observation, inspection and testing and of satisfactory reconstruction, (including but not limited to fees and charges of engineers, architects, attorneys and other professionals), and OWNER shall be entitled to an appropriate decrease in the Contract Price, and, if the parties are unable to agree as to the amount thereof, may make a claim therefor as provided in Article 11. If, however, such Work is not found to be defective,

CONTRACTOR shall be allowed an

increase in the Contract Price or an extension of the Contract Time, or both, directly attributable to such uncovering, exposure, observation, inspection, testing and reconstruction; and, if the parties are unable to agree as to the amount or extent thereof, CONTRACTOR may make a claim therefor as provided in Articles 11 and 12.

Owner May Stop the Work:

13.10 If the Work is defective, or CONTRACTOR fails to supply sufficient skilled workers or suitable materials or equipment, or fails to furnish or perform the Work in such a way that the completed Work will conform to the Contract Documents. OWNER may order CONTRACTOR to stop the Work, or any portion thereof, until the cause for such order has been eliminated; however, this right of OWNER to stop the Work shall not give rise to any duty on the part of OWNER to exercise this right for the benefit of CONTRACTOR or any other party.

Correction or Removal of Defective Work:

13.11 If required by ENGINEER, CONTRACTOR shall promptly, as directed, either correct all defective Work, whether or not fabricated, installed or completed, or, if the Work has been rejected by ENGINEER, remove it from the site and replace it with nondefective Work. CONTRACTOR shall bear all direct, indirect and consequential costs of such correction or removal (including but not limited to fees and charges of engineers, architects, attorneys and other professionals) made necessary thereby.

One Year Correction Period:

13.12 If within one year after the date of Substantial Completion or such longer period of time as may be prescribed by Laws or Regulations or by the terms of any applicable special guarantee required by the Contract Documents or by any specific Provision of the Contract Documents, any Work is found to be defective, CONTRACTOR shall promptly, without cost to OWNER and in accordance with OWNER's written instructions, either correct such defective Work, or if it has been rejected by OWNER, remove it from the site and replace it with nondefective Work. If CONTRACTOR does not promptly comply with the terms of such instructions, or in an emergency where delay would cause serious risk of loss or damage, OWNER may have the defective Work corrected or the rejected Work removed and replaced, and all direct, indirect and consequential costs of such removal and replacement (including but not limited to fees and charges of engineers, architects, attorneys and other

professionals) will be paid by CONTRACTOR. In special circumstances where a particular item of equipment is placed in continuous service before Substantial Completion of all Work, the correction period for that item may start to run from an earlier date if so provided in the Specifications or by Written Amendment.

Acceptance of Defective Work:

13.13 If, instead of requiring correction or removal and replacement of defective Work, OWNER (and, prior to ENGINEER's recommendation of final payment, also ENGINEER) prefers to accept it, OWNER may do so. CONTRACTOR shall bear all direct, indirect and consequential costs attributable to OWNER's evaluation of and determination to accept such defective Work (such costs to be approved by ENGINEER as to reasonableness and to include but not be limited to fees and charges of engineers, architects, attorneys and other professionals). If any such acceptance occurs prior to ENGINEER's recommendation of final payment, a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work; and OWNER shall be entitled to an appropriate decrease in the Contract Price, and, if the parties are unable to agree as to the amount thereof, OWNER may make a claim therefor as provided in Article 11. If the acceptance occurs after such recommendation, an appropriate amount will be paid by CONTRACTOR to OWNER.

OWNER May correct Defective Work:

13.14 If CONTRACTOR fails within a reasonable time after written notice of ENGINEER to proceed and to correct defective Work or to remove and replace rejected Work as required by ENGINEER in accordance with paragraph 13.11, or if CONTRACTOR fails to perform the Work in accordance with the Contract Documents, or if CONTRACTOR fails to comply with any other provision of the Contract Documents, OWNER may, after seven days' written notice to CONTRACTOR, correct and remedy any such deficiency. In exercising the rights and remedies under this paragraph OWNER shall proceed expeditiously. To the extent necessary to complete corrective and remedial action, OWNER may exclude CONTRACTOR from all or part of the site, take possession of all or part of the Work, and suspend CONTRACTOR's services related thereto, take possession of CONTRACTOR's tools, appliances, construction equipment and machinery at the site and incorporate in the Work all materials and equipment stored at the site or for which OWNER has paid CONTRACTOR but which are stored elsewhere.

CONTRACTOR shall allow OWNER, OWNER's representatives, agents and employees such access to the site as may be necessary to enable OWNER to exercise the rights and remedies under this paragraph. All direct, indirect and consequential costs of OWNER in exercising such rights and remedies under this paragraph will be charged against CONTRACTOR in an amount approved as to reasonableness by ENGINEER, and a Change Order will be issued incorporating the necessary revisions in the Contract Documents with respect to the Work; and OWNER shall be entitled to an appropriate decrease in the Contract Price, and, if the parties are unable to agree as to the amount thereof, OWNER may make a claim therefor as provided in Article 11. Such direct, indirect and consequential costs will include but not be limited to fees and charges of engineers, architects, attorneys and other professionals, all court and arbitration costs and all costs of repair and replacement of work of others destroyed or damaged by correction, removal or replacement of CONTRACTOR's defective Work. CONTRACTOR shall not be allowed an extension of the Contract Time because of any delay in performance of the Work attributable to the exercise by OWNER of OWNER's rights and remedies hereunder.

ARTICLE 14 - PAYMENTS TO CONTRACTOR AND COMPLETION

Schedule of Values:

14.1 The schedule of values established as provided in paragraph 2.9 will serve as the basis for progress payments and will be incorporated into a form of Application for Payment acceptable to ENGINEER. Progress payments on account of Unit Price Work will be based on the number of units completed.

Application for Progress Payment:

14.2 At least fifteen days before each progress payment is scheduled (but not more often than once a month), CONTRACTOR shall submit to ENGINEER for review an Application for Payment filled out and signed by CONTRACTOR covering the Work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents. If payment is requested on the basis of materials and equipment not incorporated in the Work but delivered and suitably stored at the site or at another location agreed to in writing, the Application for Payment shall also be accompanied by a bill of sale, invoice or other documentation warranting that OWNER has received the materials and equipment free

and clear of all liens, charges, security interests and encumbrances (which are hereinafter in these General Conditions referred to as "Liens") and evidence that the materials and equipment are covered by appropriate property insurance and other arrangements to protect OWNER's interest therein, all of which will be satisfactory to OWNER. The amount of retainage with respect to progress payments will be as stipulated in the Agreement.

CONTRACTOR's Warranty of Title:

14.3 CONTRACTOR warrants and guarantees that title to all Work, materials and equipment covered by an Application for Payment, whether incorporated in the Project or not, will pass to OWNER no later than the time of payment free and clear of all Liens.

Review of Applications for Progress Payment:

14.4 ENGINEER will, within five days after receipt of each Application for Payment, either indicate in writing a recommendation of payment and present the Application to OWNER, or return the Application to CONTRACTOR indicating in writing ENGINEER's reasons for refusing to recommend payment. In the latter case, CONTRACTOR may make the necessary corrections and resubmit the Application. Ten days after presentation of the Application for Payment with ENGINEER's recommendation, the amount recommended will (subject to the provisions of the last sentence of paragraph 14.7) become due and when due will be paid by OWNER to CONTRACTOR.

14.5 ENGINEER's recommendation of any payment requested in an Application for Payment will constitute a representation by ENGINEER to OWNER, based on ENGINEER's on-site observations of the Work in progress as an experienced and qualified design professional and on ENGINEER's review of the Application for Payment and the accompanying data and schedules that the Work has progressed to the point indicated; that, to the best of ENGINEER's knowledge, information and belief, the quality of the Work is in accordance with the Contract Documents (subject to an evaluation of the Work as a functioning whole prior to or upon Substantial Completion, to the results of any subsequent tests called for in the Contract Documents, to a final determination of quantities and classifications for Unit Price Work under paragraph 9.10, and to any other qualifications stated in the recommendation); and that CONTRACTOR is entitled to payment of the amount recommended. However, by recommending any such payment ENGINEER will not thereby be deemed to have represented that exhaustive or continuous

on-site inspections have been made to check the quality or the quantity of the Work beyond the responsibilities specifically assigned to ENGINEER in the Contract Documents or that there may not be other matters or issues between the parties that might entitle CONTRACTOR to be paid additionally by OWNER or OWNER to withhold payment to CONTRACTOR.

14.6 ENGINEER's recommendation of final payment will constitute an additional representation by ENGINEER to OWNER that the conditions precedent to CONTRACTOR's being entitled to final payment as set forth in paragraph 14.13 have been fulfilled.

14.7 ENGINEER may refuse to recommend the whole or any part of any payment if, in ENGINEER's opinion, it would be incorrect to make such representations to OWNER. ENGINEER may also refuse to recommend any such payment, or, because of subsequently discovered evidence or the results of subsequent inspections or tests, nullify any such payment previously recommended, to such extent as may be necessary in ENGINEER's opinion to protect OWNER from loss because:

14.7.1 the Work is defective, or completed Work has been damaged requiring correction or replacement,

14.7.2 the Contract Price has been reduced by Written Amendment or Change Order.

14.7.3 OWNER has been required to correct defective Work or complete Work in accordance with paragraph 13.14, or

14.7.4 of ENGINEER's actual knowledge of the occurrence of any of the events enumerated in paragraphs 15.2.1 through 15.2.9 inclusive.

OWNER may refuse to make payment of the full amount recommended by ENGINEER because claims have been made against OWNER on account of CONTRACTOR's performance or furnishing of the Work or Liens have been filed in connection with the Work or there are other items entitling OWNER to a set-off against the amount recommended, but OWNER must give CONTRACTOR immediate written notice (with a copy to ENGINEER) stating the reasons for such action.

Substantial Completion:

14.8 When CONTRACTOR considers the entire Work ready for its intended use CONTRACTOR shall notify OWNER and ENGINEER in writing that the entire Work is substantially complete (except for items specifically listed by CONTRACTOR as incomplete) and request that ENGINEER issue a certificate of Substantial Completion. Within a reasonable time

thereafter, OWNER, CONTRACTOR and ENGINEER shall make an inspection of the Work to determine the status of completion. If ENGINEER does not consider the Work substantially complete, ENGINEER will notify CONTRACTOR in writing giving the reasons therefor. If ENGINEER considers the Work substantially complete, ENGINEER will prepare and deliver to OWNER a tentative certificate of Substantial Completion which shall fix the date of Substantial Completion. There shall be attached to the certificate a tentative list of items to be completed or corrected before final payment. OWNER shall have seven days after receipt of the tentative certificate during which to make written objection to ENGINEER as to any provisions of the certificate or attached list. If, after considering such objections, ENGINEER concludes that the Work is not substantially complete, ENGINEER will within fourteen days after submission of the tentative certificate to OWNER notify CONTRACTOR in writing, stating the reasons therefor. If, after consideration of OWNER's objections, ENGINEER considers the Work substantially complete, ENGINEER will within said fourteen days execute and deliver to OWNER and CONTRACTOR a definitive certificate of Substantial Completion (with a revised tentative list of items to be completed or corrected) reflecting such changes from the tentative certificate as ENGINEER believes justified after consideration of any objections from OWNER. At the time of delivery of the tentative certificate of Substantial Completion ENGINEER will deliver to OWNER and CONTRACTOR a written recommendation as to division of responsibilities pending final payment between OWNER and CONTRACTOR with respect to security, operation, safety, maintenance, heat, utilities, insurance and warranties. Unless OWNER and CONTRACTOR agree otherwise in writing and so inform ENGINEER prior to ENGINEER's issuing the definitive certificate of Substantial Completion, ENGINEER's aforesaid recommendation will be binding on OWNER and CONTRACTOR until final payment.

14.9 OWNER shall have the right to exclude CONTRACTOR from the Work after the date of Substantial Completion, but OWNER shall allow CONTRACTOR reasonable access to complete or correct items on the tentative list.

Partial Utilization:

14.10 Use by OWNER of any finished part of the Work, which has specifically been identified in the Contract Documents, or which OWNER, ENGINEER and CONTRACTOR agree constitutes a separately functioning and usable part of the Work that can be used by OWNER without significant

interference with CONTRACTOR's performance of the remainder of the Work, may be accomplished prior to Substantial Completion of all the Work subject to the following:

14.10.1 OWNER at any time may request CONTRACTOR in writing to permit OWNER to use any such part of the Work which OWNER believes to be ready for its intended use and substantially complete. If CONTRACTOR agrees, CONTRACTOR will certify to OWNER and ENGINEER that said part of the Work is substantially complete and request ENGINEER to issue a certificate of Substantial Completion for that part of the Work. CONTRACTOR at any time may notify OWNER and ENGINEER in writing that CONTRACTOR considers any such part of the Work ready for its intended use and substantially complete and request ENGINEER to issue a certificate of Substantial Completion for that part of the Work. Within a reasonable time after either such request, OWNER, CONTRACTOR and ENGINEER shall make an inspection of that part of the Work to determine its status of completion. If ENGINEER does not consider that part of the Work to be substantially complete, ENGINEER will notify OWNER and CONTRACTOR in writing giving the reasons therefor. If ENGINEER considers that part of the Work to be substantially complete, the provisions of paragraph 14.8 and 14.9 will apply with respect to certification of Substantial Completion of that part of the Work and the division of responsibility in respect thereof and access thereto.

14.10.2 OWNER may at any time request CONTRACTOR in writing to permit OWNER to take over operation of any such part of the Work although it is not substantially complete. A copy of such request will be sent to ENGINEER and within a reasonable time thereafter OWNER, CONTRACTOR and ENGINEER shall make an inspection of that part of the Work to determine its status of completion and will prepare a list of the items remaining to be completed or corrected thereon before final payment. If CONTRACTOR does not object in writing to OWNER and ENGINEER that such part of the Work is not ready for separate operation by OWNER, ENGINEER will finalize the list of items to be completed or corrected and will deliver such list to OWNER and CONTRACTOR together with a written recommendation as to the division of responsibilities pending final payment between OWNER and CONTRACTOR with respect to security, operation, safety, maintenance, utilities, insurance, warranties and

guarantees for that part of the Work which will become binding upon OWNER and CONTRACTOR at the time when OWNER takes over such operation (unless they shall have otherwise agreed in writing and so informed ENGINEER). During such operation and prior to Substantial Completion of such part of the Work, OWNER shall allow CONTRACTOR reasonable access to complete or correct items on said list and to complete other related Work.

14.10.3 No occupancy or separate operation of part of the Work will be accomplished prior to compliance with the requirements of paragraph 5.8 in respect of property insurance.

Final Inspection:

14.11 Upon written notice from CONTRACTOR that the entire Work or an agreed portion thereof is complete, ENGINEER will make a final inspection with OWNER and CONTRACTOR and will notify CONTRACTOR in writing of all particulars in which this inspection reveals that the Work is incomplete or defective. CONTRACTOR shall immediately take such measures as are necessary to remedy such deficiencies.

Final Application for Payment:

14.12 After CONTRACTOR has completed all such corrections to the satisfaction of ENGINEER and delivered all maintenance and operating instructions, schedules, guarantees, Bonds, certificates of inspection, marked-up record documents (as provided in paragraph 6.19) and other documents - all as required by the Contract Documents, and after ENGINEER has indicated that the Work is acceptable (subject to the provisions of paragraph 14.16), CONTRACTOR may make application for final payment following the procedure for progress payments. The final Application for Payment shall be accompanied by all documentation called for in the Contract Documents, together with complete and legally effective releases or waivers (satisfactory to OWNER) of all Liens arising out of or filed in connection with the Work. In lieu thereof and as approved by OWNER, CONTRACTOR may furnish receipts or releases in full; an affidavit of CONTRACTOR that the releases and receipts include all labor, services, material and equipment for which a Lien could be filed, and that all payrolls, material and equipment bills, and other indebtedness connected with the Work for which OWNER or OWNER's property might in any way be responsible, have been paid or otherwise satisfied; and consent of the surety, if any, to final payment. If any Subcontractor or Supplier fails to furnish a release or receipt in full, CONTRACTOR

may furnish a Bond or other collateral satisfactory to OWNER to indemnify OWNER against any Lien.

Final Payment and Acceptance:

14.13 If, on the basis of ENGINEER's observation of the Work during construction and final inspection, and ENGINEER's review of the final Application for Payment and accompanying documentation - all as required by the Contract Documents, ENGINEER is satisfied that the Work has been completed and CONTRACTOR's other obligations under the Contract Documents have been fulfilled, ENGINEER will, within ten days after receipt of the final Application for Payment, indicate in writing ENGINEER's recommendation of payment and present the Application to OWNER for payment. Thereupon ENGINEER will give written notice to OWNER and CONTRACTOR that the Work is acceptable subject to the provisions of paragraph 14.16. Otherwise, ENGINEER will return the Application to CONTRACTOR, indicating in writing the reasons for refusing to recommend final payment, in which case CONTRACTOR shall make the necessary corrections and resubmit the Application. Thirty days after presentation to OWNER of the Application and accompanying documentation, in appropriate form and substance, and with ENGINEER's recommendation and notice of acceptability, the amount recommended by ENGINEER will become due and will be paid by OWNER to CONTRACTOR.

14.14 If, through no fault of CONTRACTOR, final completion of the Work is significantly delayed and if ENGINEER so confirms, OWNER shall, upon receipt of CONTRACTOR's final Application for Payment and recommendation of ENGINEER, and without terminating the Agreement, make payment of the balance due for that portion of the Work fully completed and accepted. If the remaining balance to be held by OWNER for Work not fully completed or corrected is less than the retainage stipulated in the Agreement, and if Bonds have been furnished as required in paragraph 5.1, the written consent of the surety to the payment of the balance due for that portion of the Work fully completed and accepted shall be submitted by CONTRACTOR to ENGINEER with the Application for such payment. Such payment shall be made under the terms and conditions governing final payment, except that it shall not constitute a waiver of claims.

Contractor's Continuing Obligation:

14.15 CONTRACTOR's obligation to perform and complete the Work in accordance with the Contract Documents shall be absolute. Neither recommendation of any progress or final payment by ENGINEER, nor the issuance of a certificate of Substantial

Completion, nor any payment by OWNER to CONTRACTOR under the Contract Documents, nor any use or occupancy of the Work or any part thereof by OWNER, nor any pact of acceptance by OWNER nor any failure to do so, nor any review of a Shop Drawing or sample submission, nor the issuance of a notice of acceptability by ENGINEER pursuant to paragraph 14.13, nor any correction of defective Work by OWNER will constitute an acceptance of Work not in accordance with the Contract Documents or a release of CONTRACTOR's obligation to perform the Work in accordance with the Contract Documents (except as provided in paragraph 14.16).

Waiver of Claims:

14.16 The making and acceptance of final payment will constitute:

14.16.1 a waiver of all claims by OWNER against CONTRACTOR, except claims arising from unsettled Liens, from defective Work appearing after final inspection pursuant to paragraph 14.11 or from failure to comply with the Contract Documents or the terms of any special guarantees specified therein; however, it will not constitute a waiver by OWNER of any rights in respect of CONTRACTOR's continuing obligations under the Contract Documents; and

14.16.2 a waiver of all claims by CONTRACTOR against OWNER other than those previously made in writing and still unsettled.

ARTICLE 15 - SUSPENSION OF WORK AND TERMINATION

Owner May Suspend Work:

15.1 OWNER may, at any time and without cause, suspend the Work or any portion thereof for a period of not more than ninety days by notice in writing to CONTRACTOR and ENGINEER which will fix the date on which Work will be resumed. CONTRACTOR shall resume the Work on the date so fixed. CONTRACTOR shall be allowed an increase in the Contract Price or an extension of the Contract Time, or both, directly attributable to any suspension if CONTRACTOR makes an approved claim therefor as provided in Articles 11 and 12.

Owner May Terminate:

15.2 Upon the occurrence of any one or more of the following events:

15.2.1 if CONTRACTOR commences a voluntary case under any chapter of the Bankruptcy Code (Title 11, United States Code), as now or hereafter in effect, or if CONTRACTOR takes any equivalent or similar action by filing a petition or otherwise under any other federal or state law in

effect at such time relating to the bankruptcy or insolvency;

15.2.2 if a petition is filed against CONTRACTOR under any chapter of the Bankruptcy Code as now or hereafter in effect at the time of filing, or if a petition is filed seeking any such equivalent or similar relief against CONTRACTOR under any other federal or state law in effect at the time relating to bankruptcy or insolvency;

15.2.3 if CONTRACTOR makes a general assignment for the benefit of creditors;

15.2.4 if a trustee, receiver, custodian or agent of CONTRACTOR is appointed under applicable law or under contract, whose appointment or authority to take charge of property of CONTRACTOR is for the purpose of enforcing a Lien against such property or for the purpose of general administration of such property for the benefit of CONTRACTOR's creditors;

15.2.5 if CONTRACTOR admits in writing an inability to pay its debts generally as they become due;

15.2.6 if CONTRACTOR persistently fails to perform the Work in accordance with the Contract Documents (including, but not limited to, failure to supply sufficient skilled workers or suitable materials or equipment or failure to adhere to the progress schedule established under paragraph 2.9 as revised from time to time);

15.2.7 if CONTRACTOR disregards Laws or Regulations of any public body having jurisdiction;

15.2.8 if CONTRACTOR disregards the authority of ENGINEER; or

OWNER may, after giving CONTRACTOR (and the surety, if there be one) seven days' written notice and to the extent permitted by Laws and Regulations, terminate the services of CONTRACTOR, exclude CONTRACTOR from the site and take possession of the Work and of all CONTRACTOR's tools, appliances, construction equipment and machinery at the site and use the same to the full extent they could be used by CONTRACTOR (without liability to CONTRACTOR for trespass or conversion), incorporate in the Work all materials and equipment stored at the site or for which OWNER has paid CONTRACTOR but which are stored elsewhere, and finish the Work as OWNER may deem expedient. In such case CONTRACTOR shall not be entitled to receive any further payment until the Work is finished. If the unpaid balance of the Contract Price exceeds the direct, indirect and consequential costs of

completing the Work (including but not limited to fees and charges of engineers, architects, attorneys and other professionals and court and arbitration costs) such excess will be paid to CONTRACTOR. If such costs exceed such unpaid balance, CONTRACTOR shall pay the difference to OWNER. Such costs incurred by OWNER will be approved as to reasonableness by ENGINEER and incorporated in a Change Order, but when exercising any rights or remedies under this paragraph OWNER shall not be required to obtain the lowest price for the Work performed.

15.3 Where CONTRACTOR's services have been so terminated by OWNER, the termination will not affect any rights or remedies of OWNER against CONTRACTOR then existing or which may thereafter accrue. Any retention or payment of moneys due CONTRACTOR by OWNER will not release CONTRACTOR from liability.

15.4 Upon seven days' written notice to CONTRACTOR and ENGINEER, OWNER may, without cause and without prejudice to any other right or remedy, elect to abandon the Work and terminate the Agreement. In such case, CONTRACTOR shall be paid for all Work executed and any expense sustained plus reasonable termination expenses, which will include, but not be limited to, direct, indirect and consequential costs (including, but not limited to, fees and charges of engineers, architects, attorneys and other professionals and court and arbitration costs).

Contractor May Stop Work or Terminate:

15.5 If, through no act or fault of CONTRACTOR, the Work is suspended for a period of more than ninety days by OWNER or under an order of court or other public authority, or ENGINEER fails to act on any Application for Payment within thirty days to pay CONTRACTOR any sum finally determined to be due, then CONTRACTOR may, upon seven days' written notice to OWNER and ENGINEER, terminate the Agreement and recover from OWNER payment for all Work executed and any expense sustained plus reasonable termination expenses. In addition and in lieu of terminating the Agreement, if ENGINEER has failed to act on an Application for Payment or OWNER and ENGINEER stop the Work until payment of all amounts then due. The provisions of this paragraph shall not relieve CONTRACTOR of the obligations under paragraph 6.29 to carry on the Work in accordance with the progress schedule and without delay during disputes and disagreements with OWNER.

ARTICLE 16 - ARBITRATION

16.1 All claims, disputes

and other matters in question between OWNER and CONTRACTOR arising out of, or relating to the Contract Documents or the breach thereof (except for claims which have been waived by the making or acceptance of final payment as provided by paragraph 14.16) will be decided by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association then obtaining subject to the limitations of this Article 16. This agreement so to arbitrate and any other agreement or consent to arbitrate entered into in accordance herewith as provided in this Article 16 will be specifically enforceable under the prevailing law of any court having jurisdiction.

16.2 No demand for arbitration of any claim, dispute or other matter that is required to be referred to ENGINEER initially for decision in accordance with paragraph 9.11 will be made until the earlier of (a) the date on which ENGINEER has rendered a decision or (b) the tenth day after the parties have presented their evidence to ENGINEER if a written decision has not been rendered by ENGINEER before that date. No demand for arbitration of any such claim, dispute or other matter will be made later than thirty days after the date on which ENGINEER has rendered a written decision in respect thereof in accordance with paragraph 9.11; and the failure to demand arbitration within said thirty days' period shall result in ENGINEER's decision being final and binding upon OWNER and CONTRACTOR. If ENGINEER renders a decision after arbitration proceedings have been initiated, such decision may be entered as evidence but will not supersede the arbitration proceedings, except where the decision is acceptable to the parties concerned. No demand for arbitration of any written decision of ENGINEER rendered in accordance with paragraph 9.10 will be made later than ten days after the party making such demand has delivered written notice of intention to appeal as provided in paragraph 9.10.

16.3 Notice of the demand for arbitration will be filed in writing with the other party to the Agreement and with the American Arbitration Association, and a copy will be sent to ENGINEER for information. The demand for arbitration will be made within the thirty-day or ten-day period specified in paragraph 16.2 as applicable, and in all other cases within a reasonable time after the claim, dispute or other matter in question has arisen, and in no event shall any such demand be made after the date when institution of legal or equitable proceedings based on such claim, dispute or other matter in question would be barred by the applicable

statute of limitations.

16.4 No arbitration arising out of or relating to the Contract Documents shall include by consolidation, joinder or in any other manner any other person or entity (including ENGINEER, ENGINEER's agents, employees or consultants) who is not a party to this contract unless:

16.4.1 the inclusion of such other person or entity is necessary if complete relief is to be afforded among those who are already parties to the arbitration,

16.4.2 Such other person or entity is substantially involved in a question of law or fact which is common to those who are already parties to the arbitration and which will arise in such proceedings, and

16.4.3 the written consent of the other person or entity sought to be included and of OWNER and CONTRACTOR has been obtained for such inclusion, which consent shall make specific reference to this paragraph; but no such consent shall constitute consent to arbitration of any dispute not specifically described in such consent or to arbitration with any party not specifically identified in such consent.

16.5 The award rendered by the arbitrators will be final, judgment may be entered upon it in any court having jurisdiction thereof, and will not be subject to modification or appeal except to the extent permitted by Sections 10 and 11 of the Federal Arbitration Act (9 U.S.C.§§10,11).

ARTICLE 17 - MISCELLANEOUS

Giving Notice:

17.1 Whenever any provision of the Contract Documents requires the giving of written notice, it will be deemed to have been validly given if delivered in person to the individual or to a member of the firm or to an officer of the corporation for whom it is intended, or if delivered at or sent by registered or certified mail, postage prepaid, to the last business address known to the giver of the notice.

Computation of Time:

17.2.1 When any period of time is referred to in the Contract Documents by days, it will be computed to exclude the first and include the last day of such period. If the last day of any such period falls on a Saturday or Sunday or on a day made a legal holiday by the law of the applicable jurisdiction, such day will be omitted from the computation.

17.2.2 A calendar day of twenty-four hours measured from midnight to the next

midnight shall constitute a day.

General:

17.3 Should OWNER or CONTRACTOR suffer injury or damage to person or property because of any error, omission or act of the other party or of any of the other party's employees or agents or others for whose acts the other party is legally liable, claim will be made in writing to the other party within a reasonable time of the first observance of such injury or damage. The provisions of this paragraph 17.3 shall not be construed as a substitute for or a waiver of the provisions of any applicable statute of limitations or repose.

17.4 The duties and obligations imposed by these General Conditions and the rights and remedies available hereunder to the parties hereto, and, in particular but without limitation, the warranties, guarantees and obligations imposed upon CONTRACTOR by paragraphs 6.30, 13.1, 13.13, 13.14, 14.3 and 15.2 and all of the rights and remedies available to OWNER and ENGINEER thereunder, are in addition, to and are not to be construed in any way as a limitation of, any rights and remedies available to any or all of them which are otherwise imposed or available by Laws or Regulations, by special warranty or guarantee or by other provisions of the Contract Documents, and the provisions of this paragraph will be as effective as if repeated specifically in the Contract Documents in connection with each particular duty, obligation, right and remedy to which they apply. All representations, warranties and guarantees made in the Contract Documents will survive final payment and termination or completion of the Agreement.

SUPPLEMENTARY GENERAL CONDITIONS

1. THE GENERAL CONDITIONS: The General Conditions shall apply to all work in the Contract Documents, except as otherwise specified in the Supplementary General Conditions. Requirements of the Supplementary General Conditions supersede those of the General Conditions.

2. COMMENCEMENT AND COMPLETION OF WORK: The Contractor shall commence the Work on the date indicated in the Notice to Proceed and shall diligently prosecute said Work so as to complete the entire project and place it in use within three (3) months.

3. SCOPE OF THE WORK: The Work includes the furnishing of all necessary machinery, equipment, tools, labor and other construction means, and all materials and equipment required to perform the Work and Specifications and including the placing of the Work into satisfactory operation.

4. LOCATION: The work under this Contract will be located in Haywood County, North Carolina as shown on the Construction Drawings.

   A Pre-Bid Conference will be held on _____

   at PM at _____.

5. EXTENSION OF TIME AND FAILURE TO COMPLETE ON TIME: Any and all extensions of time shall be in accordance with the General Conditions, except as otherwise hereinafter provided.

   Failure to complete the Project on or before the stipulated completion date will result in the assessment of liquidated damages in the amount of Five Hundred ($500.00) Dollars per day.

6. CONSTRUCTION DRAWINGS: The Work shall conform to the following construction drawings.

Sheet No.	Title Sheet
	Title Sheet
1	Boundary Information
1A	Existing Conditions for Entire Site
2	Existing Conditions for Landfill Cell & Spring Relief
3	Bottom Grades & Phase I Erosion Control
4	Final Grades & Phase II Erosion Control
5-9	Cross-Sections
10-13	Miscellaneous Details
14	Erosion Control Details
15	Monitor Well Sampling & Analysis Plan
16	Groundwater Monitoring Well Design
17	General Operations Plan

7. REPORTS AND DRAWINGS USED BY THE ENGINEER: In the preparation of Drawings and Specifications, ENGINEER has relied upon:

A. The following drawings of physical conditions in or relating to existing surface and subsurface structures (except Underground Facilities) which are contiguous to the site of the Work:

Copies of these reports and drawings that are not included in the Bidding Documents may be examined at _____ during normal business hours. These reports and drawings are not part of the Contract Documents, but the technical data contained therein upon which CONTRACTOR is entitled to rely as provided in GC-4.2 and as identified and established above are incorporated therein by reference.

8. SANITARY CONVENIENCES: The CONTRACTOR shall provide adequate sanitary conveniences for use of those employed on the work and their use shall be strictly enforced. Such conveniences shall be made available when the first employees arrive on the site and shall be removed after the departure of the last employees from the job.

9. ENVIRONMENTAL IMPACT: The CONTRACTOR shall conduct all operations so as to minimize, to the greatest extent possible, adverse environmental impact.

a. Noise: All equipment and machinery shall be provided with exhaust mufflers maintained in good working order to reduce operating noise to minimum levels.

b. Dust/Smoke: All equipment movements shall be accompanied by a minimum of dust. Traveled surfaces and earthwork shall be maintained in a moist condition to avoid the generation of dust or the airborne movement of particulate matter under all prevailing atmospheric conditions.

Burning operations will be conducted only with written permission of the OWNER and/or appropriate regulatory agency. The CONTRACTOR shall be responsible for obtaining all permits and comply with all codes, ordinances and regulations pertaining to the burning.

c. Traffic: Trucks shall be routed over roads which will result in the least effect on traffic and nuisance to the public. All material shall be loaded in a manner which will preclude the loss of any portion of the load in transit, including covering, if necessary.

d. Sedimentation: All points of concentrated runoff from rainfall shall be visually monitored to determine that no eroded material from the construction site is being deposited offsite. Measures shall be taken to promptly eliminate such a deposition if occurring, including the installation of detention basins.

10. CONSTRUCTION STAKEOUT: The OWNER will provide benchmarks and baselines for horizontal and vertical control at the site of the work.

From the baselines and benchmarks the CONTRACTOR shall complete the layout of the work and shall be responsible for all measurements that may be required for the execution of the work prescribed in the specifications or on the Drawings, subject to such modifications as may be required to meet changed conditions or as a result of necessary modifications to the Work.

The CONTRACTOR shall furnish, at his own expense, all such stakes, spikes, steel pins, templates, platforms, equipment, instruments, tools and material and all labor as may be required in laying out any part of the Work from the baselines and benchmarks.

It shall be the responsibility of the CONTRACTOR to maintain and preserve all stakes and other marks established by the OWNER until authorized to remove them, and if such marks are destroyed by the Contractor or through his negligence prior to their authorized removal, they may be replaced by the OWNER at his discretion, and the expense of replacement will be deducted from any amounts due or to become due the CONTRACTOR.

All survey data shall be recorded in accordance with standard and approved methods. All field notes, sketches, records and computations made by the CONTRACTOR in laying out the work shall be available at all times during the progress of the work for the ready examination by the OWNER or his duly authorized representative.

The OWNER may make original and final surveys and make computations to determine the quantities of work performed or finally in place, if required.

The CONTRACTOR shall make such surveys and computations as are necessary to determine the quantities of work performed or placed during each period for which a progress payment is to be made.

All original field notes, computations and other records, or facsimile copies thereof, taken by the CONTRACTOR for the purpose of construction and for progress surveys, shall be furnished promptly to the representative of the OWNER for permanent records and for determining the proper amount of progress payments due to the CONTRACTOR. Unless waived in each specific case, quantity surveys made by the CONTRACTOR shall be made during the presence of a representative of the OWNER.

The OWNER may make checks as the work progresses to verify lines and grades established by the CONTRACTOR and to determine the conformance of the completed work as it progresses with the requirements of Contract Documents and Drawings. Such checking by the OWNER or his representative shall not relieve the CONTRACTOR of his responsibility to perform all work in accordance with the Contract Documents and Drawings and the lines and grades given therein. In the event that location marks as established by the CONTRACTOR are found to be inaccurate or inadequate, work shall be suspended until corrections have been made.

No separate payment will be made for the costs involved in the survey work, layout work or staking performed by the CONTRACTOR. All such costs will be considered as incidental to the Work.

11. UTILITIES: Utilities such as sewer, water and electric lines encountered in the work shall be protected from injury and maintained in service until moved or replaced as required under this Contract or by others as the case may be, or abandoned as may be necessary for the proper construction and use of the new work.

12. ADJUSTMENT OF DISCREPANCIES: In all cases of discrepancies between the various dimensions and details shown on drawings, or between the drawings and these specifications, the more expensive construction shall be estimated before construction is started, the matter shall be submitted to the OWNER for clarification. Without such a decision, discrepancies shall be adjusted by the CONTRACTOR at his own risk and in settlement of any complications arising from such adjustment, the CONTRACTOR shall bear all of the extra expense involved.

13. RESTORATION: The CONTRACTOR shall conduct his operations so that restoration of roadways, driveways, curb and gutter, ditches and easements is complete at the time a request for final review is made by the Contractor.

Reasonable care shall be taken during construction to avoid damage to vegetation. Ornamental shrubbery and tree branches shall be temporarily tied back, where appropriate, to minimize damage.

Trees which receive damage to branches shall be trimmed to those branches to improve the appearance of the tree. Tree trunks receiving damage from equipment shall be treated with a tree dressing.

14. MAINTENANCE DURING CONSTRUCTION: The CONTRACTOR shall maintain the Work from the beginning of construction operations until final acceptance.

This maintenance shall constitute continuous and effective work prosecuted day by day with adequate equipment and forces to the end that the site and structures thereon are kept in satisfactory condition at all times, including satisfactory signing or marking as appropriate and control of traffic where required by use of traffic control devices as required by the State in which this project is located.

Upon completion of the Work, the CONTRACTOR shall remove all construction signs and barriers before final acceptance.

While undergoing improvements, the roads shall be kept open to all traffic by the CONTRACTOR The CONTRACTOR shall keep the portion of the site being used by public traffic, whether it be through or local traffic, in such condition that traffic will be adequately accommodated. The CONTRACTOR shall bear all cost of signs and markings as required and other maintenance work during construction and before the Work is accepted and of constructing and maintaining such approaches, crossings, intersections, and other features as may be necessary without direct compensation.

15. BARRICADES, DANGER, WARRING & DETOUR SIGNS: The CONTRACTOR shall provide, erect, and maintain all necessary barricades, suitable and sufficient lights, danger signals, signs and other traffic control devices, and shall take all necessary precautions for the protection of the work and safety of the public. Highways and streets closed to traffic shall be protected by effective barricades, and obstructions shall be lighted during hours of darkness. Suitable warning signs shall be provided to properly control and direct traffic.

The CONTRACTOR shall furnish, install, and maintain all necessary barricades, warning signs, and other protection devices in accordance with the State requirements in which the project is located. Temporary signs may be reused, provided they are in good condition and legible. All protective devices shall be kept in a good, legible condition while in use.

As soon as construction advances to the extent that temporary barricades, and signs are no longer needed to inform the traveling public,such signs shall be promptly removed.

The cost of furnishing, erecting, maintaining, and removing protective devices will not be paid for as a separate Bid Item. Where the CONTRACTOR is required to perform any of these functions, the cost thereof shall be included in the overall Bid submitted. Ownership of the temporary warning devices shall remain with the CONTRACTOR.

16. ACCESS FOR INSPECTION: Access for inspection shall be provided for representatives of the North Carolina Department of Environment, Health and Natural Resources.

17. The limits of liability for the insurance required by paragraph 5.3 of the General Conditions shall provide coverage for not less than the following amounts or greater where required by Laws and Regulations:

a. Workers' Compensation, etc. under paragraphs 5.3.1 and 5.3.2 of the General Conditions:

(1)	State:	Statutory
(2)	Applicable Federal (e.g. Longshoreman's):	Statutory
(3)	Employer's Liability:	$ 200,000

b. Comprehensive General Liability (under paragraphs 5.3.3 through 5.3.6 of the General Conditions):

(1) Bodily Injury (including completed operations and products liability):

$ 500,000	Each Occurrence

Property Damage:

$ 100,000	Each Occurrence
$ N/A	Annual Aggregate
or a combined single limit of	$ 200,000

(2) Property Damage liability insurance will provide Explosion, Collapse and Underground coverages where applicable.

(3) Personal Injury, with employment exclusion deleted

$ 1,000,000	Annual Aggregate

C. Comprehensive Automobile Liability:

Bodily Injury:

$ 200,000	Each Person
$ 500,000	Each Occurrence

Property Damage:

$ 100,000	Each Occurrence
or combined single limit of	$ 200,000

D. Builders Risk Insurance (Fire and Extended Coverage).

N/A

E. Contractual Endorsement:

The Contractual Liability required by paragraph 5.4 of the General Conditions shall provide coverage for not less than the following amounts:

(1) Bodily Injury:

$ N/A	Each Occurrence

(2) Property Damage:

$ N/A	Each Occurrence
$ N/A	Annual Aggregate

J

CONSTRUCTION SEQUENCE

1. Obtain applicable permits and hold pre-construction conference at least one week prior to construction.

2. Flag work limits and buffer areas. Install construction entrance.

3. Clear site of all vegetation and debris and dispose of on site as directed by the Owner.

4. Install french drains along perimeter of the landfill. Maintain clearing limits and buffer areas. Mulch and seed area after completion of this construction.

5. Install sediment basin, perimeter diversions, etc. as first construction activity.

6. Commence initial excavation; maintaining soil stockpile area; construct channels, diversion dikes and install sediment fence as needed. Maintain diversions along fill slope daily. Mulch bare areas should construction be discontinued for more than three (3) weeks.

7. After initial excavation installation, if deemed necessary by the Engineer and the State Inspectors, the Contractor shall begin installing the dewatering trenches; maintaining diversions and channels, so that storm drainage is adequately conveyed to the sediment basin. It is possible that based on the results of the french drain installation, that these trenches could be reduced in number and/or totally eliminated; therefore, this item could be eliminated depending on site conditions.

8. Mulch and apply temporary seeding to the site; check and correct all erosion control items (i.e. check dams, sediment fence, riprap, etc.).

9. Refer to the Erosion Control Notebook for the required maintenance of the erosion control measures during construction.

K

TECHNICAL SPECIFICATIONS

SECTION NO. 1

CLEARING AND GRUBBING

1.01 Scope: Remove and properly dispose of all objectionable material on site as defined herein from areas designated on the drawings or authorized by the Engineer.

1.02 Definitions:

A. Objectional Material: All material included in the definition of clearing or grubbing.

B. Clearing and Grubbing:

1. Removal and proper on-site disposal of all natural and man-made objectionable materials from the construction areas. This work shall be performed in advance of grading operations and in accordance with the requirements herein stated, subject to erosion control requirements. The natural ground surface shall be cleared of all vegetable growth, such as trees, logs, stumps, roots of downed trees, brush, grass, weeds.

1.03 Methods:

A. Removal Procedures:

1. Stumps: Remove to a depth at least 3 feet below finished subgrade and backfill with suitable material to a density not less than that of the proposed subgrade.

2. Abandoned Obstructions: Remove or break down masonry and asphalt structures to a depth of at least 1 foot below finished subgrade. Thoroughly crack or otherwise break abandoned structures remaining in place which may impound water where they exist within 10 feet of finished grade backfill with suitable material to a density not less than that of adjacent soil.

3. Tap Roots and Other Significant Objectionable Material: Remove to a depth of at least 1 foot below subgrade.

4. Protect from damage those trees and bushes not designated on the Drawings to be removed, and those in the Buffer Zone.

5. Accomplish clearing and grubbing well in advance of earth work to allow sufficient time for inspection, staking, and topographic survey, as described in the Supplementary General Conditions No. 10.

B. Existing Utilities:

1. Do not damage or remove existing utilities, unless specifically designated on the Drawings to be removed and plugged.

2. Notify utility owner in advance of any work which might affect utility system facilities.

3. Assume full responsibility for unauthorized damage to existing utilities.

4. Exact location of existing utilities shown or not shown on the plans is the responsibility of the Contractor.

C. Construction Area: Unless otherwise authorized, the area to be cleared and grubbed shall include the work area plus three feet outside the work area. At no time will clearing and grubbing extend beyond property lines.

D. Topsoil: Topsoil shall be stripped from the construction areas. Material determined suitable by the Engineer shall be stockpiled on site at a location designated by the Engineer.

E. Installation of Silt Fencing: Silt fence shall be installed at locations shown on the drawings as soon as practical but prior to clearing operations beginning. Installation procedure shall be as detailed on the Plans.

F. On-Site Burning of Brush, Limbs, Trees, Etc.: The Contractor shall be responsible for obtaining all necessary permits to burn any cleared wooden materials on-site. The Contractor shall abide by all federal, state and local ordinances associated with any burning activities.

SECTION NO. 2

EARTHWORK

2.01 Related Work: Drawings and general provisions of Contract, including General and Supplementary Conditions apply to work of this section.

2.02 Description of Work: The extent of earthwork is shown on drawings.

This work includes but is not limited to:

1. Preparation of the subgrade for the landfill cells and leachate pond.
2. Construction of the access roads and sediment pond.

2.03 Quality Assurance: Perform excavation work in compliance with applicable requirements of governing authorities having jurisdiction.

Soil tests and field density tests performed in accordance with paragraph 2.12 shall be made by a materials testing laboratory approved by the Engineer in writing and paid for by invoice to the Owner.

2.04 Job Conditions:

A. Existing Utilities: Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of protection during earthwork operations.

Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair damaged utilities to satisfaction of utility owner.

Do not interrupt existing utilities serving facilities occupied and used by Owner or others, except when permitted in writing by Engineer and then only after acceptable temporary utility services have been provided.

B. Protection of Persons and Property: Barricade open excavations occurring as part of this work and post with warning lights.

Operate warning lights as recommended by authorities having jurisdiction.

Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

2.05 Soil Materials: Satisfactory soil materials are defined as those complying with American Association of State Highway and Transportation Officials (AASHTO) M145, soil classification Groups A-1, A-2-4, A-2-5, and A-3.

Unsatisfactory soil materials are those defined in AASHTO M145 soil classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7; also, peat and other highly organic soils.

A. Backfill and Fill Materials: Satisfactory soil materials free of rock or gravel larger than 2" in any dimension, debris, waste, frozen materials, vegetable and other deleterious matter.

2.06 Rock Excavation:

A. Rip-Rock: Any material that cannot be removed by scrapers, loaders, pans, dozers or graders; and require the use of a single-tooth ripper drawn by a crawler tractor having a draw bar pull of not less than 56,000 pounds (Caterpillar D-8k or equivalent).

B. Trench Rock: Any material which cannot be excavated with a backhoe having a bucket curling force rating of not less than 25,700 pounds (Caterpillar 225 or equivalent), and occupying an original volume of at least one-half cubic yard.

2.07 Excavation: Excavation consists of removal and disposal of material encountered when establishing required pre-grade elevations.

Earth excavation includes removal and disposal of material of any classification and other materials encountered that are not classified as unauthorized excavation or rock excavation.

Topsoil excavation shall include excavation and stockpiling of ±6 inches of topsoil material. This material shall be placed in the final lift of areas to be grassed.

Unauthorized excavation consists of removal of materials beyond indicated pre-grade elevations or dimensions without specific direction of Engineer. Unauthorized excavation, shall be at Contractor's expense.

Rock excavation includes removal and disposal of materials classified as rock according to paragraph 2.06 that are encountered when establishing required pre-grade elevations. Removal of materials classified as rock excavation will be paid for at unit prices established in the Proposal.

Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classification.

A. Additional Excavation: When excavation has reached required pre-grade elevations, notify Engineer who will make an inspection of conditions.

If unsuitable bearing materials are encountered at required pre-grade elevations, carry excavations deeper and replace excavated material with satisfactory backfill.

Removal of unsuitable material and its replacement as directed will be paid on basis of unit prices established in the Proposal.

B. Stability of Excavations: Slope sides of excavations shall comply with local codes and ordinances and O.S.H.A. regulations having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.

Maintain sides and slopes of excavations in safe condition until completion of backfilling.

C. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers and cross-braces, in good serviceable condition.

Establish requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.

Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.

D. Dewatering: Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area.

Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.

E. Material Storage: Stockpile satisfactory excavated materials where directed, for backfill or fill. Place, grade and shape stockpiles for proper drainage.
Locate and retain soil materials away from edge of excavations.

Dispose of excess soil material and waste materials as herein specified.

F. Excavation for Roads and Lined Areas: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10'.

Contractor shall grade the landfill cells, ponds and road areas subgrades to allow for the required base courses. Depth of subgrade below finished contours and elevations shall be as indicated in the Drawings.

G. Excavation for Pipe Trenches: Dig pipe trenches to the uniform width for particular item to be installed, sufficiently wide to provide ample working room compaction.

Excavate pipe trenches to depth indicated or required. Carry depth of trenches for piping to establish indicated flow lines and invert elevations.

Grade bottoms of trenches as indicated, notching under pipe bells to provide solid bearing for entire body of pipe.

Do not backfill trenches until tests and inspections have been made and backfilling authorized by Engineer. Use care in backfilling to avoid damage or displacement of pipe systems.

2.08 Proofrolling:

A. General: All landfill cells and roadway areas to receive earth fill shall be proofrolled prior to placement of fill. Proofrolling shall consist of trafficking the area in perpendicular directions utilizing a heavily loaded dump truck (20 tons minimum).

Any areas which pump or rut excessively and which cannot be densified by continued rolling shall be scarified and allowed to dry sufficiently before compacting. Proofrolling shall be observed by an experienced geotechnical engineer.

2.09 Compaction:

A. General: Control soil compaction during construction providing minimum percentage of density specified for each area classification.

B. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum dry density for soils which exhibit a well-defined moisture density relationship determined in accordance with ASTM D 698; and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship.

C. Ponds, Pavement Subgrades and Utility Trenches: All lifts shall be compacted to at least 95 percent of the Standard Proctor Maximum Dry Density (ASTM D698) to subgrade levels.

D. Grassed Areas: The final lift of areas to be grassed shall be compacted to at least 85 percent of the Standard Proctor maximum dry density (ASTM D698).

2.10 Backfill and Fill:

A. General: Place satisfactory soil material in layers to required subgrade elevations, for each area classification listed below.

1. In excavations, use satisfactory excavated or borrow material.

2. Under grassed areas, use satisfactory excavated or borrow material. Use stockpiled topsoil if available for the final lift.

3. Under walks and pavements, use subbase material as described in Section 8.02, or satisfactory excavated or borrow material, or combination of both.

4. Under "HDPE" liner, use satisfactory backfill or fill material.

Backfill excavations as promptly as work permits, but not until completion of the following:

5. Removal of concrete formwork.

6. Removal of shoring and bracing, and backfilling of voids with satisfactory materials.

7. Removal of trash and debris.

B. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break-up sloped surfaces steeper than 1 vertical to 4 horizontal so that fill material will bond with existing surface.

When existing ground surface has a density less than that specified under "Compaction" for particular area classification, break up ground surface, pulverize, moisture-condition to optimum moisture content, and compact to specified percentage of maximum density.

C. Placement and Compaction: Place backfill and materials in layers not more than 12" in loose depth for material compacted by heavy compaction equipment, and not more than 4" in loose depth for material compacted by hand operated tampers.

Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

Place backfill and fill materials evenly adjacent to structures, to required elevations. Take care to prevent wedging action of backfill against structures by carrying material uniformly around structure to approximately same elevation in each lift.

2.11 Grading:

A. General: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.

B. Grading Outside Landfill Cell Lines: Grade areas adjacent to the landfill to drain away and to prevent ponding. Finish surfaces free from irregular surface changes, and as follows:

1. Lawn and Unpaved Areas: Finish areas to receive topsoil to within not more than 0.20' above or below required elevations. Areas shall be free of stones, pebbles and etc. 1-1/2" and larger.

2. Roadway Areas: Shape surface of roadway areas to line, grade and cross-section, with finish surface not more than 2/2" above or below required subgrade elevation.

C. Grading Surface of Fill Under "HDPE" Liner: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 0.20' when tested with a 10' straightedge.

2.12 Field Quality Control:

A. Quality Control Testing During Construction: The Contractor shall allow testing service to inspect and approve subgrades and fill layers before further construction work is performed. An experienced geotechnical engineer shall observe the proofrolling of the landfill cells, ponds and roadways. Submit two (2) copies of results of Compaction Test to Engineer.

1. Perform filed density tests in accordance with ASTM D 2937 (sand cone method), ASTM D 2167 (rubber balloon method), as applicable, or nuclear method ASTM D 2922.

2. Testing Frequency: Make at least one field density test for each 12-inch layer of subgrade for every 20,000 sq. ft. of fill or subgrade.

If in opinion of Engineer, based on testing service reports and inspection, subgrade or fills which have been placed are below specified density, the Contractor shall provide additional compaction and testing at no additional expense to the Owner.

2.13 Maintenance:

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.

B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather scarify surface, reshape, and compact to required density prior to further construction.

2.14 Insufficient Fill Material: If the quantity of grading material is insufficient to provide finished grade elevations shown on the drawings, the contractor shall adjust on-site grades with the written approval of the Engineers to provide the required material.

2.15 Excess Cut Material: If the quantity of grading material is in excess of the quantities necessary to provide sub-grade and finish grade elevations indicated on the drawings, the excess material shall be placed at the direction of the Engineer.

2.16 Initial and Final Topographic Survey: The method used to determine actual excavation volumes will require initial and final topography of the effected area. After the Contractor has cleared the construction area, the Contractor's Surveyor shall determine initial topographic information.

The Contractor shall allow adequate time, during and after clearing operations, to perform this survey. The final topographic survey shall be performed by the Contractor's Surveyor after subgrade elevations have been reached and accepted by the Engineer.

SECTION NO. 3

EROSION AND SEDIMENTATION CONTROL

3.01 Description: This Section consists of the furnishing and installing of silt fences, rip rap, and other provisions as necessary for the purpose of governing land-disturbing activities.

3.02 Materials: All rip-rap shall meet the specifications described in The North Carolina Department of Transportation Standard Specifications, 1990. This material shall be Class B as described in the referenced section.

Construction of the silt fence shall be according to the detail drawings and the referenced specifications.

3.03 Vegetation: Stripping of vegetation, regrading and other development activities shall be conducted in such a manner so as to minimize erosion. Whenever feasible, natural vegetation shall be retained, protected and supplemented.

3.04 Disturbed Soil: The disturbed area and the duration of exposure to erosive elements shall be kept to a practicable minimum. All disturbed soil shall be stabilized as quickly as practicable. Temporary vegetation or mulching as described in Section 4, shall be employed to protect exposed critical areas during development.

3.05 Erosion Control Measures: All structures shall be installed as described on the Construction Drawings.

A. Sediment and erosion control devices shall be installed prior to beginning grading in an area serviced by those devices.

B. All areas disturbed in the buffer zone shall be grassed immediately in accordance with Section 4 of these specifications.

C. Silt fence shall be erected down gradient of all soil stockpiles, or as directed.

3.06 Surface Run-Off Water: Sediment in run-off water must be trapped by the use of debris basins, sediment basins, silt traps, or similar measures as described on the Construction Plans until the disturbed area is stabilized. Adequate provisions must be provided to minimize damage from surface water to the cut face of excavations or the sloping surfaces of fills.

3.07 Maintenance: The contractor shall be responsible for maintaining all erosion and sediment control measures and structures, whether temporary or permanent.

SECTION NO. 4

GRASSING

4.01 Description: This item consists of the furnishing and sowing of grass seed, including the preparation of the ground, furnishing and applying mulch and water, and the furnishing and applying of fertilizer.

4.02 Areas to be Grassed: The areas to be grassed shall include all areas disturbed by construction. Areas not receiving permanent cover that will be exposed for more than 3 months shall receive temporary cover.

4.03 Seeding

A. Temporary Seeding

Temporary seeding shall provide protection for areas that will be left disturbed for longer than 30 days and no more than 1 year, during which time permanent stabilization should be initiated.

Grading shall be completed before preparing seedbeds and all necessary erosion control structures shall be installed such as dikes, waterways and basins. If soils become compacted during grading, loosen them to a depth of 6-8 inches, using a ripper, harrow, or a chisel plow.

Evenly apply seed using a cyclone seeder (broadcast), drill, cultipacker seeder, or hydroseeder. Small grains should be planted no more than 1 inch deep, and grasses and legumes no more than 1/2 inch. Broadcast seed must be covered by raking or chain dragging, and then lightly firmed with a roller or cultipacker.

Temporary Seeding
Recommendations for Late
Winter and Early Spring

Seeding Mixture Species	Rate (lb/acre)
Rye (Grain)	120
Annual Lespedeza (Kobe in Piedmont & Coastal Plain, Korean in Mountains)	50

Omit annual lespedeza when duration of temporary cover is not to extend beyond June.

Seeding Dates

Piedmont - January 1 - May 1

Soil Amendments

Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10 fertilizer.

Mulch

Apply 4,000 lb/acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

Maintenance

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

Temporary Seeding
Recommendations for Summer

Seeding Mixture Species	Rate (lb/acre)
German Millet	40

In the Piedmont and Mountains, a small-stemmed Sudangrass may be substituted at a rate of 50 lb/acre.

Seeding Dates

Piedmont - May 1 - August 15

Soil Amendments

Follow recommendations of soil tests or apply 2,000 lb/acre ground agricultural limestone and 750 lb/acre 10-10-10-fertilizer.

Mulch

Apply 4,000 lb/acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

Maintenance

Refertilize if growth is not fully adequate. Reseed, refertilize and mulch immediately following erosion or other damage.

Temporary Seeding
Recommendations for Fall

Seeding Mixture Species	Rate (lb/acre)
Rye (Grain)	120

Seeding Dates

Coastal Plain and Piedmont - August 15 - December 30

Soil Amendments

Follow soil tests or apply 2,000 lb/acre ground agricultural limestone and 1,000 lb/acre 10-10-10 fertilizer.

Mulch

Apply 4,000 lb/acre straw. Anchor straw by tacking with asphalt, netting, or a mulch anchoring tool. A disk with blades set nearly straight can be used as a mulch anchoring tool.

Maintenance

Repair and refertilize damaged areas immediately. Top dress with 50 lb/acre of nitrogen in March. If it is necessary to extend temporary cover beyond June 15, overseed with 50 lb/acre Kobe (Piedmont and Coastal Plain or Korean (Mountains) lespedeza in late February or early March.

B. Permanent Seeding

Areas to be stabilized with permanent vegetation must be seeded or planted within 30 working days or 120 calendar days after final grade is reached, unless temporary stabilization is applied.

Areas designated for permanent seeding shall be grassed as described below:

Seeding Mixture	Rate (lb/acre)
Tall Fescue	100
Sericea Lespedeza	30
Kobe Lespedeza	10

Seeding Notes:

1. In Eastern Piedmont, add 25 lb/acre Pensacola Bahiagrass or 10 lb/acre common Bermudagrass.
2. After August 15, use unscarified sericea seed.
3. Where a neat appearance is desired, omit sericea and substitute 40 lb/acre Bahiagrass or 15 lb/acre Bermudagrass.
4. To extend spring seeding dates into June, add 15 lb/acre hulled Bermudagrass. However, it is preferable to seed temporary cover and seed fescue in September.

Nurse Plants

Between May 1 and August 15, add 10 lb/acre German millet or 15 lb/acre Sudangrass. Prior to May 1 or after August 15, add 40 lb/acre rye (grain).

Seeding Dates	Best	Possible
Fall:	Aug. 25 - Sept. 15	Aug. 20 - Oct. 15
Late Winter:	Feb. 15 - March 21	Feb. 1 - April 15

Fall is best for tall fescue and late winter for lespedezas. Overseeding of Kobe lespedeza over fall-seeded fescue is very effective. Use unhulled Bermudagrass seed in fall.

Soil Amendments

Apply lime and fertilizer according to soil tests, or apply 4,000 lb/acre ground agricultural limestone and 1,000 lb/acre 10-10-10 fertilizer.

Mulch

Apply 4,000-5,000 lb/acre grain straw, or equivalent cover of another suitable mulching material. Anchor mulch by tacking with asphalt, roving, or netting. Netting is the preferred anchoring method on steep slopes.

Maintenance

Refertilize in the second year, unless growth is fully adequate. May be mowed once or twice a year, but mowing is not necessary. Reseed, fertilize, and mulch damaged areas immediately.

4.04 Watering: After seeding, water shall be applied until an adequate soil moisture content has been reached. Watering shall be continued daily as long as necessary to promote a rapid growth of grass.

4.05 Coverage: The coverage required of grassing shall be at least 90% with no bare areas larger than one square foot.

SECTION NO. 5

STORM DRAINAGE

5.01 Scope: Construction of storm sewers and other drainage related appurtenances, including all labor, equipment, and material required to excavate trenches, place pipe and appurtenances, place compacted backfill and pavement.

5.02 Materials: All materials shall conform to the standards included in the North Carolina Department of Transportation Standard Specifications, latest edition, Division 3, Pipe Culverts. Any pipe not meeting these specifications will be rejected and the Contractor shall be required to replace any pipe not meeting these specifications at no additional cost to the Owner.

5.03 Installation: Drainage structures shall be installed in accordance with the Specifications and in conformance with the details as shown on the Plans. Installation of the pipe will be in conformance with Section 300 of the North Carolina D.O.T. Standard Specifications.

5.04 Class II Bedding:

A. Scope: Provide and place Class II bedding as defined in ASTM D2321 where directed by the Engineer to provide a stable subgrade for pipe installation.

B. Material: Submit suppliers name, address, telephone number and gradation for Engineer's approval of aggregate proposed to be used for Class II bedding.

C. Placement: The Contractor shall be responsible for the proper placement and compaction of the bedding. Class II bedding shall be used only in areas where groundwater is encountered. The bedding shall be installed to a depth to insure proper stabilization of the subgrade. Any bedding improperly placed or compacted will be at the expense of the Contractor and no expense to the Owner.

SECTION NO. 6

CAST-IN-PLACE CONCRETE

6.01 General:

A. The General Conditions and Special Conditions of the Specification are incorporated herein. Also incorporated herein is ACI Standard 301-72, "Specifications for Structural Concrete for Buildings," and ACI Standard 318-63, "Building Code Requirements for Reinforced Concrete."

B. ACI Standard 301-72 mentioned above is incorporated in its entirety with modifications, exclusions, expansions, noted hereinafter. Items noted thus (*_____) refer to the indicated section of ACI Standard 301-72.

C. Copies of ACI Standard 301-72 are obtainable at a nominal cost from the American Concrete Institute, P.O. Box 4754, Redford Station, Detroit, Michigan 38219. A copy of this standard will be maintained in the Contractor's job site office at all times.

D. Shop Drawings: Submit in accordance with General Conditions; obtain final corrections and review prior to fabrication.

1. Reinforcing Steel: Show dimensions, schedule, bending details, bar lists, and placing plans. Shop drawings showing all dimensions necessary for fabrication and placing of the reinforcing steel and accessories, with out reference to the project drawings, shall be submitted for approval. Approval shall be obtained before fabrication.

2. Checking: The Contractor shall require that the material supplier submit a signed written statement, in conjunction with the shop drawing submittal, that the drawings have been checked for compliance with the contract requirements. Such checking shall include but not be limited to size, shape, length, quantity, and location. The checking shall have been performed by a person or persons regularly engaged in drawing checking, and shall not be the person or persons who prepare the drawings.

6.02 Admixtures: Air-entraining admixtures (ASTM C260-77) are required in all concrete unless noted. Calcium chloride admixture (ASTM D98-80) will not be permitted. Use of "Pozzolith" water-reducing admixture (manufactured by the Master Builders Company) will be required in all concrete used in the base slabs, interior division walls, and perimeter walls. (*2.2)

6.03 Type: Concrete shall be ultimate stress type.

6.04 Strength: All concrete shall develop 3000 psi compressive strength at 28 days. All concrete shall be of normal weight. (*3.2).

6.05 Durability: All concrete exposed to the weather shall contain an air-entraining agent for protection against potentially destructive exposure. (*3.4).

6.06 Slump: Concrete shall be vibrated and slump shall be in accord with Table 305(a) of ACI 301-66.

6.07 Proportioning of Ingredients: Mix designs shall be established by Method 2 or Alternate Procedure (d), but all 3000 psi concrete shall contain not less than 5.8 bags of cement per cubic yard of concrete except that the 3000 psi O" slump concrete shall contain not less than 4-3/4 nor more than 5-1/4 bags of cement per cubic yard of concrete, and not more than 7.5 gallons of water per bag of cement. (*3.8).

6.08 Formwork: Earth cuts may be used as forms for footings only where sides of cut will stand without danger or caving.

6.09 Removal Strength: Shoring shall be removed from formed slabs when concrete attains 75% of design strength, but not earlier than 7 days after placing. Testing of field cured cylinders is required to established strength for form removal. Cylinders shall be molded and tested as specified ASTM C31-69 (Reapproved 1980), ACI 301-72. Testing to determine field strength shall be made at no extra cost to the Owner.

6.10 Reinforcing Steel: All reinforcing steel shall be of 60,000 psi yield point strength. (*chapter 5). Welded wire mesh shall conform to ASTM A185-79.

6.11 Expansion Joints: Premolded expansion joint filler shall conform to ASTM D1751-73 (Reapproved 1978) (*6.2).

6.12 Cast In Anchors:

A. Dovetail Slots & Anchors: Provide anchors for each 8-inch (or fraction thereof) of masonry abutting concrete, at 16-inches o.c. vertical spacing. Slots shall be continuous. Slots shall be 16 gauge, galvanized, 1-inch wide back x 5/8 inch wide face x 1 inch deep (Hohmann & Barnard #305). Anchors shall be corrugated, galvanized, 1 inch wide x 5-1/2 inches long, 16 gauge, (Hohmann & Barnard #303).

6.13 Curing: Use of compounds as noted in (b) (5) is prohibited for curing. All curing shall be damp curing. Where floors are scheduled for cement finish, floors shall be treated, after final curing, with 3 full, even coats of Sonneborn Building Products, Inc.'s Lapidolith Liquid Floor Hardener, Euclid Chemical Company's Euco Liquid Floor Hardener, or A.C. Horn Products' Hornolith. (*Chapter 12).

6.14 Testing:

A. The Engineer will select a recognized commercial testing laboratory.

B. The following functions shall be performed by personnel who have been qualified by the North Carolina Qualification Committee for Field Test of Concrete, and shall be provided by the Contractor at no extra cost to the Owner.

1. Sampling of fresh concrete and making compression test specimens. Specimens shall be tested by the selected laboratory and the cost thereof shall be the responsibility of the contractor.

2. Performing tests for slump, air content, and unit weight of concrete required by the Project Specifications.

3. Protecting and initially curing test specimens for the first 24 hours after sampling.

4. Transporting or preparing and shipping test specimens to designated laboratory.

5. Completing Field Test Data sheet for each set of concrete test specimens and transmitting same to designated laboratory. Data sheets shall include slump, air content and unit weight, and the name and qualification number of the person responsible for their preparation.

C. In addition to the number of cylinders required by ACI Standard 301-72, the Contractor shall mold and the laboratory will test one extra cylinder at 7 days, which will be solely for advance information (*Chapter 16).

6.15 Mill Test Reports: Mill test reports on cement and reinforcing steel shall be furnished by the Contractor (*16.7.4.4).

SECTION NO. 7

CONCRETE REINFORCEMENT

7.01 Shop Drawings

A. Five (5) copies of the shop drawings for the fabrication and placing of reinforcing steel shall be submitted to the Engineer for approval, after being checked and approved by the Contractor and before proceeding.

B. Placing plans shall show dimensions, details, notes, location, size, length and each bar mark together with the accessories belonging to the reinforcing for the concrete.

C. Schedules shall show all information and be of the same general form as those on the Contract Documents.

D. Concrete wall reinforcing shall be shown in elevation.

E. Detail all reinforcing steel in accordance with the Manual of Standard Practice for detailing Reinforced Concrete Structures ACI 315-80 unless otherwise indicated on the drawings.

7.02 Material

A. Reinforcement shall be fabricated from ASTM A615-79 and Supplement S1 Deformed Billet Steel Bars for Concrete Reinforcement of the grades indicated on the drawings.

B. Welded smooth wire fabric (W) shall conform to "Specifications for Welded Steel Wire Fabric for Concrete Reinforcement" ASTM 185-73 and shall be fabricated from plain wire conforming to "Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement" ASTM A82-76.

C. Welded deformed wire fabric (D) shall conform to "Specifications for Welded Deformed Steel Wire Fabric for Concrete Reinforcement" ASTM A497-72 and shall be fabricated from deformed wire conforming to "Specifications for Deformed Steel Wire for Concrete Reinforcement" ASTM A496-72.

D. Wire bar supports shall conform to the National Bureau of Standards PS7-66, "Wire Bar Supports for Reinforced Concrete Construction."

E. Precast concrete block bar supports shall be Precast Concrete Doweled Blocks or Precast Concrete Blocks with wires as indicated in the Manual of Standard Practice CRSI 23rd Edition, 1980.

F. Bar supports shall be as follows:

1. On Ground: Precast Concrete Block Supports or Class "A" Bright Basic Bar Supports with earth-bearing bases (sand plates) of 20 gauge metal;

2. Interior: Class "B" Pregalvanized Bar Supports or Class "E" Special Stainless Supports;

3. Exterior: Class "D" Hot Dipped Galvanized Bar Supports conforming to Table I, ASTM A153-73 or Class "E" Special Stainless Bar Supports; and,

4. Tie wire shall not be less than 16 gauge black annealed wire.

7.03 Fabrication

A. All hooks shall be bent using the pin diameters and dimensions as defined as "ACI Standard Hooks" in the Manual of Standard Practice CRSI 23rd Edition, 1980, unless otherwise shown on the drawings.

B. Reinforcing bars shall not be bent or straightened in a manner that will injure the materials.

C. Reinforcing bars shall conform to the dimensions shown on the plans and within the fabrication tolerances as shown in the Manual of Standard Practice CRSI 23rd Edition, 1980.

7.04 Placing Reinforcement

A. Reinforcement shall be placed in designated positions in the forms and held in place, before and during the placing of concrete by means of bar supports, to carry the reinforcing bars they support within the following tolerances from the positions shown on the drawings or specified herein:

1. For clear concrete protection and for depth "d" inflexural member, walls, and compression members where "d" is:

8 inches or less ..... ±1/4 inch
More than 8 inches but
less than 24 inches ..... ±1/2 inch
24 inches or more ..... ±1.0 inch

but the cover shall not be reduced by more than one half of the specified cover.

2. For longitudinal location of bends and ends of bars:

   ±2 inches except at discontinuous ends of members where tolerance shall be ±1/2 inch.

3. For spacing:

   ±2 inches except that total number of bars shall not be reduced.

B. Except as shown otherwise on structural drawings, concrete cover for reinforcing bars shall be as follows:

1. Cast against and permanently exposed to earth ..... 3 inches

2. Exposed to earth and weather..... 2 inches

3. Interior formed surfaces:

   Piers and Columns ..... 2 inches
   Beams ..... 1-1/2 inches
   Walls ..... 1 inch
   Slabs ..... 3/4 inch

C. Vertical bars in piers and columns shall be offset one bar diameter at lapped splices. Furnish templates for setting dowels.

D. Bars which are straight except for hooks are listed in schedules as straight bars. Lengths shown are for straight segments, not hooks.

E. "Continuous" bars unless indicated otherwise on the drawings shall be lapped 30 diameters at splices. Provide corner bars at corner conditions.

F. Splices not shown in Contract Documents shall be subject to approval.

G. Lap welded wire fabric not less than the spacing of the cross wires plus 2 inches and wire together at splices.

H. Support all reinforcing bars. Space bar supports a maximum of 4 feet on center with the first support not greater than 2 feet from the end of bars. Tie to prevent displacement during concreting operations.

I. Reinforcement shall not be "field" bent after being embedded in hardened concrete except where specifically shown on the drawings.

SECTION NO. 8

MEMBRANE LINER SYSTEM

8.01 Material Type: A synthetic liner system shall be used for leachate containment in the solid waste cells and leachate pond. The material shall have physical properties to resist leachate chemical components, and provide strength for puncture resistance and imposed load durability.

8.02 Installation Methods:

A. Bottoms and Slopes:

1. Intersections between planes shall be along straight lines.

2. Radius of intersection between planes shall be 1/2 foot or more.

3. Bottoms and side slopes shall conform to the grading planes.

4. Corners of basins with sloped sides shall be sectors of cones.

5. Bottom elevations shown on the plans are the top of the synthetic liner elevations.

B. Subbase Preparation: Bottom Grades shown on page 3 of 17 of the plans represent the top of the composite liner as detailed on sheet 11 of 17 in the Plans. Construction will begin by excavating and/or filling existing grade with native soil in a particular cell/trench to an elevation 36 inches below the elevation of the top of the synthetic liner. The fill/cut areas below the composite liner will be called the "sub-base". All excess excavated material shall be stockpiled as shown on the Plans or as directed by the Owner's Engineer. All material stockpiled shall be spread to a uniform appearance with side slopes no greater than 2'H to 1'V. Stockpile soil shall not be placed within 25 feet of any excavated trench wall. The subbase will be constructed according to Section 2 of the Specifications.

C. Base Preparation: The base, which will be placed directly above the subbase will consist of one foot of clean compacted native soil. The base shall be free of rocks, roots, stumps, and other debris. If any portion of the base is disturbed by rain, wind, or weather, steps shall be taken as necessary to restore the surface prior to the installation of the composite liner. At a minimum, the following construction specifications shall be adhered to:

- Placement of the base materials shall be made in multiple lifts not to exceed 6 inches per lift.

- Each lift shall be compacted to a minimum of 95% as determined by the Standard Proctor Test, ASTM-D698.

- Testing for the base material shall be as follows:

-Borrow source testing:

Test	Method	Frequency
Grain Size	ASTM D422	1,000 yd^3
Moisture Content	ASTM D2216	1,000 yd^3
Atterberg Limits	ASTM D4318	5,000 yd^3
Moisture-density	ASTM D 698	5,000 yd^3 Curve and All Changes in Material
Lab permeability (remolded samples)	US Army Corps EM 1110-2-1902	10,000 yd^3

-Base testing during construction:

Test	Method	Frequency
Density	ASTM D2922 or D2937 or D2167	10,000 ft^2/lift
Moisture Content	ASTM D2216	10,000 ft^2/lift
Undisturbed Permeability	US Army Corps EM 1110-2-1902	40,000 ft^2/lift
Moisture Content (UD sample)	ASTM D2216	40,000 ft^2/lift
Atterberg Limits	ASTM D4318	40,000 ft^2/lift
Grain Size	ASTM D422	40,000 ft^2/lift

D. Clay Liner Installation: The clay liner beneath the synthetic HDPE liner shall be a combination of native soils and Volclay as manufactured by American Colloid Company (See Appendix C). These soils shall be tested to insure that their permeabilities are 1 x 10^{-7} cm/sec or lower.

The clay liner shall be as a minimum twenty-four (24) inches in thickness and shall be placed directly above the base layer. The contractor shall construct a test strip to determine the required admixture of Volclay to native soils, the proper number of passes needed with a roller to achieve compaction and permeability, etc. At a minimum, the following construction specifications shall be adhered to:

- Placement of the liner materials shall be made in multiple lifts not to exceed 6 inches per lift.

- Each lift shall be compacted to a minimum of 95% as determined by the Standard Proctor Test, ASTM-D698.

- The finished layer shall be kept moist and shall not under any circumstances be allowed to dry prior to placement of the HDPE liner.

- A vertical hydraulic conductivity value of 1×10^{-7} cm/sec or lower shall be maintained for all clay liner materials.

- The top of the clay shall be rolled with a steel wheel roller to assure a smooth, even surface for the HDPE liner installation. If any portion of the clay liner is disturbed by weather or other causes, steps shall be taken as necessary to restore the surface prior to the installation of the remaining HDPE liner.

- Written reports and records of the testing shall be submitted to the Engineer. The Contractor shall receive written approval from the Engineer prior to installing the HDPE liner.

E. <u>Geomembrane Placement:</u>

1. <u>Materials:</u> The synthetic liner shall consist of high density polyethylene (HDPE). The clay liner shall be overlain with a 60 mil HDPE liner. A smooth 60 mil liner may be used on the bottom area of the balefill, while a texture 60 mil liner will be required on the sideslopes of the balefill. The HDPE liner shall conform to, or exceed the requirements of the National Sanitation Foundation Standard Number 54(NSF-54). The textured liner shall have physical properties that are equal that of the smooth liner. Exhibit IV-1 shows the NSF-54 requirements for HDPE.

2. Field Panel Identification: A field panel is the unit area of geomembrane which is to be seamed in the field, i.e., a field panel is a roll or a factory panel or a portion of roll or factory panel cut in the field. Two cases can be considered:

   - If the geomembrane is fabricated into panels in a factory panel cut in the field.
   - If the geomembrane is not fabricated into factory panels, a field panel is a roll or a portion of roll cut in the field.

   It shall be the responsibility of the Contractor to ensure that each field panel is given an "identification code" (number or letter-number) consistent with the layout plan. This field panel identification code shall be as simple and logical as possible.

   The Contractor shall establish a table or chart showing correspondence between roll numbers, factory panels, and field panel identification codes. The field panel identification code shall be used for all quality assurance records.

3. Field Panel Placement:

   a. Location: The Contractor shall verify that field panels are installed at the location indicated in the layout plan, as approved or modified.

   b. Installation Schedule: Field panels may be installed using any one of the following schedules:

      - All field panels are placed prior to field seaming (in order to protect the subgrade from erosion by rain);
      - Field panels are placed one at a time and each field panel is seamed immediately after its placement (in order to minimize the number of unseamed field panels exposed to wind); and
      - Any combination of the above.

      If all field panels are placed prior to field seaming, begin in the sump area and proceed upward and outward with "shingle" overlaps to facilitate drainage in the event of precipitation. Also proceed in the direction of prevailing winds. The Contractor is fully responsible for placement procedures.

The Engineer shall evaluate every change in the schedule proposed by the Contractor and advise him on the acceptability of the change in writing. The Contractor shall verify that the condition of the supporting soil has not changed detrimentally during installation.

The Contractor shall record the identification code, location, and date of installation of each field panel.

c. Weather Conditions: Geomembrane placement shall not proceed at an ambient temperature below 5°C (40°F). Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, dew), in an area of ponded water, or in the presence of excessive winds.

The Contractor shall verify that the above conditions are fulfilled.

The Contractor shall inform the Engineer if the above conditions are not fulfilled.

d. Method of Placement: The Contractor shall verify the following:

- Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons or other means.

- The prepared surface underlying the geomembrane has not deteriorated since previous acceptance, and is still acceptable immediately prior to geomembrane placement.

- All personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities which could damage the geomembrane.

- No track vehicles will be allowed on top of the liner. Only articulating wheeled vehicles will be allowed in placement of the liner.

- The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.

- The method used to place the panels minimizes wrinkles (especially differen-

- Adequate temporary loading and/or anchoring (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, continuous loading, e.g., by adjacent sand bags, is recommended along edges of panels to minimize risk of wind flow under the panels).

- Direct contact with the geomembrane is minimized; i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected.

The Contractor shall inform the Engineer if the above conditions are not fulfilled.

e. Damage: The Engineer shall inspect each panel, after placement and prior to seaming, for damage. The Engineer shall advise the Contractor which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels which have been rejected shall be marked and their removal from the work area recorded by the Engineer. Repairs shall be made according to procedures described in Section 8.03.B.2.d.(12).

8.03 A. Material Specifications: The liner system shall comprise of 12 inches of recompacted base consisting of native materials. The base will be overlain with 24 inches of earthen material mixed with Volcaly (clay liner) providing a tested permeability of no more than 1×10^{-7} cm/sec. The clay liner shall be overlain with a 60 mil high density polyethylene (HDPE) liner. The HDPE liner shall conform to or exceed the requirements of the National Sanitation Foundation Standard No. 54 (NSF-54). The textured liner must also meet or exceed these same material properties. The subgrade (beneath membrane and clay liners) shall be constructed according to Section No. 2.

B. Geomembrane Manufacture, Fabrication and Delivery:

Described in this section are the specifications, and quality control for the geomembrane manufacture fabrication and delivery.

1. Manufacturing

a. Raw Material: The raw material shall be first quality polyethylene resin containing no more than 2% clean recycled polymer by weight, and meeting the following specifications:

Specific Gravity (ASTM D792 Method A or ASTM D1505): $\geq$ 0.935
Melt Index (ASTM D1238 Condition 190/2.16):
0.1 - 0.3 g/10 min (for HDPE geomembranes)
0.1 - 1.1 g/10 min (for all PE geomembranes including HDPE and LLDPE)

Conformance testing shall be carried out by the Manufacturer to demonstrate that the product meets this specification. It is the Contractor's responsibility to insure that the manufacturer performs the conformance testing. At the Owner's discretion, additional testing may be carried out for purposes of conformance by the Owner's Laboratory, and paid for by the Owner. If the results of the Manufacturer's and the Owner's Laboratory's testing differ, the testing shall be repeated by the Owner's Laboratory and the Manufacturer shall be allowed to monitor this testing. The results of this latter series of tests will prevail, provided that the applicable test methods have been followed.

Prior to the installation of any geomembrane material, the Contractor shall provide the Engineer and the Owner with the following information:

- the origin (Resin Supplier's name and resin production plant), identification (brand name, number) and production date of the resin;
- a copy of the quality control certificates issued by the Resin Supplier;
- reports on the tests conducted by the Manufacturer to verify the quality of the resin used to manufacture the geomembrane rolls assigned to the considered facility [these tests should, at the least, include specific gravity (ASTM D792 Method A or ASTM D1505) and melt index (ASTM D1238 Condition 190/2.16)]; and
- a statement that no reclaimed polymer is added to the resin (however, the use of polymer recycled during the manufacturing process may be permitted if done with appropriate cleanliness and if recycled polymer does not exceed 2% by weight).

The Engineer shall review these documents and shall report any discrepancies with the above requirements to the Owner.

b. <u>Geomembrane Manufacturing:</u>

The Contractor shall provide the Engineer with the following:

- a properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the specifications, or equivalent;
- a list of quantities and descriptions of materials other than the base polymer which comprise the geomembrane;
- the sampling procedure and results of testing; and
- a certification that property values given in the properties sheet are guaranteed by the Geomembrane Manufacturer.

c. <u>Rolls:</u> Prior to shipment, the Contractor shall provide the Engineer with a quality control certificate for each roll of geomembrane provided.

The quality control certificate shall be signed by a responsible party employed by the Geomembrane Manufacturer, such as the production manager. The quality control certificate shall include:

- roll numbers and identification; and
- sampling procedures and results of quality control tests - as a minimum, results shall be given for thickness, tensile strength, and tear resistance, evaluated in accordance with the methods indicated in the specifications or equivalent methods approved by the Engineer. No rolls shall be accepted for the work without predelivered quality control certificates.

2. Factory Panel Fabrication:

a. Definition of a Factory Panel: A factory panel is a combination of rolls seamed together by the Manufacturer.

b. Field Seaming:

Seam Layout: The Contractor shall provide the Engineer with a seam layout drawing, i.e., a drawing of the facility to be lined showing all expected seams. The Engineer shall review the seam layout drawing and verify that it is consistent with accepted state of practice. No panels not specifically shown on the seam layout drawing may be used without the Engineer's prior approval.

In general, seams should be oriented parallel to the line of maximum slope, i.e., oriented along, not across, the slope. In corners and odd-shaped geometric locations, the number of seams should be minimized. No horizontal seam should be less than 1.5 mm (5 ft.) from the toe of the slope, or areas of potential stress concentrations.

A seam numbering system compatible with the panel numbering system shall be shown on the layout drawing.

c. Requirements of Personnel: All personnel performing seaming operations shall be qualified by experience or by successfully passing seaming tests similar to those described in Section 8.03, B.2.d.(6).

At least one seamer shall have experience seaming a minimum of 100,000 m^2 (1,000,000 ft^2) of polyethylene geomembrane using the same type of seaming apparatus to be used to fabricate the site-specific geomembrane. The most experienced seaming, the "master seamer", shall provide direct supervision over less experienced seamers.

The Contractor shall provide the Engineer and with a list of proposed seaming personnel and their experience records. This document shall be reviewed by the Engineer.

d. Seaming Equipment and Products: Approved seaming processes for fabrication are extrusion welding and fusion welding. Proposed alternate processes shall be documented and submitted to the Engineer for approval. Only apparatus which have been specifically approved by make and model shall be used.

The Engineer shall approve all seaming processes and apparatus.

(1) Extrusion Process: The extrusion-welding apparatus shall be equipped with gauges giving the extradite temperature in the apparatus and at the nozzle.

The Contractor shall provide documentation regarding the extradite to the Engineer and shall certify that the extradite is compatible with the specifications, and in any event is comprised of the same resins as the geomembrane sheeting.

Prior to the installation of any geomembrane material, the Contractor shall submit quality control records, including apparatus temperatures, extradite temperatures, and ambient temperatures to the Engineer. The Engineer and the shall review these data and verify their acceptability.

(2) Fusion Process: The fusion-welding apparatus must be automated vehicular-mounted devices. The fusion-welding apparatus shall be equipped with gauges giving the applicable temperatures and pressures.

Prior to the installation of any geomembrane material, the Contractor shall submit seaming quality control records, including ambient temperatures and applicable apparatus temperatures and pressures, to the Engineer. The Engineer shall review these data and verify their acceptability.

(3) Seam Preparation: The Contractor shall:

- Prior to seaming, clean the seam area of moisture, dust, dirt, debris of any kind, and foreign material.
- If seam overlap grinding is required, complete the process according to the Geomembrane Manufacturer's instructions within one hour of the seaming operation in a way that does not damage the geomembrane.
- Align seams are with the fewest possible number of wrinkles and "fishmouths".

(4) Weather Conditions for Seaming: The required weather conditions for seaming are as follows:

- No seaming shall be attempted at an ambient temperature below 5°C (40°F) or above 40°C (104°F).
- Between ambient temperatures of 5°C (40°F)and 10°C (50°F), seaming is allowed if the geomembrane is preheated by either sun or hot air device, and if there is no cooling resulting from wind.
- Above an ambient temperature of 10°C (50°F), no preheating is required.
- In all cases, the geomembrane shall be dry and protected from wind.

The Contractor shall verify that these weather conditions are fulfilled and will advise the Engineer if they are not. The Engineer shall then decide if the installation shall be stopped or postponed.

(5) Overlapping and Temporary Bonding: The Contractor shall:

- Overlap the panels of geomembrane a minimum of 75 mm (3 in.) for extrusion welding and 125 mm (5 in.) for fusion welding, but in any event provide sufficient overlap to allow peel tests to be performed on the seam.

- Insure that the procedure used to temporarily bond adjacent panels together does not damage the geomembrane; in particular, the temperature of hot air at the nozzle of any spot welding apparatus is controlled such that the geomembrane is not damaged.

The Contractor shall log all appropriate temperatures and conditions, and shall log and report to the Engineer any non-compliances.

(6) Trial Seams: Trial seams shall be made on fragment pieces of geomembrane liner to verify that seaming conditions are adequate. Such trial seams shall be made at the beginning of each seaming period, and at least once each four hours, for each seaming apparatus used that day. Also, each seamer shall make at least one trial seam each day. Trial seams shall be made under the same conditions as fabrication seams.

The trial seam sample shall be at least 0.6m (2 ft.) long by 0.3 m (1 ft.) wide (after seaming) with the seam centered lengthwise. Finished seam overlaps shall be 3 inches (75mm) for extrusion welding and 5 inches (125 mm) for fusion welding. Two adjoining specimens, each 25 mm (1in.) wide, shall be cut from the trial seam sample by the Fabricator. The specimens shall be tested at the factory respectively in shear and peel and should not fail in the seam.

If a specimen fails, the entire operation shall be repeated.

If the additional specimen fails, the seaming apparatus or seamer shall not be accepted and shall not be used for fabrication seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved.

After completion of the above described tests, the remaining portion of the trial seam sample can be discarded.

(7) General Seaming Procedure: Unless otherwise specified, the general seaming procedure used by the Fabricator shall be as follows:

- For fusion welding, a movable protective layer of plastic may be required to be placed directly below each overlap of geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded, especially if fabrication is done outdoors.

- If required, a firm substrate shall be provided by using a flat board, a conveyor belt, or similar hard surface directly under the seam overlap to achieve proper support.

- Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkle in order to achieve a flat overlap.

  The cut fishmouths or wrinkles shall be seamed and any portion where the overlap is inadequate shall then be patched with an oval or round patch of the same geomembrane extending a minimum of 150 mm (6 in.) beyond the cut in all directions.

(8) Nondestructive Seam Continuity Testing:

(a) Concept: The Fabricator shall nondestructively test all factory seams over their full length using a vacuum test unit, air pressure test (for double fusion seams only), or other approved method. Vacuum testing and air pressure testing are described in Section 8.03,B.2.d.(8)(b) and B.2. d.(8).(c) respectively.

The purpose of the nondestructive test is to check the continuity of seams. It does not provide any information on seam strength. Continuity testing shall be carried out as the seaming work progresses, not at the completion of all factory seaming.

Tests shall be fully documented by the Fabricator, and a copy of the documentation shall be forwarded to the Engineer by the Contractor.

Any seams which fail nondestructive testing shall be repaired in accordance with Section 8.03, B.2.d.(10). Repairs shall be fully documented by the Contractor and the Fabricator shall submit such documents to the Engineer.

Notwithstanding the nondestructive testing program required of the Fabricator, the Owner reserves the right to have partial or full time third party Construction Quality Control and/or Construction Quality Assurance. These services will be paid for by the Owner, and decisions from those parties regarding repair or remedial measures will be binding.

All repairs will be carried out at the Fabricator's expense.

(b) Vacuum Testing: The equipment shall be comprised of the following:

- a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft neoprene gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge;

- a steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections;

- a rubber pressure/vacuum hose with fittings and connections;
- an approved applicator;
- a soapy solution.

The following procedures shall be followed:

- energize the vacuum pump and reduce the tank pressure to approximately 35 kPa (5 psi) (10 in. of Hg) gauge;
- wet a strip of geomembrane approximately 0.3 m by 1.2 m (12 in by 48 in) with the soapy solution;
- place the box over the wetted area;
- close the bleed valve and open the vacuum valve;
- ensure that a leak tight seal is created;
- for a period of not less than 30 seconds, examine the geomembrane through the viewing window for the presence of soap bubbles;
- if no bubble appears after 30 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 75 mm (3 in.) overlap, and repeat the process;
- all areas where soap bubbles appear shall be marked and repaired in accordance with Section 8.03, B.2.d. (10).

(c) <u>Air Pressure Testing (For Double Fusion Seam Only):</u> The following procedures are applicable to those processes which produce a double seam with an enclosed space.

The equipment shall be comprised of the following:

- an air pump (manual or motor driven) equipped with pressure gauge capable of generating and sustaining a pressure between 160 and 200 kPa (25 and 30 psi);
- a rubber hose with fittings and connections;
- a sharp hollow needle, or other approved pressure feed device.

The following procedures shall be followed:

- seal both ends of the seam to be tested;
- insert needle or other approved pressure feed device into the tunnel created by the fusion weld;
- energize the air pump to a pressure between 160 and 200 kPa (25 and 30 psi), close valve, and sustain pressure for approximately 5 minutes;
- if loss of pressure exceeds 15 kPa (2 psi), or does not stabilize,locate faulty area and repair in accordance with Section 8.02, B.2.c. (7);
- remove needle or other approved pressure feed device and seal.

(9) Destructive Seam Strength Testing:

(a) Concept: Destructive seam tests shall be performed at selected locations.

The purpose of these tests is to evaluate seam strength. Seam strength testing shall be done as the seaming work progresses, not at the completion of fabrication seaming.

(b) Location and Frequency:
Those locations shall be established as follows:

- A minimum frequency of one sample per 150 m (500 ft.) of seam length (this minimum frequency is to be determined as an average taken from all the panels), and a minimum average of one sample per factory panel, whichever gives the largest number of samples.

- The samples shall be taken, if possible, from extra material at the beginning or end of factory panel seams such that the factory panel is not damaged and the factory panel geometry is not altered.

(c) Sampling Procedure: Samples shall be cut by the Fabricator as the seaming progresses in order to have laboratory test results before completion of factory panel fabrication. The Fabricator shall assign a number to each sample, mark it accordingly, and record sample location on the layout drawings.

All holes, if any, in the geomembrane resulting from destructive seam sampling shall be immediately repaired in accordance with repair procedures described in Section 8.03,B.2.d. (10). The continuity of the new seams in the repaired area shall be tested according to Section 8.03, B.2.d. (8).

(d) Size of Samples: The samples shall be 0.3 m (12 in.) wide by 1.1 m (44 in.) long with the seam centered lengthwise. One 25 mm (1 in.) wide strip shall be cut from each end of the sample and these shall be tested at the fabrication factory. The remaining sample shall be cut into three parts and distributed as follows:

- one portion to the Fabricator for laboratory testing, 0.3 m x 0.3 m (12 in. x 12 in.);

- one portion to the Owner for archive storage, 0.3 m x 0.3 m (12 in. x 12 in.); and

- one portion shall be retained by the Owner for possible future testing.

(e) Field Testing: The two 25 mm (1 in.) wide strips mentioned in the section above shall be tested in the field, by hand or tensiometer, for peel and shear respectively and shall not fail in the seam. Also, the shear and peel strength shall be at least 90% and 60%, respect-ively, of the typical minimum average yield strength of the parent material. If any field test samples fails to pass, then the procedures outlined in Section 8.03.B.2.d.(9) shall be followed.

The Engineer shall witness all field tests and mark all samples and portions with their number. The Engineer shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressure, and pass or fail description, and attach a copy to each sample portion.

(f) Quality Assurance Laboratory Testing: Destructive test samples shall be packaged and shipped, if necessary, under the responsibility of the Contractor in a manner which will not damage the test sample. The Contractor will verify that packaging and shipping conditions are acceptable. The Engineer will be responsible for storing the archive samples. Test samples shall be tested by the Geosynthetic Construction Quality Assurance Laboratory. The Contractor shall pay all costs involved in destructive test at the QA Laboratory. The Geosynthetic Construction Quality Assurance Laboratory shall be selected by the Contractor and approved in writing by Engineer.

Testing shall include "Seam Strength" [ASTM D638 with type M-1 specimen 10 mm (0.5 in.) wide tested at 50 mm (2 in.) per minute] and "Peel Adhesion" (ASTM D413 as modified in NSF Appendix A). These terms are defined in the specifications. The minimum acceptable values to be obtained in these tests are those indicated in Table 8-1, and the specifications. At least 5 specimens shall be tested for each test method. Specimens shall be selected alternately by test from the samples (i.e., peel, shear, peel, shear..).

The Geosynthetic Construction Quality Assurance Laboratory shall provide test results no more than 48 hours after they receive the samples.

The Engineer shall review laboratory test results as soon as they become available, and make appropriate recommendations to the Contractor. Should field tensiometer testing be carried out, the following procedure should be followed: if the test passes, the sample qualifies for testing in the laboratory; if it fails, the seam should be repaired in accordance with Section 8.03.B.2.d.(12).

(g) Testing at the Fabrication Factory: The two 25 mm (1 in.) wide strips mentioned in Section 8.03, B.2.d. (12) shall be tested at the fabrication factory by hand or tensiometer, for peel and shear respectively, and shall not fail in the seam. If any test sample fails to pass, then the procedures outlined in Section 8.03,B,2.d. (10) shall be followed.

The Fabricator shall mark all samples and portions with their number.

The Fabricator shall also log the date and time, ambient temperature, number of seaming unit, name of seamer, welding apparatus temperatures and pressures, and pass or fail description, and attach a copy to each sample portion.

(h) Fabricator's Laboratory Testing: If no full time Construction Quality Assurance is provided, destructive tests similar to those described in Section 8.03 B. 2.d. (9) shall be conducted by the Fabricator's laboratory.

In any case, the Fabricator's laboratory test results shall be presented to the Engineer for comments.

TABLE 5. MATERIAL PROPERTIES

HIGH DENSITY POLYETHYLENE (HDPE)

Property	Test Method	Unsupported(U) 30	36	40	50	60	80	100
Gauge (nominal)	—	30	36	40	50	60	80	100
Thickness, mils minimum ±10%	ASTM D1593 Para 8.1.3	27	32	36	45	54	72	90
Specific Gravity (minimum)	ASTM D792 Method A	0.940	0.940	0.940	0.940	0.940	0.940	0.940
Minimum Tensile Properties (each direction)	ASTM D638							
1. Tensile Strength Yield (lb/in width)		50	60	70	90	120	140	180
2. Tensile Strength at Break (lb/in width)		90	108	120	150	180	240	300
3. Elongation at Yield (percent)		10	10	10	10	10	10	10
4. Elongation at Break (percent)		500	500	500	500	500	500	500
5. Modulus of Elasticity (lbs/sq in)		80,000	80,000	80,000	80,000	80,000	80,000	80,000
Tear Resistance (lb, minimum)	ASTM D1004 Die C	15	18	20	25	30	40	50
Low Temperature, °F	ASTM D746 Procedure B	-40	-40	-40	-40	-40	-40	-40
Dimensional Stability (each direction, percent change maximum)	ASTM D1204 212°F, 15 min.	±3	±3	±3	±3	±3	±3	±3
Resistance to Soil Burial (percent change maximum in original value)	ASTM D3083 (as modified in Appendix A)							
1. Tensile Strength Yield		10	10	10	10	10	10	10
2. Tensile Strength at Break		10	10	10	10	10	10	10
3. Elongation at Yield		10	10	10	10	10	10	10
4. Elongation at Break		10	10	10	10	10	10	10
5. Modulus of Elasticity		10	10	10	10	10	10	10
Environmental Stress Crack (minimum, hours)	ASTM D1693 (as modified in Appendix A)	500	500	500	500	500	500	500
		Factory and Field Seam Requirements[1]						
Bonded Seam Strength (factory seam, breaking factor, ppi width)	ASTM D3083 (as modified in Appendix A)	45	54	63	81	108	108	135
Peel Adhesion (lb/in minimum)	ASTM D413 (as modified in Appendix A)	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB
Dead Load								
Room Temperature 73°F 50% Bonded Seam Load	See Appendix A	Pass	Pass	Pass	Pass	Pass	Pass	Pas
Elevated Temperature 158°F 25% Bonded Seam Load	See Appendix A	Pass	Pass	Pass	Pass	Pass	Pass	Pas
Resistance to Soil Burial	ASTM D3083 (as modified in Appendix A)							
Peel Adhesion		FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB[2]	FTB
Bonded Seam Strength (percent change maximum in original value)		-10	-10	-10	-10	-10	-20	-20

[1]Factory bonded seam strength is the responsibility of the fabricator. Factory seams are further idscussed in Item 4.2.

[2]FTB - Film Tear Bond

This table provides a reliable and dependable means for industry to furnish such materials of known and consistent quality. Before selection of any material for an FML, however, the user should consult with appropriate manufacturers, because these materials may not be appropriate for every application. Specific information should be obtained from the manufacturer regarding installation requirements, exposure conditions, performance expectations, and experience factor.

(i) Procedures for Destructive Test Failure: The following procedures shall apply whenever a sample fails a destructive test, whether that test conducted by the Fabricator's laboratory, or by tensiometer. The Fabricator has two options:

- the seam is entirely reconstructed and retested by both nondestructive and destructive methods; or
- the panel is rejected.

The Fabricator shall document all actions taken in conjunction with destructive test failures.

(10) Repairs: All repairs shall be conducted in accordance with Section 8.03,B.2.d.(10). Each patch or other type of repair shall be numbered and logged by the Fabricator.

All repairs shall be subjected to the non-destructive seaming testing procedure described in Section 8.03, B.2.d.(8).

All repair documentation shall be provided by the Contractor to the Engineer.

(11) Factory Panel Certification: Prior to shipment of the factory panels to the site, the Fabricator and/or Contractor shall provide the Engineer with a quality control certificate for each shift's production of factory panels. The quality control certificate shall be signed by a responsible party employed by the Fabricator, such as the production manager. The quality control certificate should include:

- factory panels numbers and identification;
- results of quality control tests including sampling procedures;
- documentation of repairs and non-destructive testing of the repairs; and

- in the event of seaming below 5°C (40°F), an addendum specifically stating that the low temperature seaming procedure does not cause any physical or chemical modification to the geomembrane that will generate any short or long term damage to the geomembrane.

- review packaging and transportation procedures to verify that these procedures are not damaging the geomembrane;

- verify that the panel packages have a label indicating name of Fabricator, type of geomembrane, dimension and panel number; and

- verify that extrusion rods and/or beads are derived from the same base resin type as the geomembrane.

(12) Defects and Repairs:

a. Identification: All seams and non-seam areas of the geomembrane shall be examined by the Engineer and the Contractor for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter. Because light reflected by the geomembrane helps to detect defects, the surface of the geomembrane shall be clean at the time of examination. The geomembrane surface shall be broomed or washed by the Contractor if the amount of dust or mud inhibits examination.

b. Evaluation: Each suspect location both in seam and non-seam areas shall be non-destructively tested using the methods described in Section 8.03.B.2.d.(8).(c) as appropriate. Each location which fails the non-destructive testing shall be marked by the Engineer and repaired by the Contractor. Work shall not proceed with any materials which will cover locations which have been repaired until laboratory test results with passing values are available.

c. Repair Procedures: Any portion of the geomembrane exhibiting a flaw, or failing a destructive or nondestructive test, shall be repaired. Several procedures exist for the repair of these areas. The final decision as to the appropriate repair procedure shall be agreed upon between the Contractor and Engineer. The procedures available include:

- Patching, used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter;
- Grinding and rewelding, used to repair small sections of extruded seams;
- Spot welding or seaming, used to repair small tears, pinholes, or other minor localized flaws;
- Capping, used to repair large lengths of failed seams;
- Topping, used to repair areas of inadequate seams, which have an exposed edge;
- Removing bad seam and replacing with a strip of new material welded into place (used with large lengths of fusion seams).

In addition, the following provisions shall be satisfied:

- Surfaces of the geomembrane which are to be repaired shall be roughened no more than one hour prior to the repair;
- All surfaces must be clean and dry at the time of the repair;
- All seaming equipment used in repairing procedures must be approved by the Engineer;

- The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the Engineer and Contractor;

- Patches or caps shall extend at least 150 mm (6 in.) beyond the edge of the defect, and all corners of patches shall be rounded with a radius of at least 75 mm (3 in.); and
- The geomembrane below large caps shall be appropriately cut to avoid water or gas collection between the two sheets.

d. Verification of Repairs: Each repair shall be numbered and logged. Each repair shall be non-destructively tested using the methods described in Section 8.03.B.2.d.(8)(c). as appropriate. Repairs which pass the non-destructive test shall be taken as an indication of an adequate repair. Large caps may be of sufficient extent to require destructive test sampling, at the discretion of the Engineer. Failed tests indicate that the repair shall be redone and retested until a passing test results. The Engineer shall observe all non-destructive testing of repairs and shall record the number of each repair, date, and test outcome.

e. Large Wrinkles: When seaming of the geomembrane liner is completed (or when seaming of a large area of the geomembrane liner is completed) and prior to placing overlying materials, the Engineer shall observe the geomembrane wrinkles. The Engineer shall indicate to the Contractor which wrinkles should be cut and reseamed. The seam thus produced shall be tested like any other seam.

f. Bridging: Bridging of the HDPE liner is not acceptable. Determinations of bridging shall be made during the coolest part of the

(13) Backfilling of Anchor Trench: The anchor trench shall be adequately drained, to prevent ponding or otherwise softening of the adjacent soils while the trench is open. The anchor trench shall be backfilled and compacted by the Contractor as outlined in the specifications and Construction Drawings. Care shall be taken when backfilling the trenches to prevent any damage to the membrane.

The Engineer shall observe the backfilling operation and advise the Contractor of any problems.

(14) Lining System Acceptance: The Contractor and the Manufacturer shall retain all ownership and responsibility for the geomembrane in the lining system until acceptance by the Owner.

The geomembrane lining system shall be accepted by the Owner when:

- The installation is finished;
- Verification of the adequacy of all seams and repairs, including associated testing, is complete;
- All documentation of installation is completed including the Engineer's final report; and
- The Contractor provides the Owner with "as built" drawings of the panel layout, panel numbers and seam numbers.

The Contractor shall certify that installation has proceeded in accordance with the Specifications and Contract Documents for this project except as noted to the Engineer.

SECTION NO. 9

LEACHATE COLLECTION SYSTEM

9.01 General: This Section shall govern the materials and installation of the leachate collection system. This system consist of the leachate underdrain and the protective sand layer.

9.02 Construction Materials:

A. Leachate Collection Pipe: The perforated HDPE pipe shall conform to the specifications of Section 10. These pipes shall be six (6) inch diameter pipes with 3/8 inch perforations as shown on the plans.

B. Stone Filter: The stone filter shall be smooth, well rounded, washed river gravel that meets the gradation specifications for #57 stone.

C. Geotextile Fabric Wrap: This geotextile shall be a 6.0 oz. non-woven filter fabric such as Trevira Type 1120 or an approved equal.

D. Protective Drainage Layer: The drainage layer is granular material placed on top of the liner to allow leachate to drain to the leachate collection pipes located within the drainage layer. A 50' swath of Fine Silica Sand shall be placed along the centerline of each trench (i.e. centerline of leachate collection pipe). The sand shall be wrapped along the bottom and sides with Trevira No. 1120 Geotextile Fabric or equal, leaving the top exposed. The depth of the sand is 2'. Outside the plan view limits of sand, the drainage layer may be a "finer granular material", as specified below:

1. Slope Stability--The material must have a slope stability factor of safety of at least 3 under the following conditions; saturated, uncompacted, resting on HDPE textured sheet at a slope of 3:1, material thickness of 2'.

2. Permeability--The compacted permeability must be greater than 10^{-5} cm/sec.

3. Acceptance--The material must be acceptable to the Engineer, Owner, and the North Carolina Department of Environment, Health and Natural Resources for its intended application.

E. 1. Ballast Material--The ballast material in the leachate pond shall be concrete slabs which are 5' in diameter and 8" thick. A sheet of Trevira Type 1145 or approved equal shall be placed between the slab and liner to protect the liner.

2. Placement--The drainage layer is to be placed in 6" lifts to a depth of 2' with the first layer left uncompacted to preclude damage to the HDPE liner. Subsequent 6" lifts are to be compacted to a stable condition.

3. Access--Only articulating rubber tired equipment is to be used in placing the drainage material. Smooth stell wheel roller may be used for compaction. Tracked vehicles, tamping foot, and grid type rollers are prohibited.

4. Protection--The Contractor shall protect newly graded/compacted areas from traffic and erosion. Keep free of trash and debris.

5. Maintenance--The Contractor shall repair and reestablish grades in settled eroded and rutted areas to specify tolerances.

6. Areas--The Contractor shall, where completed compacted areas are disturbed by subsequent construction operations or adverse weather, reshape, and compact to required density prior to further construction.

9.03 Installation:

A. Collection Pipes: The leachate collection pipes shall be installed according to the specifications of Section 10.04. The perforated pipe shall be placed so that the perforations are positioned as shown in the detail.

B. Extra Liner Strip: A strip of 60 mil HDPE liner shall be installed beneath the leachate underdrain. This liner shall be a minimum of eleven (11) feet wide for the entire length of the underdrain. The liner shall be installed and tested according to the specifications in Section 8.

C. Stone Filter: The stone filter material shall be installed in such a manner that minimizes damage to the collection pipe and geomembrane liner. The stone shall be placed as shown in detail drawings.

D. Geotextile Fabric Wrap: The stone filter shall be completely wrapped with the geotextile. This material shall be overlapped to insure that the sand does not enter the stone filter. The fabric shall be placed in such a manner that minimizes damage to the geotextile.

E. Protective Sand Layer: The Contractor shall verify that sand and ballast soil placement are consistent with the state of the art such as:

1. Placement of soils on the geomembrane shall not proceed at an ambient temperature below 5°C (40°F) nor above 40°C (104°F).

2. Placement of soils on the geomembrane shall be done in a manner that minimizes wrinkles in the liner. If large wrinkles are formed, the Contractor shall cut and reseam the wrinkled area.

3. Equipment used for placing soil shall not be driven directly on the geomembrane.

4. A minimum thickness of 2.0-2.5' of soil is required between rubber-tired vehicles and the geomembrane.

5. In heavily trafficked areas such as access ramps, soil thickness shall be at least 0.9 m (3 ft.).

The Contractor shall:

1. Measure soil thickness and verify that the required thicknesses are maintained.

2. Verify that final thicknesses are consistent with design.

3. Verify that placement of soil was done in such a manner that geomembrane damage is unlikely.

The Contractor shall inform the Engineer if the above conditions are not fulfilled.

F. Leachate Cleanouts: A leachate cleanout assembly shall be provided as shown on the plans. This shall include a concrete pad and a PVC end cap for the collection pipe. Also, a 4"x4" marker shall be provided as shown on the detail drawing.

SECTION NO. 10

POLYETHYLENE LEACHATE PIPE

10.01 Description: This specification shall govern the materials and installation of polyethylene gravity leachate mains.

10.02 Materials:

A. Pipe and Fittings: The pipe supplied under this specification shall be high performance, high molecular weight, high density polyethylene pipe equal to Driscopipe 1000 as manufactured by Phillips Driscopipe, Inc., Dallas, Texas and shall conform to ASTM D 1248 (Type III, Class C, Category 5, P34). Minimum cell classification values shall be 345434C as referenced in ASTM D 3350 - 1981a. The fittings supplied under this specification shall be molded from a polyethylene compound having a cell classification equal to or exceeding the compound used in the pipe or shall be manufactured using a polyethylene compound having a cell classification equal to or exceeding the cell classification of the pipe supplied under this specification shall be of the same manufacture as the pipe being supplied.

B. Physical Properties of Pipe Compound:

1. Density: The density shall be no less than 0.941-0.955 gms/cm^3 as referenced in ASTM D1505.

2. Melt Flow: Melt Flow shall be no greater than 0.4 gms/10 min. when tested in accordance with ASTM D 1238 - Condition E.

3. Flex Modulus: Flexural Modulus shall be 110,000 to less than 180,000 psi as referenced in ASTM D 790.

4. Tensile Strength at Yield: Tensile strength shall be 3,000 to less than 3,500 psi as referenced in ASTM D 638.

5. ESCR: Environmental Stress Crack Resistance shall be in excess of 1,000 hours with zero failures when tested in accordance with ASTM D 1693 - Condition C.

6. Hydrostatic Design Basis shall be 1,600 psi as 23°C when tested in accordance with ASTM D 2837.

C. Rejection: Polyethylene pipe and fittings may be rejected for failure to meet any of the requirements of this specifications.

10.03 Pipe Dimensions: Pipe supplied under this specification shall have a nominal IPS (Iron Pipe Size) OD unless otherwise specified. The SDR (Standard Dimension Ratio) of the pipe supplied shall be as specified in the Construction Drawings.

10.04 Construction Practices:

A. Handling of Pipe: Pipe shall be stored on clean, level ground to prevent undue scratching or gouging of the pipe. If the pipe must be stacked for storage, such stacking should be done in accordance with the pipe manufacturer's recommendations. The handling of the pipe should be done in such a manner that it is not damaged by dragging over sharp objects or cut by chokers or lifting equipment.

B. Repair of Damaged Sections: Segments of pipe having cuts or gouges in excess of 10% of the wall thickness of the pipe should be cut out and removed. The undamaged portions of the pipe shall be rejoined using the butt fusion joining method.

C. Pipe Joining: Sections of polyethylene pipe should be joined into continuous lengths on the job site above ground. The joining method shall be the butt fusion method and shall be performed in strict accordance with the pipe manufacturer's recommendations. The butt fusion equipment used in the joining procedures should be capable of meeting all conditions recommended by the pipe manufacturer, including, but not limited to, temperature requirements, alignment, and fusion pressures.

D. Handling of Fused Pipe: Fused segments of pipe shall be handled so as to avoid damage to the pipe. When lifting fused sections of pipe, chains or cable type chokers shall be prohibited. Nylon slings are required. Spreader bars shall be used when lifting long fused sections. Care shall be exercised to avoid cutting or gouging the pipe.

E. Testing for Non-Perforated HDPE Pipe: When a length of pipe approved by the Engineer is ready for testing, the following procedures shall be used.

1. Preparation: Provide a test pump, an accurate meter, and all other accessories required to make the test. Provide and remove all temporary bulkheads, plugs, and flanges required to perform the pressure test.

2. Test Pressure and Leakage: Test the pipe line at ±15 psi. Sustain the pressure for 2 hours. The pressure shall not drop by more than 2 psi during this period.

   If leaks are detected, locate, repair, and retest. If results are not totally satisfactory, the Engineer may require testing for a longer period of time.

10.05 Trenching and Backfill:

A. Trench Construction: The trench and trench bottom shall be constructed in accordance with ASTM D 2321 - Section 7.

B. Embedment Material: Embedment materials shall be Class I materials as defined by ASTM D 2321 - Section 6. The use of Class II, Class III, Class IV and Class V materials for embedment is prohibited.

C. Bedding: Bedding of the pipe shall be performed in accordance with ASTM D 2321 - Section 8. Compaction rates shall be as specified in ASTM D 2321.

D. Haunching and Initial Backfill: Haunching and initial backfill shall be as specified in ASTM D 2321 - Section 9 using Class I, Class II, or Class III materials. Materials used and compaction rates shall be as specified.

E. Special Conditions: ASTM D 2321 - Section 11.2, Minimum Cover for Load Application, Section 11.3, Use of Compaction Equipment, and Section 11.4, Removal of Trench Protection apply.

SECTION NO. 11

LEACHATE MANHOLES

11.01 Description: This item shall govern the construction of manholes complete and in place, including the furnishings, adjustment to grade, installation of manhole frames and covers, and installation of all HDPE pipe fittings within the manhole.

11.02 Materials:

A. Cast Iron: Cast iron for manhole frames, covers and steps shall conform to the shape and dimensions shown on the detailed drawings and shall be clean and perfect, free from sand and blow holes or other defects. Cast Iron shall conform to ASTM Designation A-48 for Class No. 20 gray cast iron.

B. Leachate Pipe and Fittings: All leachate pipe and fittings shall meet the requirements as specified in Polyethylene Gravity Leachate Mains, Paragraph B, Materials of Section 10.02.

C. Mortar: All cement used in mortar shall conform to ASTM Designation C-150, and the latest revision thereof. All mortar used shall be composed of one part Portland Cement and two parts of fine sand.

D. Concrete: Concrete shall be Class "A" and shall conform to the applicable provisions of ASTM Designation C-150, C-175, C-33 (Aggregates). Class "A" concrete shall have a minimum 28 day compressive strength of 3000 psi.

E. HDPE Manhole: Polyethylene manholes shall be produced using polyethylene compounds conforming to the requirements of Type III, Category "3", Class B, as defined and described in ASTM D-1248. Clean reworked materials or reprocessed material may be used in the manufacture provided that the manhole components meet all the requirements of the product specification.

11.03 Construction Methods:

A. Manholes shall be constructed at the locations shown on the plans. Manholes shall be to the depth shown on the plans. Details of manholes are shown on the plans and construction shall be in accordance with these details.

B. Where polyethylene pipes enter and exit a manhole, the hole shall be sealed with grout and a neoprene rubber boot.

C. After the manhole construction has been completed to the proper elevation, the cast iron manhole frame shall be set in a full bed of mortar and adjusted to the elevation established by the Plans.

D. Backfilling around manholes shall be in accordance with the applicable provisions for backfilling trenches specified in Section 2.09.

E. HDPE Manhole: See manufacturer's guidelines for installation.

11.04 Precast Sewer Manholes: The Contractor shall furnish and install precast reinforced concrete manholes which shall meet all requirements of ASTM Designation C478 (the latest version).

A. Types: Precast risers and grade rings shall be of one type and precast top sections shall be of "flat top" type.

B. Joints: The reinforced concrete manhole in riser sections, excepting grade rings, shall be formed with male and female ends with rubber gasket ring between the male and female end to reduce infiltration. These joints shall be preformed plastic gasket with primer to meet Federal Specification SS-S-00210, "Ram-Nek" or approved equal. Assemble according to manufacturer's recommendations.

C. Manhole Steps: Manhole steps shall conform to North Carolina D.O.T. Standard 840.66.

D. Finished Grade: Precast manholes shall be furnished and set with proper allowance for the cast iron frame and cover to be set at the correct finished grade.

E. Dimensions: All precast manholes shall be a standard 5'-0" inside diameter.

SECTION NO. 12

MEASUREMENT AND PAYMENT

12.01 Clearing and Grubbing:

A. Measurement: The area of completed and accepted clearing and grubbing will be measured in acres. Only the area actually cleared and grubbed, as described in Section 1.03.C. or as designated by the Engineer will be measured.

B. Payment: The items of this section will be paid for at the unit price bid per acre.

12.02 Earthwork:

A. Measurement: The unclassified excavation necessary for on site earthwork will be measured in cubic yards. The quantity shown in the proposal is estimated from an aerial photo using the average end area method. The actual volume excavated will be measured using initial and as-built topographic surveys. The average end area method will be used to compute these volumes. The excavation of topsoil shall be measured in cubic yards and include excavation, stockpiling, and respreading.

B. Payment: Unclassified excavation shall be paid for by unit price bid per cubic yard. Excavation of topsoil shall be paid for at the unit bid price per cubic yard. The measurement and payment for the 12" base above the subgrade in the lines areas shall be paid for as described in Section 14.08. Payment for placement of compacted crusher run shall be paid for at the unit price bid per linear foot.

12.03 Erosion and Sedimentation Control:

A. Measurement: The quantity of silt fence to be paid for shall be the actual number of linear feet of silt fence, measured in place from end post to end post, which has been completed and accepted. The quantity of rip-rap shall be the square yards of accepted material of the specified thickness.

B. Payment: Silt fence shall be paid for at the unit price bid per linear foot. Such payment shall include furnishing all materials, erecting and maintaining the silt fence. Rip-rap shall be paid for at the unit price bid per square foot. Such payment shall include stone rip-rap and filter fabric, complete and in place.

12.04 Grassing: Grassing shall be paid for by the unit price bid per acre. This shall include seeds, mulch, fertilizer and water needed to establish a permanent grass cover. Temporary grassing shall include seeds, mulch and water necessary to establish grass in areas not requiring a permanent cover.

12.05 Storm Drainage: Storm drain pipe shall be paid for by the unit price bid per linear foot. This shall include excavation, pipe, anti-seep collars (where required), Class II bedding (if required) and backfill in place. Sediment Pond overflow structure and trashguard shall be paid for at the price bid.

12.06 Cast-In-Place Concrete: The concrete used as ballast material for the outlet structure shall be paid for by the unit price bid per cubic yard. This shall include the concrete, reinforcement, testing and invert for the outlet structure in place and complete. The concrete headwall for the sediment pond outlet pipe shall be paid for by the unit price bid for the complete headwall structure as shown in the detail drawing, including forming, reinforcement, testing and other incidentals for a complete job.

12.07 Concrete Reinforcement No separate payment will be made for concrete reinforcement. All reinforcement used shall be included in the price for the item to which it pertains.

12.08 Membrane Liner System: The 12" base shall be paid for at the unit price bid per square foot. This shall include the placement and compaction of the base, in place, complete and accepted. The soil testing will be paid for by invoice to the Owner. The 60 mil HDPE liner shall be paid for at the unit price bid per square foot. This shall include complete installation and testing of the liner. The anchor trenches shall be paid for at the unit price bid per linear foot. This shall include excavation, liner placement and backfill.

Liner penetrations shall be paid for at the unit price bid per each.

12.09 Leachate Control and Management System: The leachate underdrain shall include installation of the extra liner strip, gravel filter, geotextile fabric and collection pipe complete and in place. The leachate cleanout shall include installation of the concrete pad, end cap and 4"x4" marker post. The sand shall be paid for by the cubic yard, in place and complete.

12.10 Polyethylene Leachate Pipe: This item shall include in place 8" non-perforated HDPE piping outside of the manholes. The unit bid price per liner foot shall include excavation, proper bedding, backfilling, joining and testing of the installed pipe.

The payment for the piping and fittings inside the manholes shall be included in the unit price bid per vertical foot for the manhole.

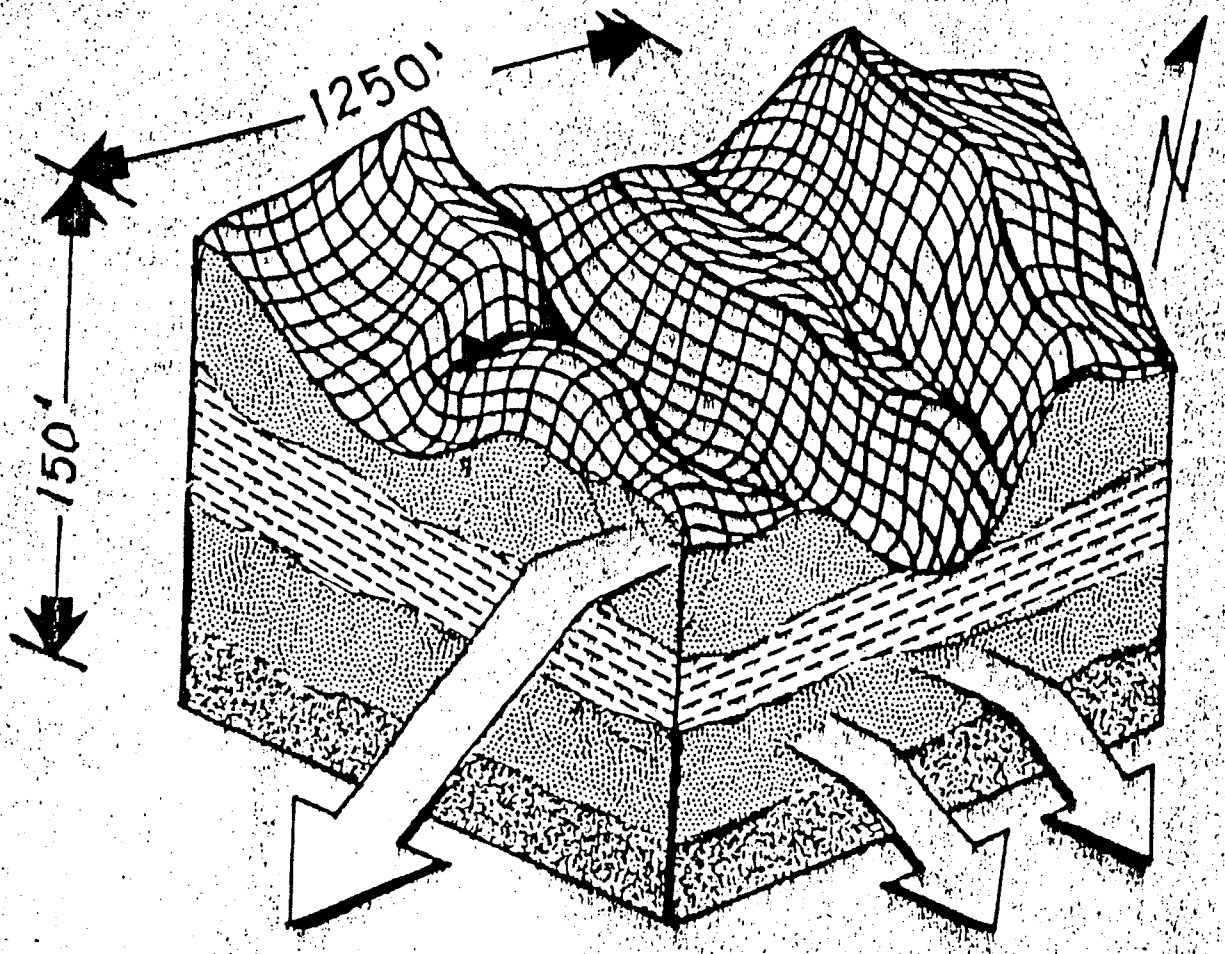
12.11 Leachate Manholes: This item shall be paid for at the unit price bid per vertical foot of concrete manhole. This shall include excavation, backfilling, manhole, gravel foundation, base, and all piping as shown in the detail drawings. The payment for the manhole frame and cover shall be the unit price bid per each..

12.12 Groundwater Monitoring Well Construction and Installation: Payment for monitoring well drilling, casing and screens shall be at the unit price bid per vertical foot. Monitoring well construction, development, and reporting shall be paid for at the unit price bid per each. Mobilization/Demobilization shall be paid for at the price bid.

12.13 Miscellaneous: Payment for sign, bench mark, silt gage, underdrain outlet marker, and surface water marker shall be at the unit price bid per each.

ATTACHMENT 2

NORTH CAROLINA WATER QUALITY MONITORING GUIDANCE DOCUMENT FOR SOLID WASTE FACILITIES



GROUND-WATER FLOW DIRECTION OF UPPER AQUIFER

GROUND-WATER FLOW DIRECTION OF LOWER AQUIFER

Prepared by the
Solid Waste Section
Solid Waste Management Division
Department of Environment, Health and Natural Resources

1987
SW-1001-87

NORTH CAROLINA WATER QUALITY
MONITORING GUIDANCE DOCUMENT FOR SOLID WASTE FACILITIES

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1987

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Michael L. Babuin, 1987

DEFINITIONS

Monitoring Well - any well constructed for the primary or incidental purpose of obtaining subsurface samples of water or other liquids. This definition excludes lysimeters, tensiometers, and other devices used to investigate the characteristics of the unsaturated zone.

Observation Well - any well constructed for the purpose of obtaining ground-water level information only

Permittee - an individual, corporation, company, association, partnership, unit of local government, State agency, Federal agency or other legal entity upon which a permit to operate a sanitary landfill has been issued.

Water Table - the upper limit of the portion of the ground wholly saturated with water.

GENERAL INTRODUCTION

The purpose of this report is to provide a simple, clear and thorough overview of acceptable methods regarding ground and surface water monitoring at solid waste facilities. The procedures and techniques outlined in this report have been compiled in response to the need for reliable, accurate and consistent data for ground-water and surface-water quality evaluation of sanitary landfills. The standardization of these methods of data collection will undoubtedly clarify proper ground-water monitoring techniques required by the State for all solid waste facilities, and subsequently, minimize much of the subjectivity associated with landfill evaluation. Clearly, it is in the best interests of each facility to utilize these guidelines whereas the probability of contamination is significantly reduced by following the steps outlined in this document.

INTRODUCTION

In order to fully acknowledge the scope and purpose of ground-water monitoring, it is of the utmost importance to fully understand and define the difference between a ground-water monitoring well and a public water supply well. This distinction is very obvious when comparing well construction techniques characteristic of various geologic formations throughout the State. For instance, the western part of North Carolina is dominated by a series of crystalline and metamorfic rocks. Subsequently, water supply wells in these regions typically are constructed by drilling through the saprolite (weathered rock) and into very hard, resistant rock bodies below the true water table. Because of the resistant lithologic character of these units, many well drillers feel that is is unnecessary to case a well characteristic of these type of conditions. This rationale may hold true for drinking water supply wells but is clearly unacceptable for ground-water monitoring purposes due to contamination problems associated with uncased or partially-cased holes and to possible logistic problems. For instance, monitoring equipment may become entangled on the bottom of a well casing which does not span the entire depth of the borehole. Subsequently, this office requires completely cased boreholes in all ground-water monitoring wells.

This office strongly urges all contractors and consultants to become familiar with well construction techniques and specifications illustrated on the ground-water monitoring well schematic (Figure 1). Further information regarding construction standards of other types of wells may be found in 15 NCAC 2C "Well Construction Standards: Criteria and Standards Applicable to Water Supply and Certain Other Types of Wells".

A. Specific Monitoring Well Construction Requirements

Because the location of ground-water monitoring wells at the proposed landfill is one of the most critical phases of site development, the importance of a thorough hydrogeologic evaluation which clearly delineates ground water elevation and flow characteristics is of the highest significance. In order to assure consistent and thorough installation techniques which are in accordance with EPA regulations, all deviations to the following methods, or questions regarding materials, monitoring well locations of other techniques, should be directed to the Solid Waste Hydrogeologist at (919) 733-0692, c.o the Solid Waste Management Division, P.O. Box 27687, Raleigh, North Carolina 27611. Additionally, the Solid Waste Management Division reserves the right to evaluate in the field, the actual well installation techniques and procedures.

Drilling through the unsaturated soil mantle to the water bearing formation is a standard procedure with most consulting and well-drilling firms. Utmost caution and discretion in minimizing the use of drilling fluids (bentonite-gel mixtures, flocculants (mixtures of sodium pyrophosphate) and excessive use of lubricants is highly recommended. If any of these products, or related products, are used in the drilling process the hole should be flushed to remove as much of the contaminants as possible.

Installation of the monitoring well and subsequent placement of the well screen is critical to assure that the ground water sample represents the

TYPICAL MONITORING WELL SCHEMATIC

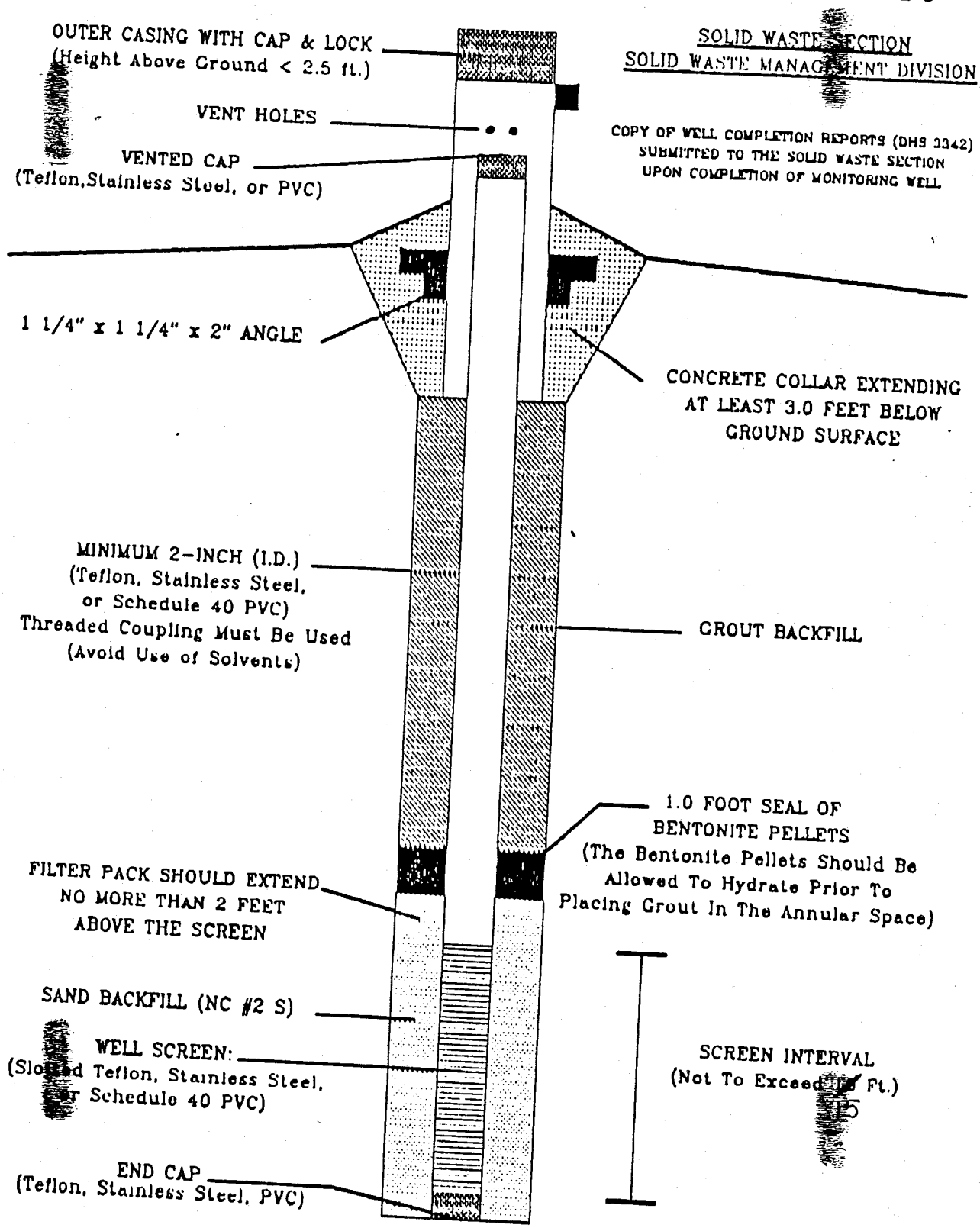


Figure 1

portion of the aquifer where contaminants may migrate. The maximum length of the screened interval is 15 feet and will be placed at a depth specified as a condition of the permit based upon hydrogeologic data collected during the site investigation. Recommended screen depths will be submitted by the applicant under the heading "proposed comprehensive ground-water monitoring plan" as part of the site plan application as per section .0504 (G)(iv). Well-sorted sand used as a pre-screening of influent ground water should be washed to remove all fines and prevent clogging of the well screen. Finally, in connecting sections of PVC pipe, clamps or threaded pipe fittings are required whereas various types of epoxy cement and other PVC glues have the potential for contaminating the ground-water reservoirs. For these reasons they are not authorized for construction of ground-water monitoring wells.

Various drilling methods and casing sizes are available for installation of monitoring wells. Generally, the most common size bore holes include those which are drilled with an eight inch hollow-stem auger. The casings which are placed in these holes are typically 4" or 2" I.D., and composed of PVC, stainless steel or teflon materials. For reasons which are discussed later under the "Ground-Water Monitoring" heading, this office recommends the use of 2" I.D. casings for wells drilled 100' or less. Ground-water monitoring wells drilled to depths exceeding 100' such as wells designed to monitor water quality through possible fracture patterns, should be cased with a 4" or 6" I.D. casing to readily promote rapid purging via jet pumps. Casings and screens may be composed of PVC or stainless steel. Teflon casings and screens are relatively maleable and may not hold-up under various conditions.

As mentioned above, this office recommends the installation of 2" I.D. cased wells for shallow and semi-shallow ground-water monitoring purposes. The use of 2" I.D. casings readily promotes rapid purging via teflon bailers. For example, a 2" I.D, cased well drilled 20 feet deep may contain up to approximately 3.3 gallons of standing water. Because three to five times the volume must be purged to avoid contamination (EPA, 1977), it is foreseeable that 9.9 to 16.5 gallons of water must be purged prior to sampling (Figure 2) in the above example. Assuming a purging minimum of 9.9 gallons of water, and also assuming that a 3' long bailer (which holds 1-liter of water) will be used for purging of the wells, it will take approximately 40 bails of water to adequately purge this well. Comparatively, a 4" I.D. cased well drilled to an extremely shallow depth of 16' will contain approximately 10.5 gallons of water, and subsequently, require between 31.5 and 52.5 gallons of purged water. Attempts to purge 52.5 gallons of water with a 1-liter bailer will require 210 bails of water-- which will undoubtly displease the field personnel and more importantly, occupy additional hours of expensive and needless labor as well.

An obvious difference shown on the schematic of a typical ground-water monitoring well (Figure 1), compared to other types of wells, is the concrete collar surrounding the stick-up (or outer casing) above the ground surface. This collar should contain small angle-irons attached to the outer casing as outlined on the diagram (Figure 1). The purpose of this set-up is to prevent accidental (or willfull) damage to the well whereas the stick-up could otherwise be pulled loose at the surface without the use of angle-irons to support the collar.

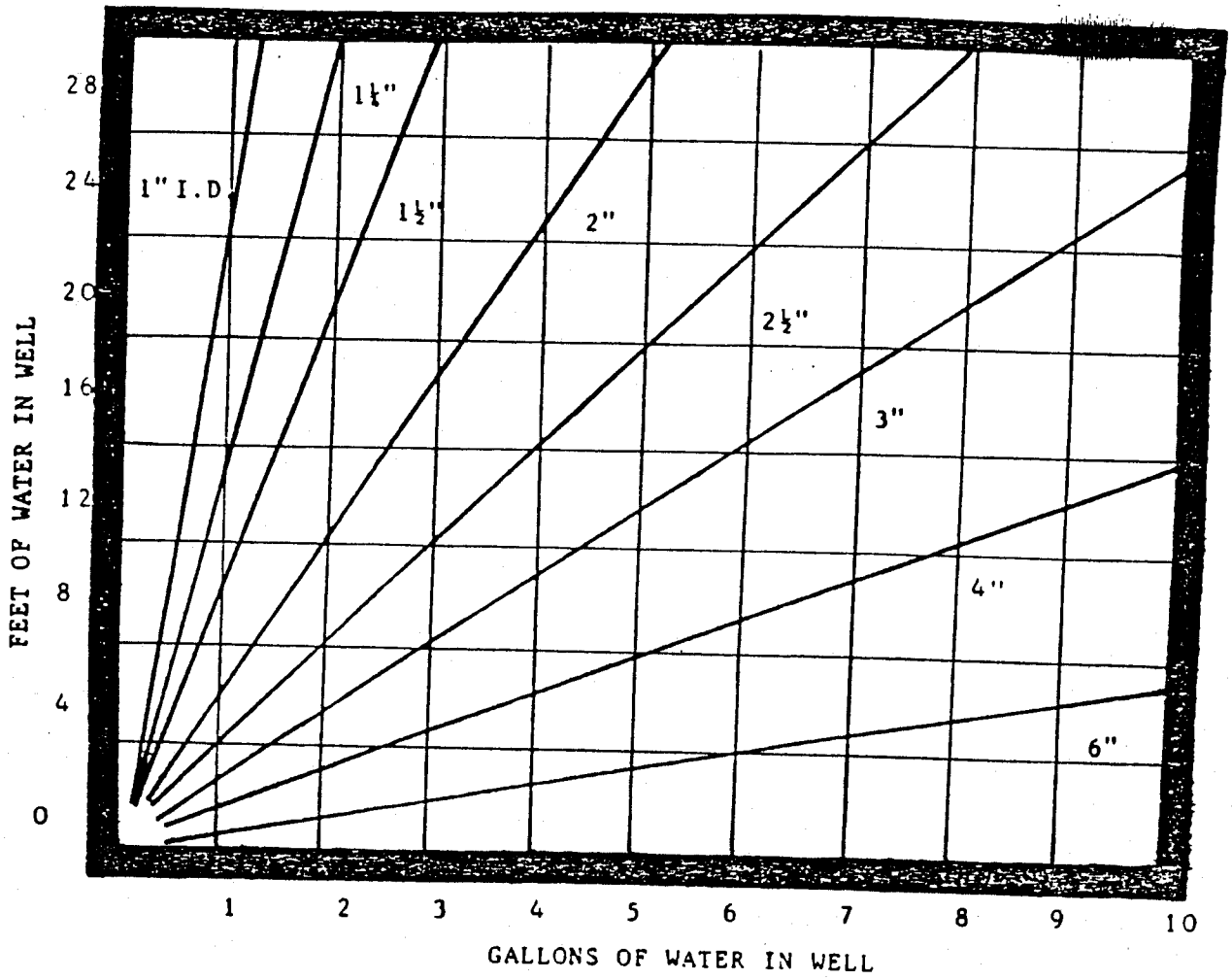


Figure 2. Graphical plot of standing volumes of water.

Because accidental or natural events may influence the status and condition of pre-existing ground-water monitoring wells, an on-going well inspection program is being conducted by personnel of the Solid and Hazardous Waste Management Branch. Some of the items which must be regularly maintained by the facility after the wells are installed include: 1) ensuring that all caps are rust-free and locked at all times, 2) ensuring that all inner casings are securely fit with a threaded cap, 3) ensuring that the outer casing is upright and undamaged from equipment or vehicles which may inadvertently back-up into the well, 4) ensuring that a clear unobstructed path, free from dense vegetation exists leading to each well. These maintenance factors are critical to the implementation of proper ground-water monitoring.

B. Ground-Water Monitoring

Because a tremendous liability is associated with water quality data obtained from analytical laboratory results, it is of the utmost importance to ensure the validity and integrity of sampling techniques and methodology. Two distinct monitoring systems exist which may be used to purge and subsequently sample a monitoring well. These systems include the portable monitoring system and the dedicated monitoring system.

Portable Monitoring

The portable monitoring system is by far the most common method of monitoring ground-water quality. This method includes purging the total standing water within the well and subsequent sampling of a representative portion of the aquifer. Purging is required in all instances in order to avoid sampling of stagnant, possibly stratified water above the well screen. In many cases, however, the recharge rate may meet or exceed the purging rate. For these instances three to five times the volume of standing water must be purged prior to sampling. Several methods exist for removing the standing water within a well. Among these methods are various types of automated pumps, compressed air, hand pumps and bailers, each of which has several advantages and disadvantages which will be discussed below.

In some instances dependant upon the hydrogeologic setting, the recharge rate may be exceptionally slow (EPA, 1977), subsequently, sampling may not be possible until the next day when the well is recharged. Generally however, all attempts should be made to purge the wells dry or purge until the necessary three to five times the well volume is extracted. In other settings where the soils are relatively permeable purging and subsequent sampling may be possible in the same day.

1. Purging Methods

Depending upon time constraints and spatial variability of the monitoring wells, the decision whether to purge and sample a facility on the same day must be made by the field personnel performing the monitoring operation. Additional concerns regarding the depth of the well, water volumes, well access and inclement weather are all important in determining which type of device to use in purging the well. For instance, if fully automated, effortless purging is desired and time is not a major concern, the use of an automated pump may be in order. The major disadvantage of

these pumps, however, include slow pumping rates (typically a maximum of 0.5 gallons/minute) and the potential for cross contamination from well to well.

The hand pump is another type of purging device which is available invarious lengths and pumping rates (typically 2.75 gallons/minute). This device has the advantage of easy assembly, low cost and relatively high pumping rates. An obvious disadvantage, however, is the need for a thorough cleaning in the field before purging from one well to the next.

Another popular purging device is the teflon bailer. Teflon is considered to be the preferred material to use for ground water monitoring because of its relatively inert chemical character. Stainless steel is also an acceptable purging/sampling mechanism for similar reasons. Regardless of the composition, bailers are available in various lengths, the most popular being the 3' bailer which holds a volume of water equal to 1 liter or 0.26 gallons.

2. Sampling Methods

Thus far the focus of this discussion has primarily been upon purging techniques, subseqently, a short discussion which addresses sampling procedures is now in order. The use of automated pumps for sampling purposes requires considerable effort to avoid contamination. Many automated pumps are designed to remain on the ground surface while a specified length of flexible tubing is placed into the well. For sampling purposes if this technique is to be used, it is mandatory that the flexible tubing be composed of teflon and adequately cleaned prior to sampling from one well to another. The inevitable question arises, however, whether or not adequate cleaning is possible in the field for these types of automated pumps.

Because laboratory analyses evaluate water quality in terms of parts per million and parts per billion, it is not recommended to clean and prepare sampling devices in the field when a laboratory cleaning will undoubtedly produce a higher quality final product. Other types of automated pumps (called bladder pumps) are designed to fit down the borehole and are typically composed of teflon and stainless steel. One inherent difficulty associated with some bladder pumps in addition to possible sample contamination problems is the inability of many bladder pumps to adequately control and regulate the rate at which the flow of water leaves the flexible tubing. This is critical for samples to be analyzed for volatile organic analysis (VOA) whereas a rapid flow rate will cause aeration which subsequently volatilizes certain chemicals. For these reasons this office urges that the utmost consideration and thought be given to the feasibility of whether or not to utilize traditional automated pumps for sampling purposes.

Hand pumps are useful tools for purging wells in a relatively short period of time but, unfortunately, are highly unsuitable for sampling. The main reason being the likelihood of contamination and the unavailability of teflon or stainless steel hand-pumps in the commercial market. Additionally, no present technology exists for regulating the effluent discharge of water from a hand pump which, as mentioned before, presents a volatilization problem for certain samples.

The overall preferred method of acquiring ground-water samples via portable monitoring is by the use of telfon bailers. In a properly established and equipped laboratory setting, a standardized cleaning and preparation procedure may be followed. The obvious advantage of laboratorycleaning includes minimal generation of contaminants and consistency in preparatory procedures.

Dedicated Monitoring

Thus far the previous discussions have all focused upon techniques and procedures related to portable ground-water monitoring systems. At this time, a short overview of dedicated systems is in order. Dedicated well monitoring differs from portable monitoring primarily by the permanency of the set-up and the higher initial cost. Because portable systems require the use of much of the same equipment from well to well, great care must be exercised in avoiding cross contamination. Dedicated systems, however, require no between-well cleaning procedures. These systems offer permanently affixed down-well and well-head components which are capped after initial set-up.

Because ground water is not in contact with incompatible constituents that otherwise may enter the well from the surface, virtually no contamination is possible from an extrinsic source during times between sampling intervals. As with all sampling methods the competency and integrety of the individual extracting the sample is of the utmost importance. For instance, a great deal of manual dexterity must be exercised in regulating the flow of water leaving the flexible tubing from dedicated systems when collecting VOA samples in order to avoid unnecessary volatilization. In conclusion, dedicated systems have the potential for accurate and reliable ground-water monitoring and are therefore recommended for consideration.

In contrast to this, many individuals are under the false impression that bailers which are initially cleaned in a laboratory and permanently placed in monitoring wells are considered dedicated systems and subsequently are acceptable for ground-water monitoring purposes. Unfortunately, this is not true due to the possibility of extrinsic contamination during sampling intervals, such as decomposition of the bailer line, airborne dirt and dust, or other accidentally induced contaminants. Because the detection limits for the various parameters are measured in terms of parts per million and parts per billion, the utmost discretion is required in selecting sampling procedures which will accomodate these analyses.

1. Equipment Cleaning Procedures

If automatic pumps and flexible tubing are used, a minimum field cleaning procedure will entail using a phosphate-free soap/deionized water solution followed by a deionized water rinse. This method constitutes an absolute minimum field cleaning procedure and should only be used for sampling one G.W. monitoring well. These pumps are not recommended or authorized for sampling more than one well due to probable contamination problems.

Stainless steel bailers require the following minimum cleaning techniques prior to groundwater sample collection:

1. Phosphate-free soap and tap water wash
2. Tap-water rinse
3. Deionized or distilled water rinse
4. Isopropyl alcohol rinse
5. Deionized or distilled water rinse
6. Air dry
7. Wrap bailer to prevent contamination before use (specify the material used for wrapping the bailer, example: aluminum foil shiny side out).

Teflon bailers require the following minimum cleaning techniques prior to ground water sample collection:

1. Phosphate-free soap and tap water wash
2. Tap water rinse
3. 10% nitric or 10% hydrochloric acid rinse
4. Deoinized or distilled water rinse
5. Isopropyl alcohol rinse
6. Deionized or distilled water rinse
7. Air dry
8. Wrap to prevent contamination before use (specify material used for wrapping for wrapping the bailer, example: aluminum foil, shiny side out).

The bailer line which attaches to the teflon or stainless steel bailers should consist of either 1) teflon coated wire, 2) single-strand stainless-steel wire, 3) other monofilament line or 4) nylon rope. In order to avoid contamination, a new segment of one of the above approved types of line should be used at each well. Reusing old line will increase the probability of cross contamination (even if the line is cleaned) and therefore is not approved. Any variation to the above cleaning procedures should be submitted to this office for approval.

Condition

The above cleaning procedures were obtained from EPA Region IV. If changes occur in any procedure specified above, the facility will be notified and be requested to make the necessary ammendments to the sampling and analysis plan.

Sample Containers

Because water samples are analyzed for various parameters, several types of containers are required for a complete sampling scheme. Routine groundwater monitoring should include (in the following order as extracted from the well): 1) VOA samples (for TOX analysis), and 2) heavy metal (inorganic) analysis. If additional analyses are required, the samples should be collected in the order listed below.

For instance, samples which are analyzed for volatile organic analysis (VOA) and/or total organic halogens (TOX) should be collected first in 40 ml glass vials with teflon caps. Two full vials per sample are required.

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

SAMPLE ANALYSES REQUEST

State Laboratory of Public Health
P. O. Box 28047
306 N. Wilmington Street
Raleigh, 27611

Site Number _____ Field Sample Number _____

Name of Site _____ Site Location _____

Collected By _____ ID# _____ Date Collected _____ Time _____

Type of Sample:

Environmental	Concentrate	Comments
____ Groundwater (1)	____ Solid (5)	_____
____ Surface Water (2)	____ Liquid (6)	_____
____ Soil (3)	____ Sludge (7)	_____
____ Other (4)	____ Other (8)	_____

INORGANIC CHEMISTRY

Extractables		Total			
Parameter	Results mg/l	Parameter	Results mg/l	Parameter	Results mg/l
____ Arsenic		____ Arsenic		____ Silver	
____ Barium		____ Barium		____ Sulfates	
____ Cadmium		____ Cadmium		____ Zinc	
____ Chromium		____ Chloride		____ Ph	
____ Lead		____ Chromium		____ Conductivity	
____ Mercury		____ Copper		____ TDS	
____ Selenium		____ Fluoride		____ TOC	
____ Silver		____ Iron		____ _____	
____ _____		____ Lead		____ _____	
____ _____		____ Manganese		____ _____	
____ _____		____ Mercury		____ _____	
____ _____		____ Nitrate		____ _____	
____ _____		____ Selenium		____ _____	

ORGANIC CHEMISTRY

Parameter	Results mg/l	Parameter	Results mg/l	Parameter	Results mg/l
____ P&T:GC/MS		____ EDB		____ Methoxychlor	
____ Acid:B/N Ext.		____ PCB's		____ Toxaphene	
____ TOX		____ Petroleum		____ 2,4-D	
____ _____		____ Endrin		____ 2,4,5-TP (silvex)	
____ _____		____ Lindane		____ _____	

MICROBIOLOGY

Parameter
____ (MF) Coliform Colonies/100mls
____ (MPN) Coliform Colonies/100mls
____ _____
____ _____

RADIOCHEMISTRY

Parameter	Results PCi/l
____ Gross Alpha	
____ Gross Beta	
____ _____	
____ _____	

Date Received _____ Date Reported _____

Date Extracted _____ Date Analyzed _____

Reported By _____ Lab Number _____

DHS 3191 (Revised 7/85)
Solid and Hazardous Waste (Review 7/87)

Figure 3. Laboratory analysis request sheet.

Chain of Custody Record

Solid & Hazardous Waste Materials

Location of Sampling: _____Generator _____Transporter _____Treatment Facility

_____Storage Facility _____Disposal Facility _____Landfill

_____Other:_____

Company's Name_____Telephone(_____)_____

Address_____

Collector's Name_____Telephone(_____)_____
signature

Date Sampled_____Time Sampled_____

Type of Process Generating Waste_____

Field Information

_____

_____

Field Sample No. _____ _____ _____ _____ _____ _____ _____

_____ _____ _____ _____ _____ _____ _____

Chain of Possession:

1. _____ _____ _____
signature title inclusive dates

2. _____ _____ _____
signature title inclusive dates

3. _____ _____ _____
signature title inclusive dates

Results reported

_____ _____ _____
signature title date

Instuctions: Complete all applicable information including signature, and submit with analysis request forms.

Figure 4. Chain of custody record.

Samples which will be analyzed for inorganic constituents such as heavy metals should be collected following the VOA Samples. These samples are collected in small, disposable, 1-quart/1-liter plastic cubes. Two full cubes per sample are required. Depending upon the source of the sample containers, particularly, containers which hold water to be analyzed for heavy metals, some containers may have a pre-measured amount of acid placed in the container to act as a preservative. In these instances do not rinse the sample container prior to use, if uncertain, consult the laboratory where the containers were purchased.

If organic contamination is suspected it may be necessary to undergo a complete organic analysis. In this event, samples which will be analyzed for organics such as an acid-base neutral analysis should be collected in one half gallon/2-liter glass jars with aluminum foil or teflon lined caps. Samples to be tested via acid-base neutral analysis require one full jar of water per sample.

Water samples to be analyzed for radiologic parameters should be collected following acid-base neutral collection. These samples must be collected in the large 1-gallon/4-liter plastic cubes.

Finally, samples which will be analyzed for bacteriological parameters should be collected last in 120ml plastic vials containing a pre-measured amount of sodium thyosulphate. One vial per sample is required to perform the analysis.

Transport and Storage of Samples

Upon completion of water samples collecting, all samples will be stored and subsequently transported on ice or in a refrigerated state to the laboratory performing the analyses (APHA, 1985; EPA 1977). The samples should be stored in such a manner as to inhibit breakage of accidental spills. Unless unusually extraordinary circumstances prevent otherwise, all samples should be delivered to the laboratory on the same day.

Administrative Procedures

Samples are to be delivered to a State Certified Drinking Water Laboratory and need to be accompanied by two administrative forms. The first form is a laboratory analysis request sheet (Figure 3). This form stipulates which constituents are to be analyzed for a given sample. The other form is a chain of custody record sheet (Figure 4). This form documents who handled the sample from collection time to lab delivery. These forms (or equivalents) will be submitted to the solid waste hydrogeologist within 15 days of receipt of the analytical results.

Per 10 NCAC 10 Section .0601 (a), routine ground-water monitoring shall be the responsibility of the permittee and may be State supervised at the discretion of the Solid Waste Management Division. Additionally, the State may request "split" or replicate samples from the facility during any of the routine sampling intervals.

Routine ground-water monitoring which encompasses the parameters listed below shall be conducted twice during the first year of operation (for newly-permitted sites) and annually thereafter. Newly-permitted facilities are required to properly install all proposed ground-water monitoring wells and subsequently notify the State within 30 days upon completion, so that the Solid Waste Section may schedule a date to observe the sampling of the wells. As mentioned above, all sampling is the responsibility of the facility. All pre-existing (permitted) facilities as of July 1, 1987 are responsible for annual ground-water monitoring activities, and shall forward a copy of the analytical laboratory results within 15 days upon receipt to the Solid Waste Hdyrogeologist, P.O. Box 27687, Raleigh, North Carolina 27611 c/o the Solid Waste Section.

All facilities (newly-permitted and pre-existing) shall send written notice by July 1, 1987 designating a tentative, annual sampling date for their facility. The purpose of which is to inform State personnel as to a specific date that they may expect the annual water quality results and to accommodate scheduling purposes by State personnel.

The following total inorganic parameters will be included for routine, annual ground-water quality analysis: arsenic, barium, cadmium, chloride, chromium, copper, fluoride, iron, lead, manganese, mercury, nitrate, selenium, silver, sulphates and zinc. The following indicators should be included in all routine, annual ground-water analysis: TOX (total organic halogens), TOC (total organic carbon, TDS (total dissolved solids), BOD (biological oxygen demand), COD (chemical oxygen demand), conductivity and PH. In the event that a contaminant plume is indicated by routine analysis of the monitoring wells, further analysis may be required to adequately assess contaminant migration and extent. Such analysis may include purge and trap analysis (utilizing the gas chromatograph and mass spectrometer) and acid base-neutral extraction. Finally, a broad level of consistency should be exercised in listing the various quantities of chemical constituents. For instance, units should be PPM (parts per million) or PPB (parts per billion) not both. It is suggested that parts per million (PPM) be used whenever possible.

C. Surface-Water Monitoring

Sites which contain and/or border small rivers, streams or branches should include within the site plan application, a prospective surface water monitoring plan. This plan will be used to gauge the effect of the landfill upon surficial flow at a given point. A simple procedure for selecting surface-water monitoring sites is to locate a point on the stream where drainage leaves the site. This promulgates detection of contamination through, and possibly downstream, of the site via discharge of surface waters. The sampling points selected should be downstream from any new, old or proposed areas which may be disturbed, including borrow and rubble areas (Babb and Glaser, 1985). An upstream surface water sample should be obtained in order to determine the water quality upstream of the influence of the sanitary landfill.

The following procedure is recommended regarding sample collection of surface water samples. Prior to collecting the sample in the appropriate

container, specific collection points should be determined. Generally, automated or semi-automated samplers or other manual devices accessible from the banks of a stream should be used whenever possible. If logistic or naturally occurring conditions inhibit this method of sample collection, the samples may be obtained manually by wading up-current (and down-stream) of the sample station. The sample should be collected in an area representative of minimal turbulence and aeration (Babb and Glaser, 1985). Because sample containers may be dipped by hand into the stream, extreme caution must be employed in avoiding contamination into the mouth of the container. The following procedures extracted from the "approved RCRA Ground-Water Sampling and Analysis Plan" (Babb and Glaser, 1985) are recommended for extraction and subsequent collection of surface water samples.

1. Hold the bottle near the base with one hand, and with the other, remove the cap.

2. Rinse the sample container with the water to be sampled prior to filling the container. One exception to this is the coliform sample bottle. This bottle may have a pre-measured amount of sodium thyosulphate to neutralize any chlorine present in the water, therefore, this container should not be rinsed prior to sampling.

3. Push the sample container rapidly into the water (mouth down) and tilt-up towards the current to fill. A depth of about six inches is satisfactory. Great care should be taken to avoid breaching the surface while filling the container.

4. During times of little current movement move the container slowly through the water laterally.

5. During times of extreme drought when stream depths are to shallow to allow submersion of the sample container, a pool may be scooped-out of the channel bottom and allowed to clear prior to sampling.

6. Lift the container from the water, and leave one-half inch of air space, and place the uncontaminated cap back-on the container.

7. Place the samples in styrofoam shipping cartons (on ice) for courier transport to the laboratory.

8. A completed Division of Health Services Form 2887 or equivalent (Figure 3) must be submitted along with the samples to the appropriate certified laboratory performing the analysis.

For additional details and further information on how to properly collect, store and transport stream samples, see N.R.C.D. draft on physical and chemical monitoring (in preparation).

D. Fractured Rock Monitoring

Many portions of Western and Central North Carolina are dominated by fractured cystalline rock. These fractures may be expressed on the surface, but more typically, are characteristic of subsurface environments. Areas

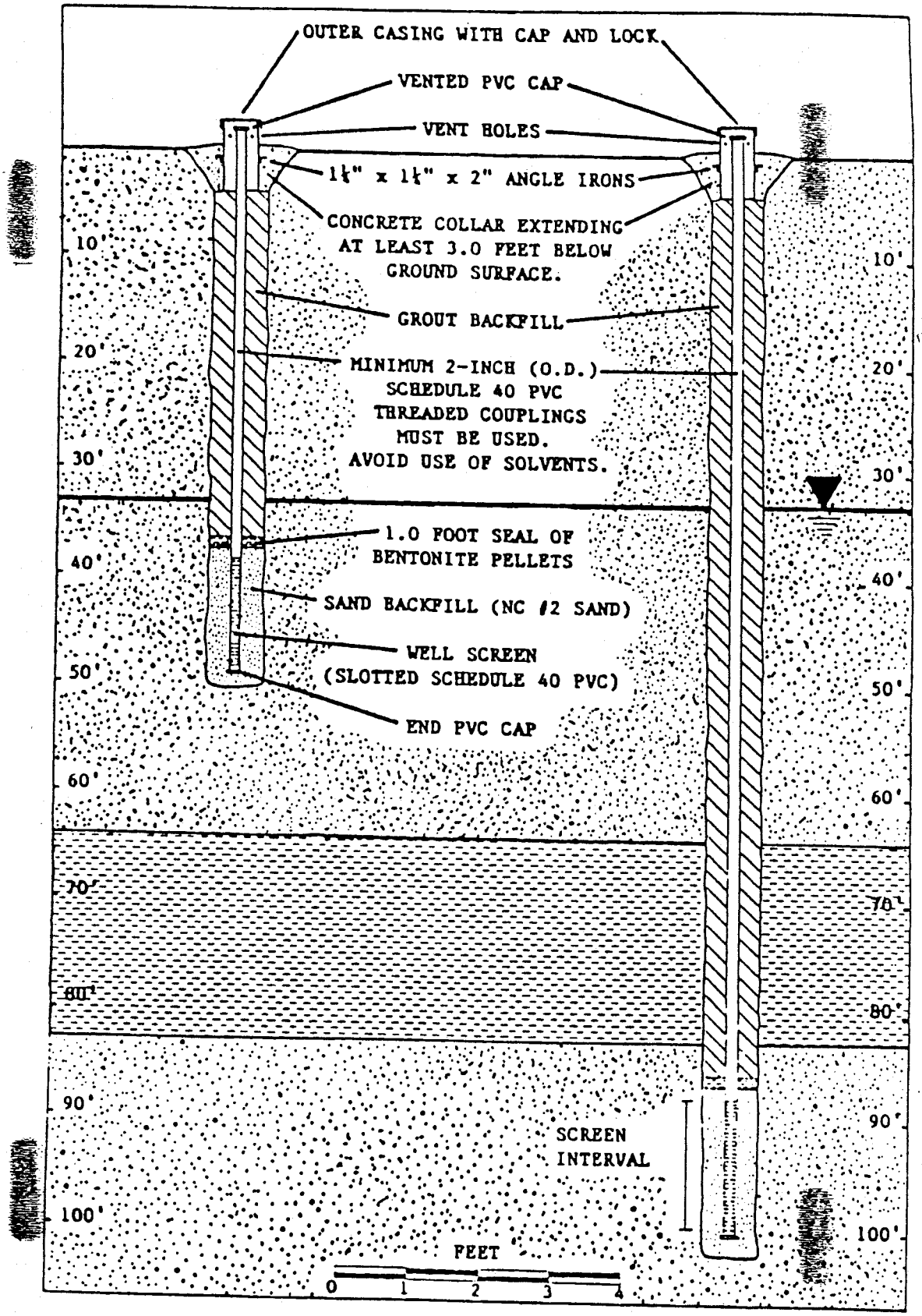


Figure 5. Typical ground-water monitoring well nest schematic.

such as these present inherent technical problems with landfill design and subsequently challenge the effectiveness and integrity of a ground-water monitoring system. The main reason being that fractured rock aquifers offer less predictability and certainty in estimating ground water flow patterns (EPA, 1977).

In order to overcome these difficulties the extent and inclination at depth of these fractures must be ascertained. The most common methods which are available to determine these factors include remote sensing and geophysical surveys. Consultants and engineering firms, may however, specifically utilize and employ these techniques as they see fit in order to adequately address the question of inclination and depth of fracture patterns.

Upon completion of a fracture trace analysis the consulting engineering firm which is responsible for submitting the site plan application will include as part of the proposed ground-water monitoring plan, tentative deep ground-water monitoring well locations at points where fractures intersect and/or at localities characteristic of pronounced lineations which may border or disect the prospective site. As with all proposed well sites, the borehole depths, screen depths and screened intervals will be defined in the report and confirmed with the Division of Health Services prior to drilling. If two aquifers exist beneath a site, a well nest (Figure 5) may be required to adequately assess the migration of potentially contaminanted ground water in both hydrologic regimes..

In most instances, fracture monitoring requires drilling 100 to 200 feet below the surface. This presents a problem for conventional purging methods as described previously in this document. For these wells, a jet pump or equivalent pump which offers a rapid displacement of water will be required for purging. Sampling is performed as described earlier via teflon bailers. A dedicated monitoring system may be used in lui of bailers if depths are not considered a major problem. Consult your industrial representative before purchasing dedicated systems to evaluate the effectiveness of the dedicated device as applied to your specific well requirements.

REFERENCES

American Public Health Association, 1985. Standard Method for the Examination of Water and Waste Water, 13th edition.

Babb, G., and Glaser, R., 1985. An Approved RCRA Groundwater Sampling and Analysis Plan. N.C. Solid & Hazardous Waste Management Branch Technical Report, 7p.

Department of Human Resources, Division of Health Services, 1985. Solid Waste Management Rules (10 NCAC 10G sections .0101-.0707), p. 1-31.

Department Natural Resources and Community Development, 1984. Criteria and Standards Applicable to Injection Wells (15 NCAC 2C sections .0200-.0214), p. 33-56.

Department of Natural Resources and Community Development, 1985. Well Construction Standards: Criterea and Standards Applicable to Water Supply and Certain Other Type Wells (15 NCAC 2C sections .0101-.0119). p.1-29.

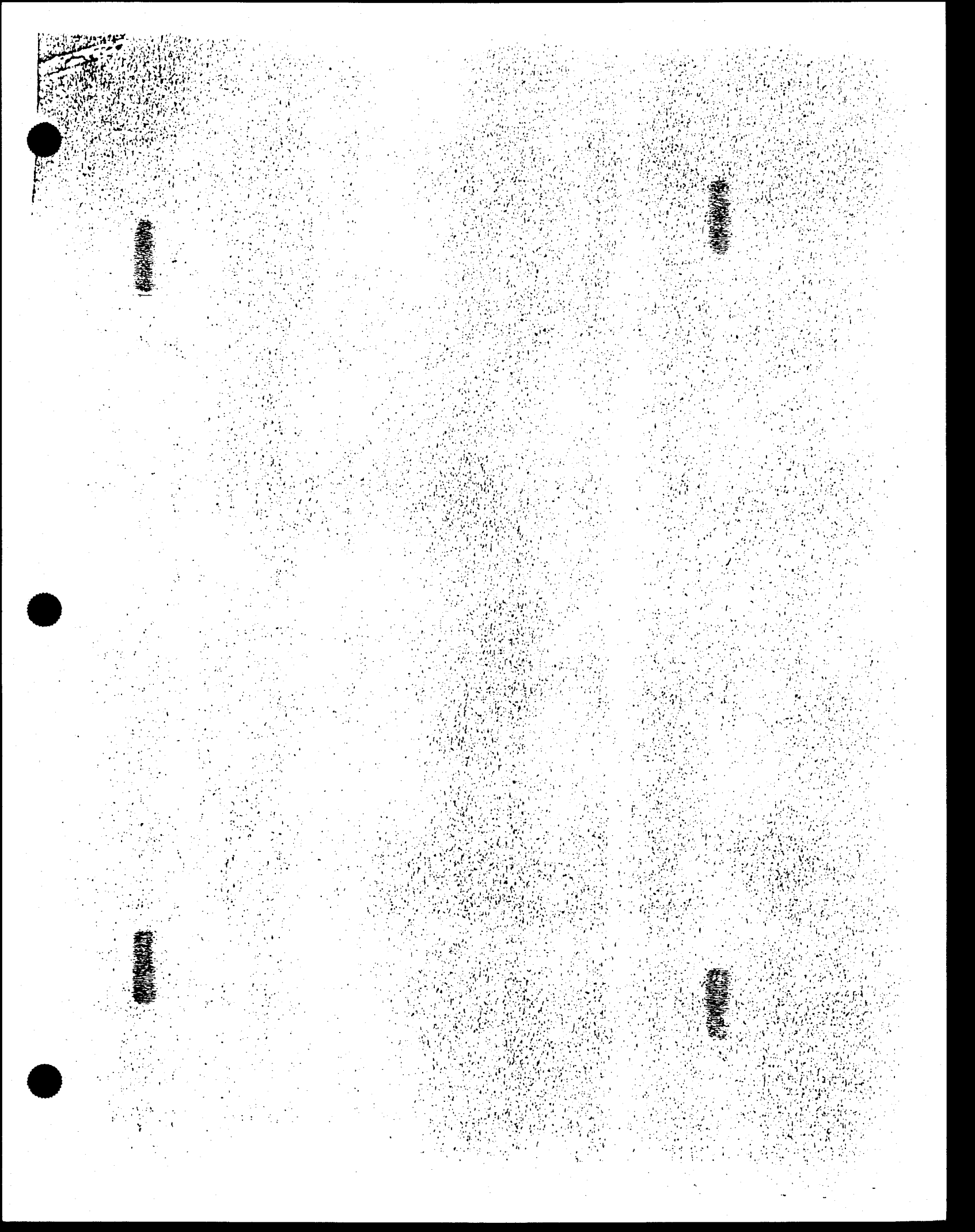
Department of Natural Resources and Community Development,1985. Classifications and Water Quality Standards Applicable to the Ground Waters of North Carolina (15 NCAC 2K sections .0101-.0319), p. 1-18.

Department of Natural Resources and Community Development, 1986. Procedures for Assignment of Water Quality Standards. (15 NCAC 2B sections .0101-.0108), p. 1-6.

Department of Natural Resources and Community Development, 1986. Classifications and Water Quality Standards Applicable to Surface Waters of North Carolina (15 NCAC 2B sections .0201-.0216), p. 7-37.

Department of Natural Resources and Community Development, Division of Environmental Management. Water Quality Section (in preparation). Standard Operating Procedures Manual-Physical and Chemical Monitoring, 165p.

Environmental Protection Agency, 1977. Procedures Manual for Ground-Water Monitoring at Solid Waste Disposal Facilities, 269p.



V

DAILY OPERATIONS

V

DAILY OPERATIONS

PURPOSE:

The intent of this section is to provide the landfill operator the necessary information needed to manage and operate the landfill as designated by the design, and State and Federal regulations.

SITE INFORMATION:

1.) Site Location:

The proposed White Oak Balefill is located approximately one-quarter mile west of S.R. 1338, 13 miles northeast of Waynesville, in Haywood County, North Carolina. Access to the site will be provided by the County constructing a private road off of S.R. 1338. The 104 acre site will accommodate approximately 10 acres to be used for a sanitary balefill disposal facility.

2.) Hours of Operation:

The proposed White Oak Landfill will accept waste from 8:00 am to 4:00 pm Monday thru Friday. The landfill will be closed on all County holidays.

3.) Waste Acceptance Policy:

The unloading of solid waste will be continuously supervised by facility personnel to insure that the following materials are not disposed of in the landfill:

a. Hazardous waste, (as defined under 40 CFR 261.3) no quantities of hazardous waste will be accepted at this facility. Additionally, users of this facility will be encouraged to utilize public programs set up to minimize the amounts of household hazardous waste in the general waste stream.

b. Waste with excessive liquids, unless the waste is leachate or gas condensate approved for recirculation, or is otherwise authorized by the North Carolina DSWM.

c. Raw sewage.

d. Materials that would adversely affect a liner or leachate collection and removal system.

e. Asbestos waste, unless the waste is containerized, labeled,and is disposed of properly.

f. Medical waste, unless it has been rendered non-infectious by an appropriate method prior to delivery to the site.

Certain wastes will be managed with special care to maintain smooth operations at the site and minimize odor generation. Sludge, dead animals, food processing wastes, and other potentially odorous wastes will be covered with refuse immediately upon placement.

Outlined below is a recommended guide for implementation of a program for detecting and preventing the disposal of regulated hazardous waste.

a. Conduct a minimum of 5 random inspections of incoming loads daily.

b. Inspect suspicious loads.

c. Maintain records of any inspections, these records will show the date, time, name of the hauling firm, driver, generator of the waste, including the abatement contractor where applicable, the quantity of the waste, all observations made by the inspector, and the approximate location of disposal in the landfill; these records will be maintained for at least 3 years.

d. Provide training for facility personnel to recognize regulated hazardous waste.

e. Conduct inspections in an area adjacent to the working face but not on the working face.

f. Should hazardous materials be detected, the area shall be cordoned off while the Site Supervisor, the NCDSWM, and emergency personnel as appropriate are contacted. Appropriate clean-up action, transport and documentation of hazardous waste shall be conducted promptly.

Asbestos will not be accepted unless the waste is managed appropriately. Disposal of asbestos wastes will follow the procedures outlined below:

a. All asbestos waste will be transported in leak proof containers (closed bags which are a minimum of 6 mils thick or a container which is otherwise designed to prevent the release of asbestos fibers to the air).

b. All containers of asbestos waste will be labeled with one of the following:

1) Caution. Contains asbestos. Avoid breaking container. Breathing asbestos is hazardous to your health.
2) Danger. Contains asbestos fibers. Avoid creating dust. Cancer and lung disease hazard.

c. Asbestos waste loads will be inspected in the waste hauling vehicle before it is unloaded. If the load is not containerized in accordance to the above specifications, the operator will either reject the load or wet the waste thoroughly before further transport or disposal.

d. Asbestos waste will be unloaded by hand or in a manner which otherwise minimizes breakage of the container, disposed of in a designated area away from vehicle traffic, immediately covered with nonasbestos containing waste before being compacted or run over by heavy equipment, compacted in a manner which prevents asbestos fibers from being released to the air or tracked to a location outside the designated area.

e. The following information will be recorded and maintained for at least three years: the generator (including the abatement contractor, where applicable), quantity, and location of disposed waste.

4.) PERSONNEL SAFETY & TRAINING:

A. Safety Precautions:

1. Access Control: An access control gate will be provided at the entrance of the facility to control vehicular access. Fencing and natural barriers will surround the active portion of the landfill to control livestock and pedestrian traffic. Sign(s) will be posted at the entrance of the facility which indicate the hours of operation, the types of waste accepted and prohibited, emergency telephone numbers and schedule of charges.

2. Fire Protection: Properly maintained fire suppression equipment will be installed in all landfill vehicles and buildings. Stockpiled soil is considered to be the most satisfactory fire fighting material for landfill fires. A minimum stockpile of 500 cubic yards will be maintained at a distance no greater than 200 feet from the working face. 500 cubic yards would provide a 10,000 ft^2 working face with over one foot of cover.

3. Security: Security will be provided for this facility with fences, locked access gate and various natural and man-made barriers.

B. Personnel Training:

The Landfill Operator will be trained and certified in accordance with current State and Federal regulations and will possess sufficient experience to manage the day to day operation of the landfill.

Equipment operators working on the landfill will have sufficient knowledge of the equipment they are operating and follow current OSHA guidelines during working hours.

C. Personnel Facilities: The following personnel facilities will be available at the site:

1. A building or shelter which is accessible to any facility personnel and has adequate heating facilities and lighting.

2. Safe drinking water.

3. Sanitary hand-washing and toilet facilities.

4. A two way radio or telephone for communications.

5. A first aid kit.

5.) EQUIPMENT

A. Operating Equipment: The facility will maintain equipment of adequate number, type and size to effectively operate the landfill according to established engineering practice and applicable regulations. The minimum proposed equipment to be utilized at this site is listed below:

1 - Steel Wheel Landfill Compactor
1 - Bulldozer
2 - Pans
1 - Motor Grader
1 - Water Truck for Dust Control
1 - Motor Forklift w/ 15 FT. Reach

Additional equipment will include pickup trucks, dump trucks, pumps, scales, office equipment, etc. as needed. Equipment will be kept on-site and made available at all times except when equipment is removed for repairs.

Backup equipment will be rented or leased as necessary within 24 hours of primary equipment breakdown. Equipment size and quantity will be adjusted up or down as required to handle the incoming waste stream.

DAILY WASTE/COVER PLACEMENT:

1.) Disposal Methods and Sequence of Operation:

This disposal facility will use both the progressive trench and area fill methods. Disposal operations will be conducted within trenches or cells, disturbing only as much area as is needed to maintain landfilling activities. The erosion and sedimentation controls for an area will be implemented prior to other land disturbing activities. After land disturbing activities have ceased in an area, that area will be stabilized with vegetative cover.

During the excavation of trenches, it is recommended that two trenches be excavated initially. This allows lining of the first trench to proceed without interference from excavating proceeding in the adjacent trench. It also provides sufficient room for liner development including a 25' buffer. No refuse will be placed in this buffer until the next area is completed and the liner connection completed. This will avoid excavating against a "highwall of garbage" as the trenches progress.

The cell construction will be sequenced numerically according to its assigned cell and lift number. Typical construction sequences are shown on the cross-sections contained in the Construction Drawings.

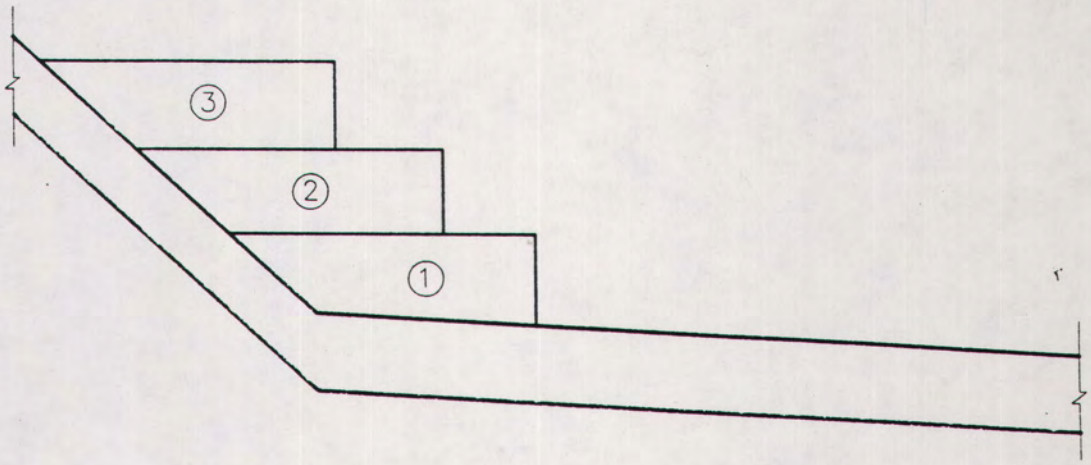
Initial access over the bottom of a new area will be conducted to avoid damaging the liner or leachate collection system. A driving surface of a minimum of 3 feet of select refuse will be provided on top of the sand drainage layer. This will prevent rutting of the sand layer and provide additional protection for the liner and leachate collection system. The unloading and turn around area at the active working face will provide the same protection from vehicular traffic.

2.) Waste Handling and Covering Program:

- Unloading, and Placement of Baled Waste: Bales are to be transported to the working face from the Materials Recovery Facility (MRF) on flatbed trucks. All waste will be weighed and categorized at the MRF before proceeding to the working face. At the working face, bales will be unloaded by a rough terrain forklift. Prior to the placement of the first bale, a dozer will rough-level the area, to provide a flat and level working surface. Bales will be placed in lifts 15' high and covered with daily cover at the end of each day. The working face will be covered with a tarp or synthetic cover at the end of each day. The grading of daily cover will be done with a dozer as needed. Synthetic may be used in lieu of the daily soil material with the permission of the Regional Landfill Inspector.

  The protective drainage layer will slide on the 3:1 side slopes of the liner if the bales are placed improperly. Bales should never be placed directly on the 3:1 side slopes nor should equipment be operated on bales near the side slopes without a substantial number of bales of the preceding lift extending toward the center of the trench in order to resist the tendency to slide. Bales should be placed against the slope from the bottom up so that the average grade of bales is never steeper than 5:1 during construction. The concept is shown in Figure 1. Lifts in cells above the excavated (lined) portion of the bale-fill are to be constructed with slopes no steeper than 3:1.

WRONG



RIGHT

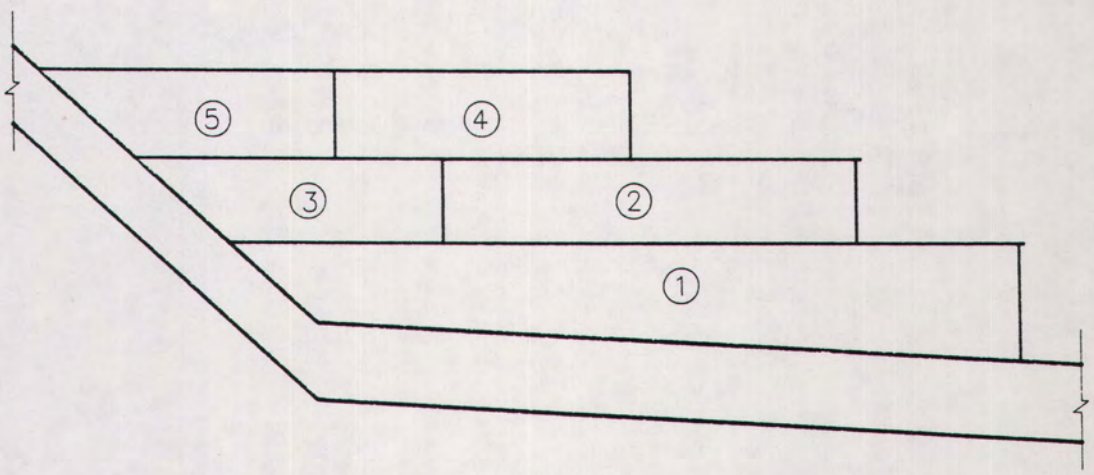
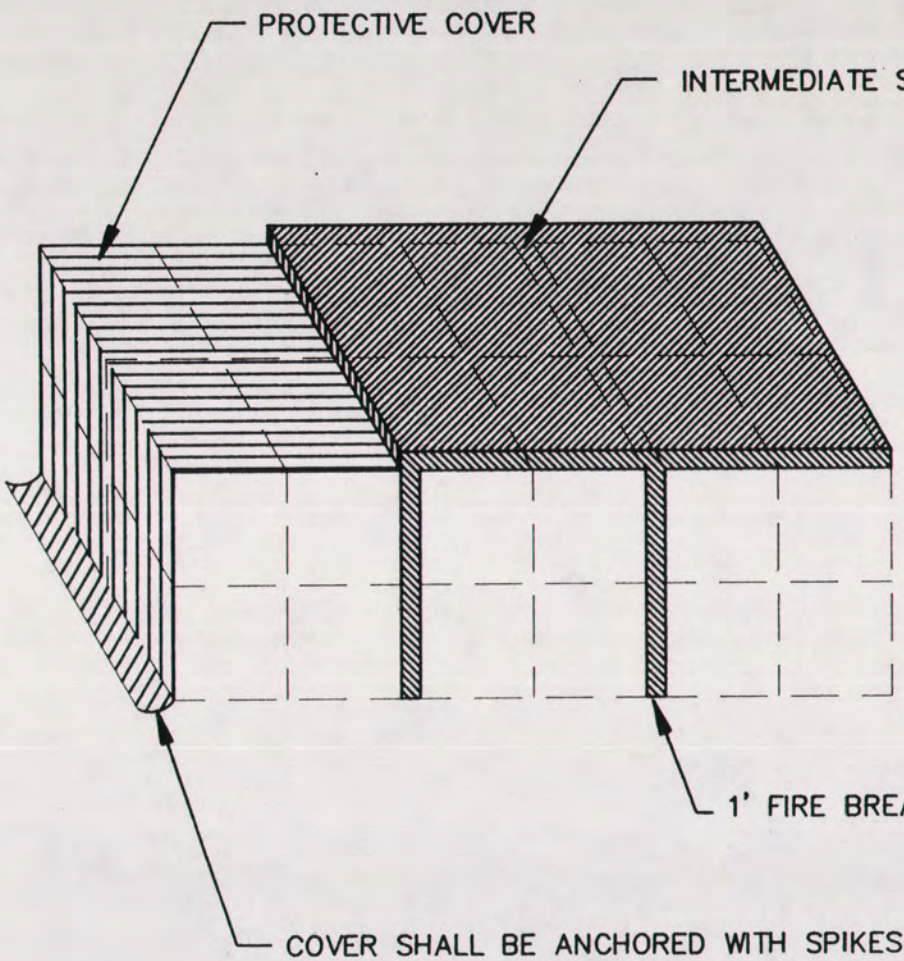


FIGURE 1

FILLING AGAINST
SLOPES



AT THE END OF THE DAY'S OPERATION ALL OF THE BALES SHALL BE COVERED BY 6" OF SOIL COVER EXCEPT THE BALES IN THE FINAL TWO ROWS. A PROTECTIVE COVER SHALL BE PLACED OVER THE FINAL TWO ROWS OF BALES TO PREVENT SURFACE WATER FROM ENTERING THE WASTE.

AT THE BEGINNING OF THE NEXT DAY'S OPERATION, THE PROTECTIVE COVER SHALL BE REMOVED AND THE PLACING OF BALES SHALL BE CONTINUED.

TWO DIFFERENT BALE SIZES WILL BE LANDFILLED:
- 36"x36"x60"
- 43"x46"x61"

FIGURE 5

BALE FILL DETAIL

N.T.S.

- Unloading, Spreading and Compacting Loose Waste: The unloading of the loose solid waste will be confined to the smallest practicable area. Upon unloading, the waste will be spread into layers not to exceed two feet in thickness and compacted to the maximum density utilizing heavy equipment (i.e.: steel wheel compactor, bulldozer, etc.).

  Waste which may have the capability of damaging the liner will not be placed within 8 feet of the protective sand layer. Items falling in this category include but are not limited to stumps, white goods (refrigerators, stoves), and boards. Such waste will be stockpiled until a suitable height of refuse above the liner has been obtained for proper disposal of these materials. All waste will be buried daily.

  Loose solid waste will only be accepted at this landfill in emergency situations. The maximum time frame that loose solid waste will be accepted is one (1) month. The working face where loose waste has been placed will be covered with daily cover and graded for placement of baled waste. The top of the working face will be graded to a smooth surface with positive drainage and compacted for placement of baled waste. When baled waste placement commences, daily cover material will be used to fill in the voids.

- Ramp Construction: Likewise, ramps which are constructed for access down into the bale-fill must be built from the bottom up with a grade no steeper than 10% during construction. The construction contractor should be requested to leave an access ramp at the site of the first temporary berm.

- Initial, Intermediate and Final Cover: The compacted solid waste will be covered at the end of each operating day with a six inch daily soil cover. Alternative daily covers may be utilized such as fabrics or foam; however, approval from the NCDSWM must be secured prior to its utilization.

  All areas left exposed with daily cover for more than one month which have not reached final grades, will be covered with a one foot intermediate soil cover to achieve a total depth of soil of one foot and then vegetated. All daily and intermediate cover depths will be maintained until either additional wastes are placed over the area or final cover is applied.

Upon achieving final grade in an area, final cover consisting of a 18 inch compacted soil layer with a permeability of 1 x 10^{-7} cm/sec overlain by a 6 inch soil layer capable of supporting vegetation and protecting the lower permeability soil will be constructed.

Vegetation schedules including seeding, fertilizers, and planting dates are contained in the construction specifications and erosion control notebook. Care will be taken to exclude plant species which have deep root systems that could have an adverse impact upon the integrity of the final cap.

- Cover Material: Cover material utilized at this facility will be soil materials excavated on-site. For types of soil found on-site, refer to the geotechnical report prepared by Law Engineering, Inc., Raleigh, North Carolina.

Listed below is a summary table of approximate cover requirements and waste volumes to be handled at this facility:

1. Total Volume Waste and Cover 478,218 Cu Yards
2. Total Cover Material Required 95,600 Cu Yards (including final cap)
   a. Available (on site) 229,050 Cu Yards
   b. Imported (off site) Not Applicable
3. Total Waste Volume 382,618 Cu Yards

Total cover material required is based on a waste to cover ratio of approximately 8 parts waste to 1 part cover.

- Dust and Litter Control: Dust control measures will be provided as necessary to prevent a nuisance to adjacent landowners or to landfill employees. No oils or chemicals (other than water) will be used for dust suppression without written approval from the NCDSWM. Minimum dust control will include a water truck for wetting dusty roads. Once areas of the landfill reach final or intermediate grade they will be seeded and maintained to encourage rapid vegetative growth. Disturbed areas on site will be stabilized as soon as possible to minimize dust sources.

Blowing litter will be controlled by a combination of prompt and efficient compaction and cover, fencing, and policing the area daily.

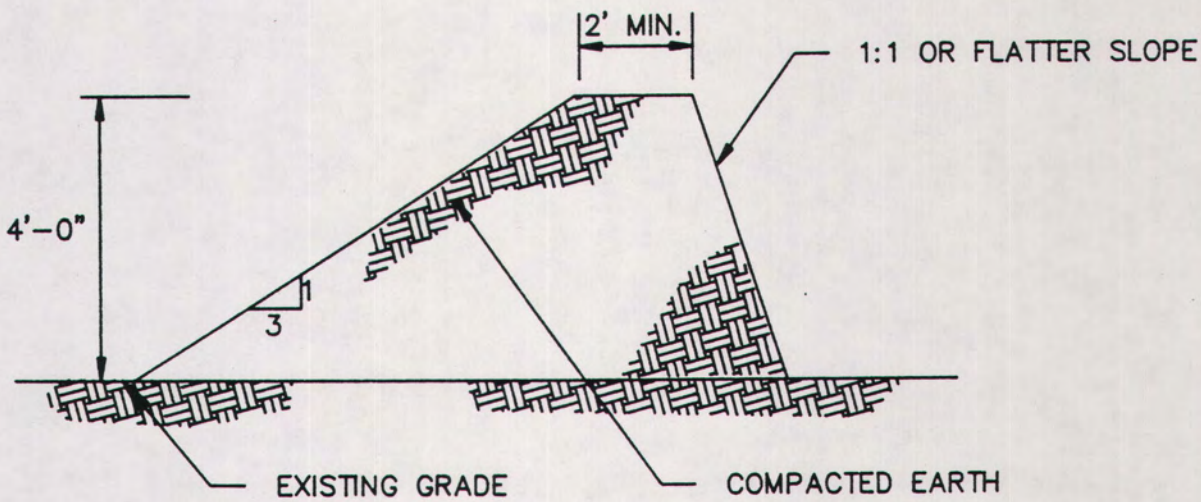
3.) Stormwater/Leachate Management:

Stormwater may be discharged to streams after it is routed through the sediment pond. Leachate however, must be hauled to the wastewater treatment plant and treated at a cost of approximately 4 cents per gallon. Therefore, it is important to maintain separation of stormwater and leachate. During operations, the bale-fill is designed to keep rain water (storm water) falling on areas of the bale-fill where bales have not yet been placed separate from leachate collecting in the protective drainage layer under bales.

A plastic stormwater cover is placed over empty trenches and the empty portion of the active trench. The stormwater cover catches rain water, diverts it to the pond through piping and drains it to the sediment pond before this water can infiltrate the drainage layer and the leachate collection piping. The stormwater cover drains through pipes in the southern end of each trench which discharge to the sediment pond. Temporary berms are placed at the northern end of the stormwater cover in the active trench to prevent leachate from jumping on top of the storm water cover.

- Temporary Berms

  Temporary storm water/leachate diversion berms will be constructed in the bale-fill as described above. These berms will be made of native soils (daily and intermediate cover material) and shall be constructed to a height of 4 feet, as shown in the enclosed Berm Detail, Figure 6. A 1' thick, 18' wide (approximate) lift of soil is placed on the drainage layer, the edge of the stormwater cover is placed on top of the lift for one half the width of the lift along the berm's entire length, then the berm is brought to it's 4 foot height with native soil. In Trench 1 the berm also serves as the access road and may be higher than 4 feet. These berms will erode during rainstorms, and therefore, must be inspected and maintained frequently to include the replacement and tamping of soil to prevent degradation by erosion. When it is necessary to move the berm, the berm material may be excavated, using rubber-tired loaders, and used as daily or intermediate cover. Care must be taken not to excavate into the protective drainage layer.



EARTH BERM

N.T.S.

FIGURE 6

- Stormwater Cover

Stormwater cover will be used to separate stormwater from the leachate collection system over those portions of the bale-fill which have not received their initial lift of bales. The stormwater cover will be constructed of rejected or off-spec HDPE plastic liner sheets. The uphill (north) edge of the sheet is embedded into the temporary berm as described above in the "Temporary Berms" section. These sheets will be lapped down the bale-fill so as to shed water from north to south. At the laps, 1' thick wide roll of Claymax, or similar material, will be placed to provide a seal between the bottom and top sheets at the lap. The laps will be tacked down with sandbags to prevent uplift of the cover by wind. HDPE sheets will float in water. If the stormwater cover drain pipes become clogged and water ponds on the stormwater cover, the sandbags are necessary to prevent the stormwater cover from floating to the surface and flooding the leachate collection system piping.

At the bottom of each trench, stormwater will be routed off the stormwater cover through pipes to the sediment pond. These pipes must be inspected frequently and cleaned to insure that they are not obstructed. Blockage of these pipes will cause ponding on the stormwater cover which could inundate the protective drainage layer and the leachate collection piping.

When it is desired to place bales on top of the stormwater cover (after relocating the temporary berm), the stormwater cover may be sliced with utility knives to provide drainage through the stormwater cover to the leachate collection system for leachate percolating from the bales. As an alternative, the plastic sheets may be stacked on top of each other to provide a clear path for leachate to migrate from the bales to the drainage layer. As a minimum every other sheet can be stacked on its neighboring sheet. Bales may be placed on top of the stacked sheets.

As described above in the Sequence of Operations Section, when the last berm is removed in each trench and just prior to the removal of the last section of stormwater cover in each trench, the stormwater pipe draining the stormwater cover in that trench must be capped, and welded to provide a waterproof seal.

As part of the closure of the 10 acre area, the stormwater pipes which drained the stormwater cover should be plugged up to the previously installed caps (located inside the landfill) from the outside of the landfill through the piping using a watertight grout or plug.

- Manholes

Any water which comes in contact with solid waste is leachate. Any stormwater which contacts leachate becomes leachate. All leachate must be routed to the leachate collection pond for transport to the wastewater treatment plant.

Manholes for the leachate collection system are located just south of each trench and along the piping leading to the leachate collection pond. Leachate from the protective drainage layer of each trench is routed to the leachate collection pond through these manholes. A manhole is also located at the leachate collection pond for removing leachate from the pond to tank trucks. There is a manhole with the stormwater piping which drains the stormwater cover and routes stormwater to the sediment pond.

4.) Landfill Gas Management:

Landfill gas accumulates in the leachate collection piping, and therefore will be in the manholes. Since the leachate manholes are interconnected, gas will be in all the leachate manholes. Due to underground gas migration, gas could also be in the stormwater manholes.

Landfill gas is explosive, and landfill gas will cause suffocation since it can be heavier than air and lacks oxygen. Therefore, leachate collection piping **manholes are a deadly environment**, requiring special precautions and equipment. It may be necessary to enter the manholes to: repair leaks, clean the leachate collection lines, etc. Since the Fire Department maintains the necessary equipment and is trained for working in explosive and suffocating environments, the Fire Department should provide the equipment, the safety personnel, and (if possible) the down hole worker. As a minimum, the Fire Department should provide the equipment, the safety personnel, and train/certify the down hole worker in the use of breathing apparatus and working in explosive/suffocating environments. Only spark and static proof equipment (US Bureau of Mines approved) should be used in manholes. No person should enter a manhole without: a self contained breathing apparatus; safety line attached to and capable of supporting that person, and tied off above ground; two safety persons (who remain above ground); and a lifting device capable of lifting the down hole worker. An additional breathing apparatus must be present should one of the safety persons need to enter the manhole to effect a rescue. Manholes must be marked with signs identifying the hazards and prohibiting entry without the above precautions.

5.) Water Monitoring:

Implementation and administration of the surface and groundwater monitoring programs are the responsibility of the Landfill Supervisor. He should review the instructions on sheets 15 thru 17 of the Construction Plans for the White Oak Sanitary Landfill, dated September, 1991. He should also verify the current requirements with the Western Area Supervisor, NC Solid Waste Section, Field Operations Unit, Winston-Salem, NC. Background water quality samples analysis must be conducted prior to bale-filling to serve as a defense to future claims that operation of the Bale-fill caused degradation of the ground or surface waters.

APPENDICES

Appendix A

Supporting Correspondence

Site Suitability Approval

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

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

William L. Meyer
Director

December 11, 1990

Dr. Richard R. Rust, P.E., Ph.D.
Tribble & Richardson Inc.
4020 Westchase Blvd., Suite 515
Raleigh NC 27607

RE: Site-Specific Landfill Design Requirements for the proposed 104 Acre Haywood County Site

Dear Dr. Rust:

The Division of Solid Waste Management has completed its review of the site plan application for the proposed Haywood County Solid Waste Management Facility, located off SR 1338. Based upon the information submitted, revised 10-22-90, the Division has determined that the applicant may prepare a construction plan which meets the requirements of 15A NCAC 13B, as outlined herein. This letter addresses the site-specific limits of the disposal area, and the design and construction standards for the referenced site.

The Division requires the submittal of a construction plan application for the proposed sanitary landfill (104 acre site) which meets the requirements of 15A NCAC 13B, Section .0503 (2), .0504 (2), and the following site-specific criteria and design standards:

Limits of the Disposal Area

(1) The actual limits of the waste disposal area shall be delineated and must incorporate the following criteria:

(a) The area approved for preparation of a construction plan is delineated on the enclosed Attachment 1. The construction plan shall be developed in five (5) year phases, illustrating the progression of development, and providing detailed plans for the first phase to be constructed.

(b) A minimum 300-foot buffer shall be maintained between the waste boundaries and all facility boundaries.

(c) A 50-foot minimum buffer shall be maintained between all streams and disposal areas.
(d) A 500-foot minimum buffer shall be maintained between the waste boundaries and all private dwellings and wells.

Additional Subsurface Investigation

(1) Engineering Design: For each phase of development, it will be necessary to provide a stabilized water table map with supporting data, and to project the long-term seasonal high water table. A boring plan must be approved by the Solid Waste Section prior to implementation.

(2) Monitoring Design: A water quality monitoring plan must be approved by the Solid Waste Section prior to issuing a permit. The plan must target the most hydraulically conductive zones of the surficial aquifer. Surface water monitoring shall be included in the plan.

Design and Construction Standards

(1) The facility design shall incorporate the following engineered systems designed to perform the specified performance functions:

(a) A composite liner system designed to prevent migration of leachate into ground water. Minimum design standards shall include a 60 mil high density polyethylene liner overlying a compacted soil liner with a minimum of 18 inches of 1 x 10(-7) cm/sec permeability soils, or an alternative design approved by the Division; and
(b) A leachate collection and removal system designed to drain liquids accumulating on the liner. The system shall be designed to maintain no greater than 1-foot of head on the liner, assuming that infiltration into the landfill is equal to the amount of precipitation produced from a 24 hour/25 year storm event; and
(c) The necessary systems for containment and/or treatment of leachate prior to disposal in accordance with the comprehensive leachate management plan. Containment design for the leachate holding ponds shall be in accordance with the minimum design standards for the landfill liner system, as established above, including a minimum four feet separation from the estimated seasonal high ground water table; and
(d) A capping system designed to minimize surface water infiltration and minimize further maintenance of the site.

(2) The construction plan shall specify performance requirements for the components of the engineered systems. Design calculations shall be reviewed to verify theoretical system performance.

(3) A comprehensive leachate management plan shall be provided, including all necessary Local, State, and Federal permits or approvals. Specific requirements may be obtained from the Division of Environmental Management. The applicant should consider the technical and economic factors associated with the available leachate management options.

(4) An extensive ground and surface water monitoring plan shall be be approved by the Solid Waste Section. Each phase of development must be monitored separately. Monitoring wells must also be established for the leachate holding ponds.

(5) A comprehensive Construction Quality Assurance(CQA) plan outlining the quality assurance measures necessary to implement the design, along with plans for developing the CQA Report, must be included in the construction plan application.

Contract technical specifications, preferably performance specifications, providing the detailed requirements for materials, equipment, testing, responsibilities and qualifications of parties, quality control, workmanship, and all special construction of the system may be submitted to address this.

Upon completion of construction, the CQA report will be reviewed and approved by the Division prior to receipt of waste in each given phase of the landfill.

(6) A closure and post-closure plan shall be prepared to gauge the long-term performance of the facility.

The requirements described above are specifically issued for the referenced 104 acre site, as submitted on October 22, 1990. The "Limits of the Disposal Area" delineates a usable area of approximately 23 acres. The original application submitted on June 6, 1990 included additional property, describing a 183 acre site. For the original 183 acre site, additional subsurface characterization will be necessary to re-submit an application for further evaluation. In accordance with the Solid Waste Management Rules requiring that permits be reviewed every five (5) years, the construction plans should be developed in five (5) year phases, with detailed plans illustrating the first phase to be constructed.

Be advised that 15A NCAC 13B has been amended, effective February 1, 1991, to include requirements which will affect this permit application. Specifically, Rule .0201 will require an operational plan including all pertinent details necessary for the development of this facility. This plan is to include the provisions for bear management, as outlined in the current submittal.

It should be noted that this letter only informs the County that they may proceed with their permit application. The only final action the Division may take on a permit application is the issuance or denial of a permit.

Haywood County is encouraged to take an aggressive approach in developing a comprehensive solid waste management facility which will lessen dependency upon conventional disposal in a sanitary landfill. Portions of this site may be suitable for other solid waste management options (recycling, composting, etc.).

If you have any questions, or would like to schedule a meeting to discuss the application, please contact Jim Coffey at (919) 733-0692.

Sincerely,

William L. Meyer, Director
Solid Waste Management Division

cc: Jim Coffey
Bobby Lutfy
James Patterson
Julian Foscue
Gary Ahlberg
Chairman of Haywood County Commissioners
Mr. John Runkle

Corp of Engineers Nationwide 26 Permit

RCF
CONSTRUCTION COMPANY

R.C.F., INC.
General Contractor - Crane Service
211 W. Main Street • P.O. Box 157
Hazelwood, North Carolina 28738
(704) 456-9570

Gary D. McKay, P.E.
President

May 16, 1990

Mr. Bob Johnson
U.S. Army Corp of Engineers
37 Battery Park Avenue
Room 75
Asheville, North Carolina 28801

Dear Mr. Johnson:

In response to your visit to the Proposed Landfill Site at Whiteoak, I am enclosing for review maps of the property. The Wetland Diaturbance is outlined in red on the Topographic Map.

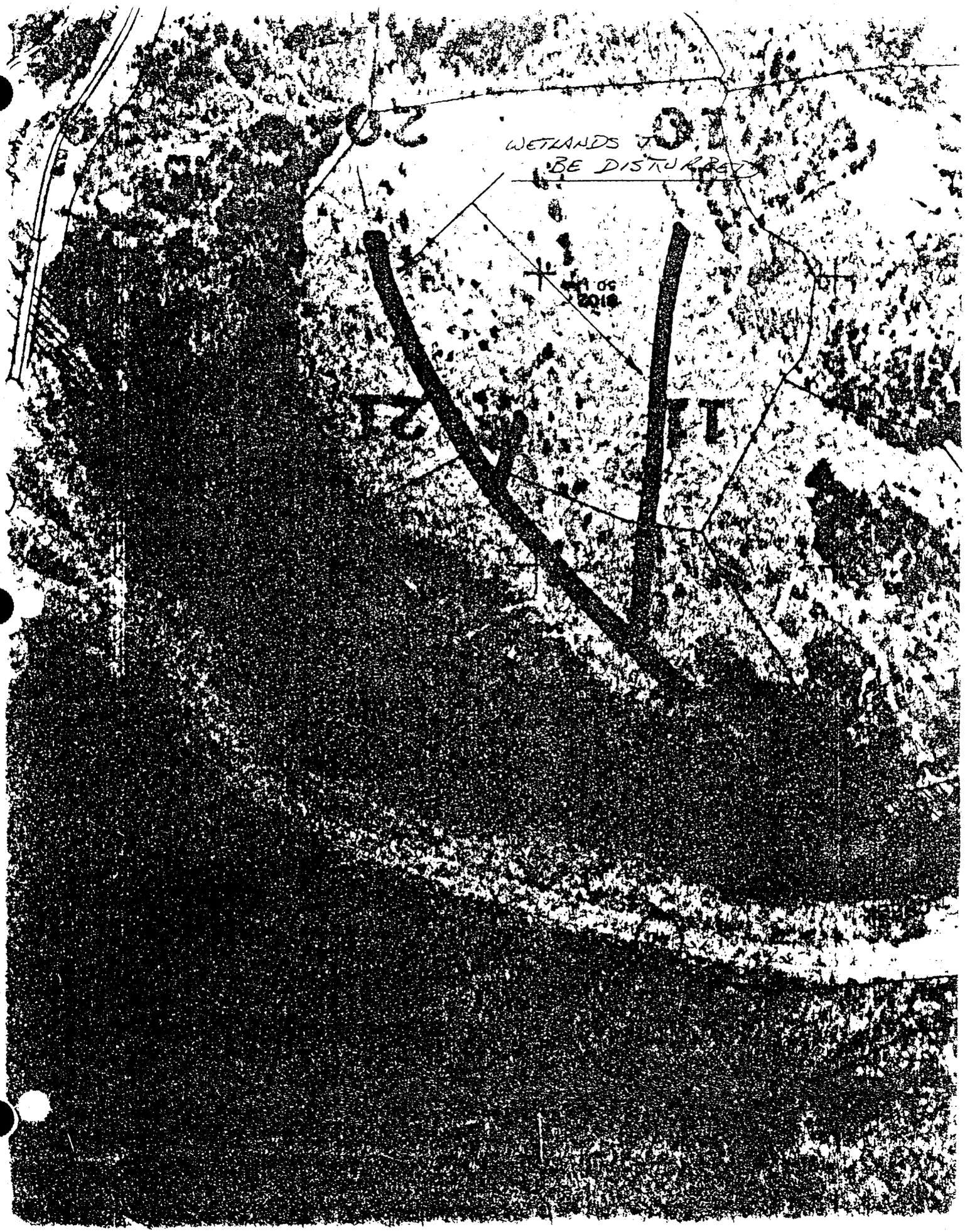
The extent of this Wetland Disturbance is approximately .8 Acres (3200 Ft. X 10 Ft.).

Haywood County is seeking permission from the Corp of Engineers to carry out this project.

Thank you for your time and interest.

Sincerely,

Gary D. (Mackie) McKay
Haywood County Landfill Engineer


WETLANDS
BE DISTURBED

DEPARTMENT OF THE ARMY
WILMINGTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1890
WILMINGTON, NORTH CAROLINA 28402-1890

June 1, 1990

RECEIVED
JUN 5 1990
Tribble & Richardson, Inc.

IN REPLY REFER TO

Regulatory Branch

SUBJECT: CESAW-CO90-D-044-Nationwide Permit No. 26

R.C.F., Incorporated
ATTN: Mr. Gary D. McKay
211 West Main Street
Post Office Box 157
Hazelwood, North Carolina 28738

Dear Mr. McKay:

Reference your May 16, 1990, letter requesting authorization for channel changes to two headwater tributaries to the Pigeon River in conjunction with the construction of a new Haywood County landfill located off S.R. 1338 in White Oak Township, Haywood County, North Carolina. Approximately 0.8 acres of waters of the United States are to be affected by the project. Neither watercourse is tributary to State designated trout waters.

For the purposes of the Corps of Engineers' Regulatory Program, Title 33, Code of Federal Regulations (CFR), Part 330, published in the Federal Register on November 13, 1986, lists nationwide permits. Authorization was provided for discharges of dredged or fill material into non-tidal rivers, streams, and their lakes and impoundments, including adjacent wetlands, that are located above the headwaters and other non-tidal waters of the United States, including adjacent wetlands, that are not a part of a surface tributary system to interstate waters or navigable waters of the United States. This general authorization is valid only for work that causes the loss or substantial adverse modification of less than an acre of waters or wetlands.

Your work is authorized by nationwide permit provided it is accomplished in strict accordance with the enclosed conditions. This verification will be valid until the nationwide permit is modified, reissued, or revoked. All the nationwide permits are scheduled to be modified, reissued or revoked prior to January 13, 1992. It is incumbent upon you to remain informed of changes to the nationwide permits. We will issue a public notice announcing the changes when they occur. Furthermore, if you commence or are under contract to commence this activty before the date the nationwide permit is modified or revoked, you will have 12 months from the date of the modification or revocation to complete the activity under the present terms and conditions of this nationwide permit. Please be aware that this authorization does not relieve you of the responsibility to obtain any required State or local approval.

If you have questions, please contact Mr. David Baker at our Asheville Regulatory Office, telephone 704-259-0856.

Sincerely,

G. Wayne Wright
Chief, Regulatory Branch

Enclosure

Copies Furnished (without enclosure):

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

Mr. William Mills
Water Quality Section
Division of Environmental Management
North Carolina Department of Environment,
Health, and Natural Resources
Post Office Box 27687
Raleigh, North Carolina 27611-7687

CONDITIONS

a. Any discharge of dredged or fill material will not occur in the proximity of a public water supply.

b. The activity will not jeopardize a threatened or endangered species as identified under the Endangered Species Act, or destroy or adversely modify the critical habitat of such species.

c. The activity will not significantly disrupt the movement of those species of aquatic life indigenous to the waterbody (unless the primary purpose of the fill is to impound water).

d. Any discharge of dredged or fill material will consist of suitable material free from toxic pollutants (no asphalt).

e. Any structure or fill will be properly maintained.

f. If the activity may adversely affect historic properties which the National Park Service has listed on, or determined eligible for listing on, the National Register of Historic Places, or if significant historic properties are encountered before or during work, the permittee will notify the District Engineer.

g. The construction or operation of the activity will not impair reserved tribal rights, including, but not limited to, reserved water rights and treaty fishing and hunting rights.

h. An individual State water quality certification must be obtained or waived. Conditions of certification will be considered to be special conditions of the Federal nationwide permit. Inquiries regarding obtaining a water quality certificate may be directed to Mr. William Mills at (919) 733-5083.

i. The following management practices will be followed to the maximum practical extent:

(1) Discharges of dredged or fill material into waters of the United States will be avoided or minimized through the use of other practical alternatives.

(2) Discharges in spawning areas during spawning seasons will be avoided.

(3) Discharges will not restrict or impede the movement of aquatic species indigenous to the waters or the passage of normal or expected high flows or cause the relocation of the waters (unless the primary purpose of the fill is to impound water).

(4) If the discharge creates an impoundment of water, adverse impacts on the aquatic system caused by the accelerated passage of water and/or the restriction of its flow will be minimized.

(5) Discharge in wetland areas will be avoided.

(6) Heavy equipment working in wetlands will be placed on mats.

(7) Discharges into breeding areas for migratory waterfowl will be avoided.

(8) All temporary fills will be removed in their entirety.

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

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

George T. Everett, Ph.D.
Director

October 4, 1990

Mr. Vance Moore
Tribble & Richardson, Inc.
4020 Westchase Boulevard, Suite
Raleigh, North Carolina 27607

Dear Mr. Moore:

Subject: Proposed Fill in Headwaters or Isolated Wetlands
Proposed Haywood County Landfill
Haywood County

Upon review of your request for Water Quality Certification to place fill material in waters of two tributaries to Pigeon River near SR 1338 to accomplish channel changes in the streams, we have determined that the proposed fill can be covered by General Water Quality Certification No. 2176 issued November 4, 1987. A copy of the General Certification is attached. This Certification may be used in qualifying for coverage under Corps of Engineers' Nationwide Permit No. 26.

If you have any questions, please contact Bill Mills at 919/733-5083.

Sincerely,

George T. Everett

GTE:BM
Attachment

cc: Wilmington District Corps of Engineers
Asheville Regional Office

GENERAL CERTIFICATION

THIS GENERAL CERTIFICATION is issued in conformity with the requirements of Section 401, Public Laws 92-500 and 95-217 of the United States and subject to the North Carolina Division of Environmental Management Regulations in 15NCAC2H, Section .0500 for the discharge of fill material to navigable waters or adjacent wetlands areas which are above the headwaters or to wetland areas that are not a part of the surface tributary system to interstate waters or navigable waters of the United States (i.e. isolated wetlands) as described in 33 CFR 330.5(a)(26) of the Corps of Engineers' regulations. The category of activities shall include any fill activity in these headwaters and isolated wetlands areas where the activity does not result in the loss or substantial modification of 10 acres or more of waters of the United States, including wetlands.

The State of North Carolina certifies that the specified category of activity will not violate Sections 301, 302, 303, 306 and 307 of the Public Laws 92-500 and 95-217 if conducted in accordance with the conditions hereinafter set forth.

Conditions of Certification:

1. Proposed fill or substantial modification of 1 to 10 acres of such waters, including wetlands, requires a written concurrence from the Division of Environmental Management. Activities involving less than one acre do not require written concurrence.
2. Excluded from this General Certification are discharges of fill in waters classified WS I, II, or III (public water supplies) and SA (shellfish waters). This exclusion also applies to fill in wetlands adjacent to these waters. Discharge proposed for these waters or wetlands must be considered for certification on a case-by-case basis;

3. That the discharge will consist of suitable material free from toxic pollutants in other than trace quantities;
4. That established erosion control practices are utilized to prevent excessive increases in turbidity and settleable solids concentrations in the water body as a result of the discharge;
5. That the discharge of fill material shall be in accordance with the conditions and management practices specified by the Corps of Engineers in 33 CFR 330.5 and 330.6 for nationwide permit number 26.

Non-compliance with or violation of the conditions herein set forth by a specific fill project shall result in revocation of this Certification for the project.

The Director of the North Carolina Division of Environmental Management may require submission of a formal application for certification for any project in this category of activity, if it is determined that the project is likely to have a significant adverse effect upon water quality or degrade the waters so that existing uses are precluded.

Public Hearings may be held for specific applications or group of applications prior to Certification if deemed in the public's best interest by the Director of the North Carolina Division of Environmental Management.

This the 5th day of November 1987.

DIVISION OF ENVIRONMENTAL MANAGEMENT

By _____

R. Paul Wilms, Director

Bear Management Plan

PROPOSED BLACK BEAR MANAGEMENT PLAN
HAYWOOD COUNTY LANDFILL

For the past three years, Haywood County has struggled with the task of siting a new landfill. The county has found out, as many other counties have, that this is a tremendously difficult task wrought with high emotions, technical difficulties, and soaring expenses. The governing body has no friends when it comes to picking the new landfill.

Through this ordeal, the Haywood County Commissioners have picked a site in White Oak, in the northern part of the county, as the best site for the new landfill. Unfortunately, this site is relatively close to the Cataloochee Valley section of the Great Smokey Mountain National Park and the Harmon Den Wildlife Refuge. All four of the final possible sites are in the northern area of the county. It has been pointed out by the U.S. Forest Service and it is well documented in techincal reports that open garbage dumps are an attraction to black bears. Therefore, such as operation would have a negative impact on the black bear population in the management areas memtioned above.

Haywood County has no intention and would not be permitted by law to operate an open dump anywhere in the county. There is much less known about the impact of controlled sanitary landfills on wildlife populations. However, it is the county's position that there should be measures taken to prevent any negative impact to the environment, including the black bear

population. Therefore, the county would propose a landfill management plan to minimize the attraction of the black bear to the disposal site.

Bears are attracted by odor and the more exposure garbage has to the atmosphere, the more odor is created. The county would propose to use a balefill system rather than landfill system to minimize exposure to the open air. This system uses a baler at another location to bale the garbage into cubes weighting approximately one ton and having a density of over 1,000 pounds per cubic yard. The surface area of the material is minimized and the bale bceomes almost waterproof. Practical applications of this system have proven to virtually elminate odor and greatly increase the efficiency of the waste disposal operation. Use of this process makes management of the garbage far more consistent throughout the year as conventional landfill operations are hampered greatly in wet weather. There is much less traffic in the fill area using bales as the site is not open to the public and therefore inclement weather is not as much of a factor. Because of the neatness of this type of operation it is possible to eliminate all odor associated with the garbage by using chemical deodorizers or maskers, provided cover soil is applied every day. The county will follow this procedure.

Because of the natural travel patterns of the black bear, it is possible for a bear to happen upon the balefill even if he is not attracted by the odor. Also, travel patterns are influenced by poaching activities. To eliminate endangering of the animal in this way, the county will ask the assistance of the N. C. Fish and Wildlife Commission to educate the public as

to habits of the bear, to monitor movements of the bear in the area of the balefill, and to detect poaching activities in this region of the county. This undertaking on the part of the county would probably do more for the long term survival of the black bear than anything that can be done by the county, simply because of the severity of the poaching problem.

The county has also investigated the use of guard dogs and electic fences at the site as a deterrent to wild animals. The bale cell will be protected by a 8' chain link fence and electrical system designed to deter large animals. A guard dog will also be kept inside the fence. While these will be effective secondary management tools, in this case the county feels that elimination of odor, control of day to day operation, and public education are the keys to this black bear management problem. Haywood County would use these techniques to co-exist with our valuable black bear population.

On September 7, 1990, Richard Wood of Tribble & Richardson, Inc. called Richard B. Hamilton, Assistant Director, North Carolina Wildlife Resources Commission, preparing Bear Management Plan for Haywood County. He was referred to John Collins, bear expert in Morganton. Unable to reach Collins, Mr. Wood phoned Mr. Hamilton back, and was then referred to Carl Betzel, Division of Wildlife Management in Raleigh.

On September 12, 1990, Mr. Betzel called back stating that he needed a letter requesting assistance from Division of Wildlife Management to help Haywood County prepare a Bear Management Plan for the Haywood County Landfill Site.

On September 24, 1990, Richard Wood received a letter stating that Jeffrey Brooks, biologist in Waynesville has been assigned to the project. The final Bear Mangement Plan will be submitted to the Division of Health, Environment and Natural Resources, Solid Waste section, as soon as the report becomes available.

North Carolina Wildlife Resources Commission

512 N. Salisbury Street, Raleigh, North Carolina 27611, 919-733-3391
Charles R. Fullwood, Executive Director

April 3, 1990

Mr. Terry J. Rogers
County Manager
Haywood County Courthouse
Waynesville, North Carolina 28786

RECEIVED
APR 5 1990

Dear Mr. Rogers:

Our Division of Wildlife Management has carefully considered the proposed White Oak landfill site for Haywood County in terms of its potential adverse impact on black bears. The attached report prepared by the Division explains our concerns over locating the landfill at the White Oak site.

We recommend that the potential problems associated with locating a landfill in occupied black bear range be considered. These problems can and should be avoided and the black bear protected from the dangers of locating the landfill in their range.

If you have questions about our position or any of this information, we are available to discuss the issue.

Sincerely,

Richard B. Hamilton

Richard B. Hamilton
Assistant Director

RBH/gm

Attachment

cc: Hal Atkinson, Chief
Division of Wildlife Management

William L. Meyer, Head
Solid And Hazardous Waste Management Division
Environment, Health and Natural Resources

A Statement on the Potential Adverse Effects to the Black Bear Population by the Establishment of a landfill in the White Oak Section of Haywood County.

Division of Wildlife Management

March 21, 1990

Historically, garbage dumps and other forms of human garbage disposal systems placed in areas inhabited by bears (all species) have served as an attractant resulting in conflicts between man and bear. The results of these conflicts include:

1. Increased road kills (proximity to I-40)
2. Habituation to human food
3. Reduced fear of man
4. Shifts in normal home ranges, travel routes and denning patterns
5. Increased vulnerability to hunters and poachers
6. Increased mortality from depredation
7. Increased morbidity and death due to accidental injuries associated with dumps
8. Reduced survival capability of offspring due to learned unnatural behavior
9. Increased physical contact (maulings) between man and bears
10. Increased chance of ingesting toxic materials

Such landfills always result in an ever increasing adverse pressure on one of the few remaining wilderness species, the black bear.

The White Oak area, located 2.7 miles from Great Smoky Mountain National Park and 3.2 miles from the Harmon Den Bear Sanctuary, could not be selected in a more unfavorable location unless it is located inside the Park or the Bear Sanctuary.

The average home range of adult female bears in the North Carolina mountains has been documented as 4,000 acres while that of the adult male is 16,000 acres. Home ranges can and do exceed these acreages during years of poor hard mast (acorns and hickorynuts) production. During these years of poor mast, bears travel for miles outside their normal home ranges in search of food that is required to build a fat reserve for utilization during hibernation. During these low mast years, problems associated with garbage dumps and bears would be magnified.

Additional bear - human conflict problems associated with a garbage dump located in bear range would further tax the time and manpower of Wildlife Resources Commission field

personnel who would be contacted in an attempt to control nuisance bears. This time can be spent on more worthwhile and productive endeavors. Due to the lack of areas uninhabited by humans in North Carolina there are not any suitable sites available for release of nuisance bears in the mountain region.

Since the Panther Creek site is located in occupied bear range and near the White Oak site, it would create the same problems associated with the White Oak site.

From a wildlife management standpoint, especially bear management, the Crabtree Site is the most desirable since it is not located in bear range; however its location will not totally prevent bear problems from developing.

The placement of a garbage dump in the White Oak or Panther Creek area would be a severe addition to a long list of adverse effects that man has inflicted on the black bear and its habitat in this area. Regardless of the disposal system selected and the precautions taken, the black bear will be adversely affected.

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

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

William L. Meyer
Director

May 2, 1990

Mr. Gary D. McKay
Post Office Box 489
Hazelwood, North Carolina 28738

Dear Mr. McKay:

Secretary Cobey has asked me to keep abreast of Haywood County's progress in siting a municipal solid waste landfill and to assist in that process as necessary.

As you know, the Solid Waste Section requested and has received information from various sources concerning the Black Bear issue associated with the "Bill Davis" site. Based on this information, the primary concern is that odors from the landfill will potentially attract bears out of the "special management areas", especially during years of poor food production. According to the comments, road kills, increased hunting efficiency and vulnerability to poaching are potential impacts on the bear.

However, the information provided did not specify a regulation which would exclude a site from further consideration based on the subject criteria (impact on black bear). Since a large portion of Haywood County may provide suitable bear habitat, the County should consider this issue, among the others, as they complete the site-selection process and prepare a site plan application.

In assessing the applicability of this issue to the permitting process, mitigative measures should be included under Section .0504 (1)(h) of the Solid Waste Management Rules, "Any other information pertinent to the suitability of the proposed site." In addition, the site plan application should include a management plan further describing logistical and operational methods to be taken to address this issue.

The Solid Waste Management Division recognizes the difficult task confronting Haywood County in siting a landfill and would like to offer its support and assistance during this process.

Please contact Jim Coffey at (919) 733-0692 for specific assistance concerning the permitting process.

Sincerely,

William L. Meyer

WLM/jcc/mj

ELEANOR M. HOERMAN
CITY CLERK/TREASURER
623-3033

VERNON F. McKINNEY
CITY INSPECTOR
623-2375

RICHARD T. WINTER
CITY ATTORNEY
623-2905

STREET COMMISSIONER
623-4754

CITY OF ANTIGO

BERNHARD JUNIOR, MAYOR
715-623-3633

617 CLERMONT STREET
ANTIGO, WIS. 54409-1986

DR. J. E. McKENNA
HEALTH OFFICER
623-2013

DAVID L. ZWICKY
PARKS, CEMETERY, & RECREATION DIRECTOR
623-2621

PAT VANDERLEEST
ASST. DIRECTOR OF PUBLIC WORKS
623-2329

September 11, 1990

R.C.F., Inc.
Solid Waste Engineer
211 W. Main St
P.O. Box 157
Hazelwood, North Carolina 28738

Dear Mr. McKay:

All of Langlade County which is in north central Wisconsin has a lot of wildlife including black bear.

Our landfill has been in operation for 20 years with daily coverage of garbage. Our balefill operation has been going since fall of 1983 with bales also being covered with soil on a daily basis. We have not seen any bears on our landfill site.

As far as the town garbage dumps are concerned, the DNR has closure orders on all town dumps in our county and most are closed already and are bringing their waste to the City operated balefill.

Sincerely,

Pat Vander Leest

Patrick Vander Leest,
Asst. Director of Public Works

lm

ATTACHMENT 1

SCHEDULE 5: EXPERIENCES OF INHABITANTS WITH VGF-COLLECTION IN SOME LOW-RISE QUARTERS (IN %)		
CITY	PARTICIPATION (%)	POSITIVELY JUDGED (%)
AMSTERDAM	89 69 (1)	99
APELDOORN	93	91
PURMEREND	98 82 (1)	90
SOW	97	91
EDE	87	--
NUENEN	90	88

1 - CORRECTED FOR NON-RESPONSE TO THE INQUIRY

INSTRUCTION ACTIVITIES FOR ALL INHABITANTS

BEFORE THE STARTING:
- Leaflet or information news-paper
- House-to-house letter of the municipality (ask for participation) or:
- Personal letter of municipality
- Invitation for instruction meeting
- Instuction meeting
- Show of video- or slide-production
- Exhibition about VGF-collection
- Posters in public buildings or on the collection vans
- Inaugurate committee of inhabitants or working-group
- House-to-house distribution of means of collection and in addition : collection calendar (if necessary)
- Separation instructions
- Means of preservation (if provided)
- If necessary stickers on buckets with the logo of separationrule
- As per the distribution of the buckets : start an information telephone service

THE START:
- Festive distribution or emptying of the first buckets

AS PER THE START:
- Information telephone line for the answering of questions
- In case of problems: visit
- Consulting-hours in the quarters (or in a mobile informationbureau)
- During the first month: inhabitants bulletin with the first results
- Regular repeat of the bulletin
- After some months: public day at the processing installation (or if this is too far : at the station of transshipment)
- Prize contest or lottery, colour picture, construction kit, and such like
- Provide free bags with compost (example on public day)

SCHEDULE 7 REQUESTED ACTIONS PER TARGET	
TARGET INSTRUCTION	REQUESTED ACTION
Local Management	- Take decision for introduction - To place a budget at disposal
Regional management (and such-like) (1)	- Co-operation/participation
Own staff (cleaning, instruction, finances etc.)	- Co-operation/dedication for the project - Working out of plans
Inhabitants in quarters involved (divided in type of house)	- Co-operation
Authorities/organisations in the municipality (2)	- Support (for inhabitants) - Co-operation, publicity
Local, regional press	- Support, publicity

1 - Neighbour municipalities, co-operation area, district, but also processers and transporters
2 - Schools, libraries, environmental groupings and other interested groupings, church halls, and local organisations
3 - Publicity organs are amongst others the quarter newspaper, local and regional newspaper, advertisement papers, the local radio or televisions stations.

SCHEDULE 8 RECOMMENDED SEPARATION RULE FOR VGF-WASTE
Separation rule : What is VGF-waste?
- Foliage, peelings and remainders of vegetables, fruit and potatoes - All left-overs, meet and remainders of fish, among which gravy and (fish-)boans - Rinds - Egg shells - Coffee-filters, coffee-grounds, tea-bags and tea leaves - Peanut- and nut-shells - Cut flowers and indoor plants, attached potting compost(only small quantities) - Muck of pets (but no cat's box grain or sand) - Grass, straw and leaves - Small lopping-waste and short-cutted branches, remainders of garden plants - A newspaper used during the peeling of potatoes, but no large quantities of newspapers

SCHEDULE 9 : MATERIALS THAT MAY CAUSE DOUBTS FOR INHABITANTS	
MAKES PART OF THE VGF-FRACTION	MAKES PART OF THE REMAINING FRACTION
Gravy, fat Boans Fish-boans Rinds Newspaper of potatoe-peeling Small quantities of compost (attached to plant) Nuts, pits	Ashes of the fire place Ashtray Cat's box grains Sand of bird-cage Vacuum cleaner bags Dog-, and cat hairs Diapers Paper Milk-pack

INSTRUCTION TO THE MANAGERS AND POLICY CONTRIBUTORS

1. BEFORE THE DECISION-MAKING

- Provide instruction material of other tests;
- Excursions to other projects;
- Show of video- or slide-production (made at other projects)
- Visit exhibitions

2. STAGE OF DECISION-MAKING

- Present and amplify a well-reasoned policy concept for the separate collection of the VGF-waste.

3. AFTER THE DECISION-MAKING

- Organise an instruction meeting, amplify plans, ask for suggestions.

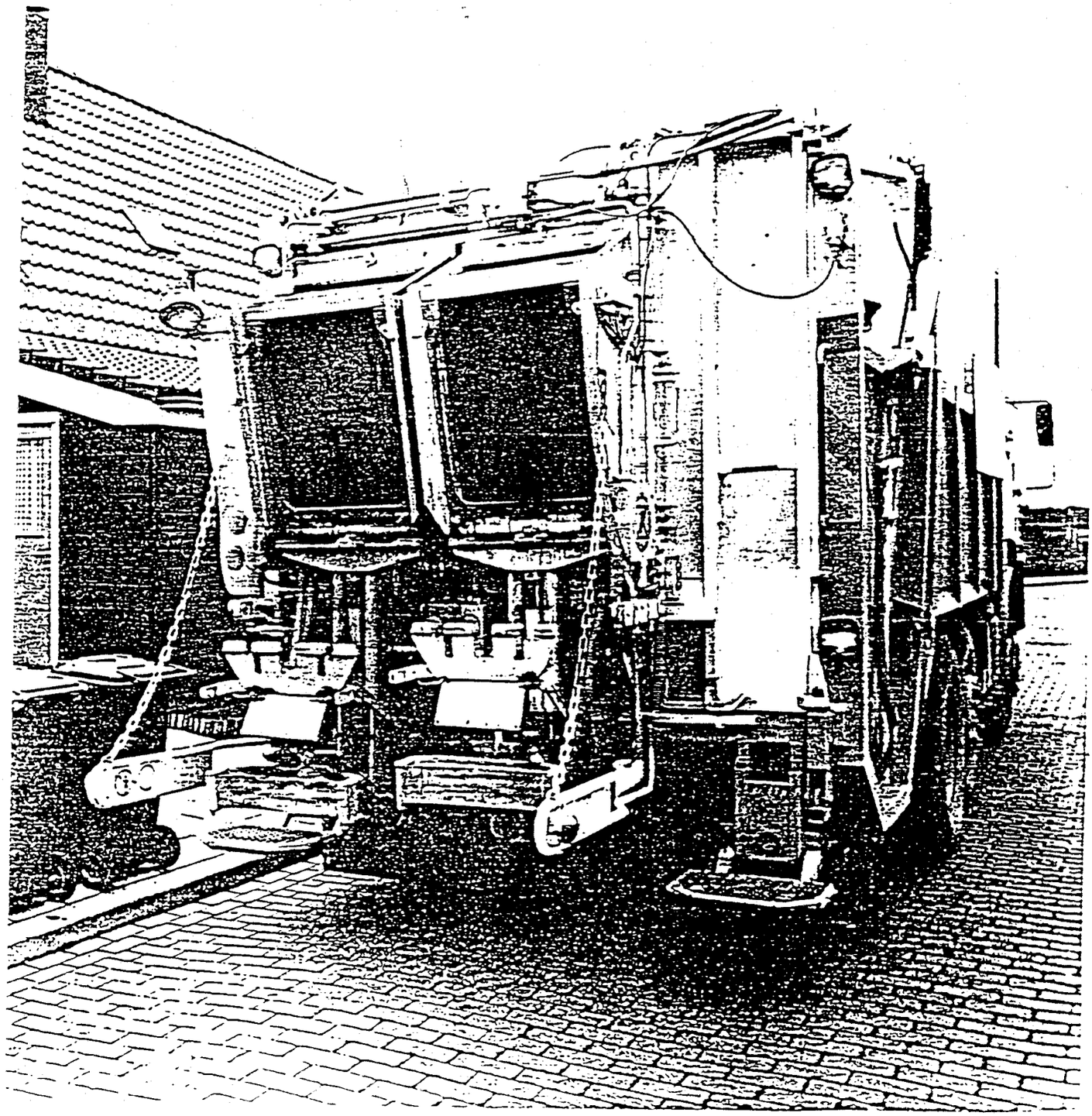
4. START COLLECTION

- Invitation for an official starting manifestation;
- Provide an information portfolio (with all instruction material, and news paper-cuttings about the intended project).

SCHEDULE 10: VGF AND REMAINDER KG/CONNECTION PER WEEK		
MUNICIPALTY	REMAINDER WASTE KG/CONNECTION	VGF-WASTE KG/CONNECTION
AMSTERDAM:	11	3,4
MIXED URBAN		
APELDOORN:		
LOW-RISE	10	7,5
HIGH-RISE	12	4,4
NUENEN:		
LOW-RISE	10	6,5
PURMEREND:		
LOW-RISE	11,5	7,6
HIGH-RISE	12	4
SOW:		
RURAL	8,8	9,7
URBAN	9	7,4
BIOCON	8,8	6,5
QUARTERS		
EDE:		
(BIOCON)		
LOW-RISE	11	5,5

ATTACHMENT 5

SEPARATED 2 BIN SYSTEM

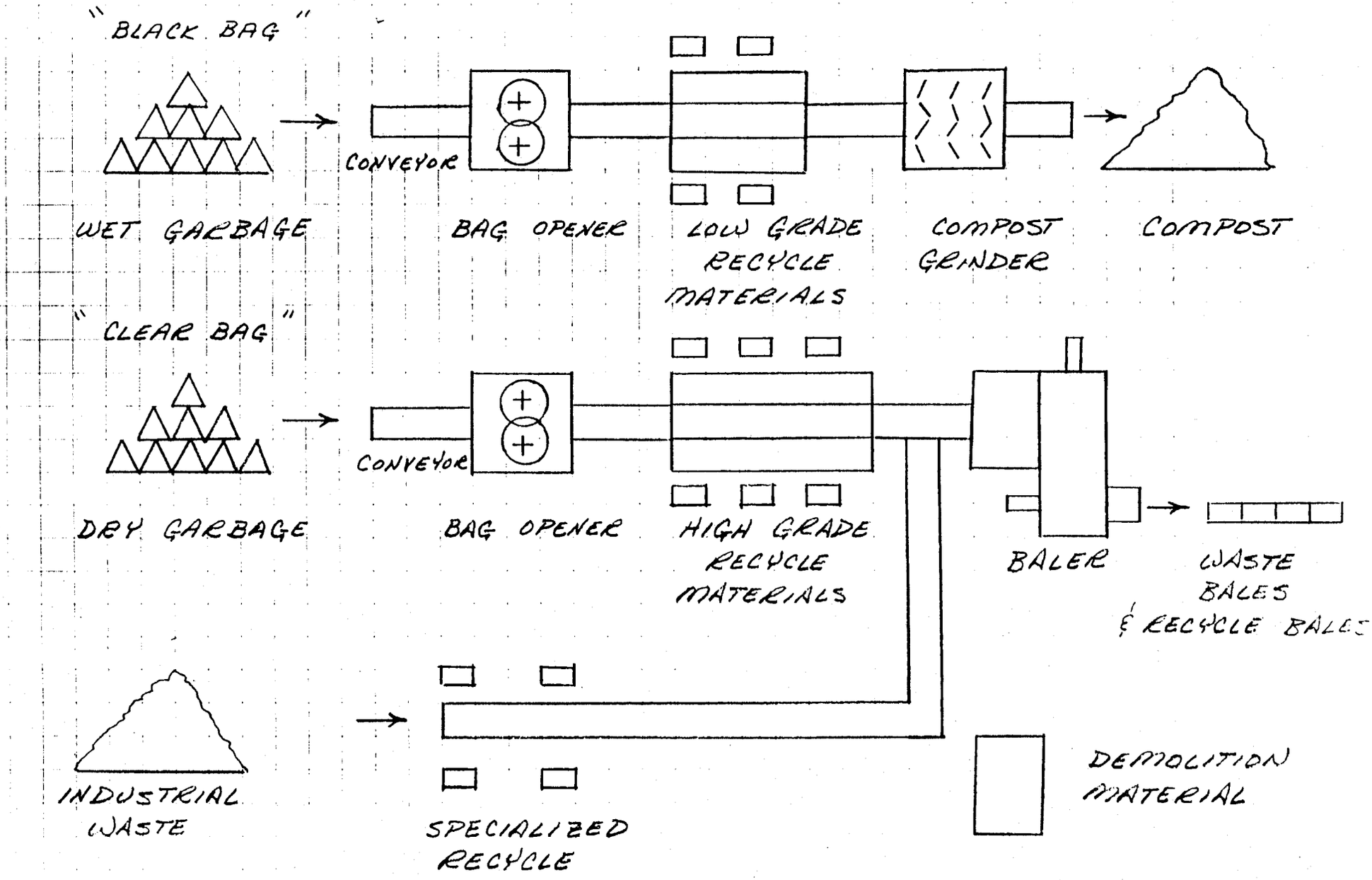


RECYCLE FACILITY

ATTACHMENT

SCHEMATIC

HAYWOOD COUNTY



KOOTENAI COUNTY
SOLID WASTE DEPARTMENT

500 GOVERNMENT WAY
C-9000
COEUR D'ALENE, IDAHO 83814-1973

OFFICE (208) 769-4402
FAX (208) 667-8534

October 1, 1990

Mr. Gary McKay, P.E.
R.C.F., Inc.
General Contractor - Crane Service
211 W. Main Street, P.O. Box 157
Hazelwood, NC 28738

Dear Mr. McKay,

Regarding our conversation on September 24, 1990 about our new landfill, I would be happy to inform you of our situation.

We are building a landfill about 17 miles south of Coeur d'Alene, Idaho. This site is surrounded by farm land and forests. We have a high population of wildlife in the area, including bear, elk, and whitetail deer. Since we have a lined site, we must restrict access to our trash cell, be it human or wildlife. Therefore, we have placed a 8' tall chainlink fence around our cell. We feel that this fence will keep bear and other wildlife off our liner.

I hope this information is helpful to you.

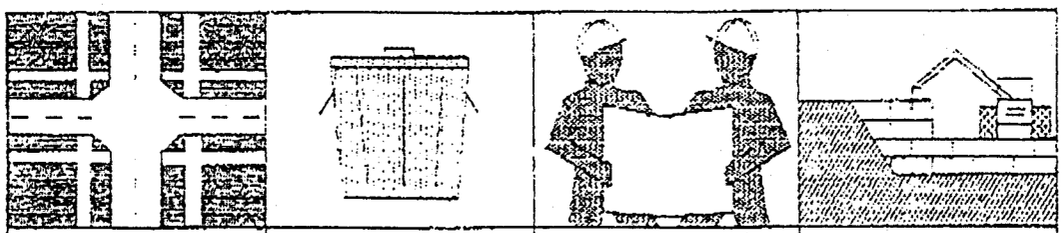
Sincerely,

Paul Jacobson
Assistant Operations Supervisor

PJ/bw

CITY OF SHAWANO
DEPARTMENT OF PUBLIC WORKS

(715) 526-3512
2905 E. RICHMOND STREET SHAWANO, WISCONSIN 54166



Director of Public Works
Rick J. Stautz, P.E.

Engineering Technician
Scott Kroening

Street Superintendant
Donald L. Pedersen

Mr. Gary D. McKay, P.E.
R.C.F. Inc.
P.O. Box 157
Hazelwood, North Carolina 28738

October 1st, 1990

Dear Mr. McKay,

I am writing in reply to your request for information on our balefill operation and our experience in dealing with black bear.

Shawano is a city with a population of approximately 7,500. With the recent changes in state and federal solid waste disposal regulations most town dumps in Shawano County have closed. The balefill serves as the waste disposal site for the city as well as most of the rest of Shawano County.

We measure the density each time we bale by weighing a bale. During the last six months our density has averaged 1220 pounds per cubic yard. The baler can make the bales more dense but, we are limited by the lifting capacity of the "iron mule" which we use to transport and place the bales.

With the solid waste compacted into bales we do not have problems with animals digging through the waste. Black bear are rarely seen in the City, but there are a few located in the less populated areas of the county. With daily cover of the garbage at the town dumps we have not experienced bear problems.

I hope this information will help you in your review of balefills. Should you have any further questions, please feel free to call.

Sincerely,

Rick J. Stautz, P.E.
Director of Public Works

RCF
CONSTRUCTION COMPANY

R.C.F., INC.
General Contractor - Crane Service
211 W. Main Street • P.O. Box 157
Hazelwood, North Carolina 28738
(704) 456-9570

Gary D. McKay, P.E.
President

October 12, 1990

RECEIVED
OCT 15 1990
Tribble & Richardson, Inc

Tribble & Richardson, Inc.
4020 Westchase Blvd., Suite 515
Raleigh, North Carolina 27607

ATT: Dr. Richard Rust

Dear Dr. Rust:

On October 4, 1990, Trudy Measer and I met with Joffery Brooks of the North Carolina Wildlife Commission in regard to a Bear Management Plan for the White Oak Landfill in Haywood County. As you know, the Solid Waste Section had requested that we have this meeting to address the potential bear problem at this site.

Mr. Brooks had two suggestions that he thought would be valuable to incorporate into the plan. The first would be to remove putrescible waste from material going to the landfill. The second idea would be to enclose the bale cell with a fence suitable to deter any bear that might pass through the area. A possible fence configuration might be an eight foot chainlink with an electric fence attached to it near the bottom.

As you know, we have previously researched both of these ideas and have found both to be feasible. Therefore, we feel that they should be incorporated into the overall design of the county's Waste Management Plan.

Sincerely,

Gary D. McKay, P. E.
Haywood County
Landfill Engineer

cc: Chip Killian
Teddy Rogers
Bill Meyers
Trudy Measer

REPORT ON SOURCE SEPARATION OF FOOD WASTE IN HAYWOOD COUNTY, NORTH CAROLINA

SEPTEMBER 26, 1990

BY: GARY D. MCKAY

Haywood County is faced with a unique problem at its proposed White Oak Landfill. The site is approximately 2 miles from the Cataloochee area of The Great Smoky Mountain National Park and about 3 miles from the "Twelve Mile Strip" area of the Pisgah National Forest. Both of these areas provide habitat for the Black Bear and are used as relocation areas for "problem" bears from other regions. Environmentalists and organized conservation groups have pointed at the White Oak site as a threat to the existence of the bear in Western North Carolina. Their claim is based on historical facts that bears are attracted to open garbage dumps and that bear-human contact at the dumps then cause problems. The bear is generally the loser when such problems arise.

The sanitary landfills and the balefills that are operated today do not furnish the same attraction as an open dump, but they still have an odor that bear-lovers claim is a magnet for bears. Research does not indicate that this potential bear problem is unmanageable. Langlade County and Shawano County in Wisconsin have operated balefills in areas with large bear populations. These balefills have been open for a combined fourteen years and have not attracted any bears at all (SEE ATTACHMENT 1). Kootenai County, Idaho is presently siting a sanitary landfill after operating a balefill for eleven years. The new landfill is seventeen miles out of town and adjacent to the Coeur D'Alene National Forest. Their experiences indicate that bears are not a major problem at these facilities, but they will use an eight-foot high chain link fence around their 6 acre cells as a final deterrent.

What odor and how much odor attracts a bear is debatable. However, it is a fact that the reason bears stay at landfills is because there is a source of food. Sanitary landfilling reduces the food source when daily cover is placed over the trash. Baling further reduces the available food by compressing it to a very high density. Elimination of the food waste in the landfill would eliminate the reason for the bear to be there.

The idea of removing food waste from the total waste stream may seem farfetched; but, in reality, that practice is common in Europe. In the Netherlands, landfilling is impractical because of a high water table. The Dutch find it necessary to maximize recycling to minimize waste. By requiring source separation of food waste, recyclable material remain uncontaminated at the recycle facility. Therefore, high-grade, top-price materials are removed for recycling; and the food waste produces an uncontaminated, desirable compost. Participation in the Netherlands program is in the range of 90% (SEE ATTACHMENT 2). The key to this success rate is an effective education program (SEE ATTACHMENT 3). Experience has shown that approximately 10% of household waste is food and organic waste (SEE ATTACHMENT 4). This figure represents about 7 tons per day for Haywood County. Equipment is available for the door-to-door pickup of source-separated wastes (SEE ATTACHMENT 5), and Haywood County has the capability for efficient control of source separation through its existing manned convenience center system. Also, the County has an appropriate means of public education through its "Keep America Beautiful" Agency.

CONCLUSION

Haywood County is mandated through the Solid Waste Act of 1989 to recycle 25% of its waste stream. Two factors are important in accomplishing that goal: there must be a recycle facility, and there must be a market for the material. The market will depend on the quality of the product, i.e. recyclables. Therefore, there is an advantage in source separation of food wastes to achieve top quality recycling at the facility. This material would then be composted to count toward the 25% recycling requirement. Once this is done, waste not composted and not recycled would be baled to maximize landfill space, but the bale would contain no food waste. As a result, the bear issue to an important degree, is resolved in the recycle process (SEE ATTACHMENT 6).

COMPOSTING MUNICIPAL SOLID WASTES

Lesson Two of the Waste Age*/University of Wisconsin composting course gets right to the heart of the matter.*

Composts can be produced from the decomposition of any biodegradable organic material. Wastes that are commonly composted include leaves, grass clippings and other yard wastes, food wastes, sewage sludges, bark and wood wastes, animal manures, etc.

Municipal solid wastes (MSW) can also be composted; approximately 70% (by weight) of MSW is decomposable organic material.

Scientific principles involved in the composting of all of these materials are the same; these were discussed in Lesson One of this course (July, 1989).

Composting or co-composting?

Composting and co-composting are two commonly used terms, the first of which can include the second. While composting generally refers to the decomposition of solid wastes, co-composting is the composting of two or more wastes with different characteristics. For example, the composting of liquid/dewatered sewage sludge with MSW is co-composting.

Composting or co-composting of MSW requires three major steps:

- Process wastes in preparation for composting.
- After the preparatory step, composting is accomplished using one of several technologies, all of which attempt to create environmental conditions that are essential to promote rapid microbial activity and decomposition.
- After composting is nearly complete, further curing (completion of the composting process) and additional processing may be necessary in preparation for markets.

Major functions of pre- and postprocessing are to improve the rate of composting and improve the physical and chemical characteristics of the compost.

By AGA S. RAZVI, PHILIP R. O'LEARY, and PATRICK WALSH

Razvi is a professor in the department of soil and water, University of Wisconsin-Stevens Point; O'Leary and Walsh are solid waste specialists with the University of Wisconsin-Madison. For additional information regarding this correspondence course, write: Phil O'Leary, Dept. of Engineering Professional Development, University of Wisconsin-Madison, 432 N. Lake St., Madison, WI 53706. Phone: 608/262-0493.

Preprocessing of MSW

The choice of MSW preprocessing steps used depends on the composting technology to be used, the waste composition and physical properties, and the quality of final product desired. Typically, the following processes may be necessary: bulky item removal; particle size reduction; magnetic removal of metals; and moisture addition and mixing.

Removal of bulky items: It is desirable to remove all bulky, noncompostable items — such as furniture, white goods, rugs or carpets, and large toys — before beginning the composting process.

If allowed to go through the composting process, these materials will add to processing time and will take up unnecessary space in the compost mass, lessening the process's efficiency. The noncompostable, bulky items may either be removed at curbside during collection or at the processing site. These noncompostables may be either recycled or landfilled.

Particle size reduction: Particle size reduction is an important and necessary aspect of composting MSW: It increases the surface area of the wastes, which allows a more complete mixing of liquids with the MSW. This increases the opportunity for microbial contact with the carbon source to be decomposed. Particle size reduction also improves the waste-handling characteristics.

One important aspect of particle size reduction is to maintain a good mix of large and small particles, so as to maintain enough void space to allow air to circulate in the composting mass. The particle size requirements depend on the type of air circulation system used.

In addition, particle size reduction allows separation of particles based on their density, through air classification. Preprocessed MSW from refuse-derived fuel (RDF) has been used as a bulking agent in the composting of sewage sludges. RDF itself can also be composted with the addition of liquid sludges or other sources of moisture.

Particle size reduction can be accomplished by tumbling the wastes in a rotating drum or shredding them using hammermills or shear shredders. Hammermills, because of their high speeds, can process larger quantities of wastes per hour than shear shredders with similar power. However, the shear shredders offer some advantages: less noise and vibration, less dust, reduced maintenance, and a lower probability of explosions.

Table One
Comparison Of Three Composting Technologies For MSW

Technology	Time To Produce End Product	Odors?	Leachate?	Amt. Of Land Required
Windrows	2 - 6 months	Some	Yes	Largest
Static pile	6 - 12 weeks	Some to none	Yes	Smaller
In-vessel	1 - 2 weeks	None	No	Smallest

Size reduction in a rotating drum is accomplishing by the tumbling action of the wastes against a series of knives, chains, or spikes, which protrude from the drum's inner wall.

The abrasive properties of any glass or minerals in the wastes, the pulping action of the liquids added as a moisture source for composting, and the heat produced in the composting process all aid in the size-reduction process.

Screens: Screens may be used to separate particles larger than a desired size after the MSW has been shredded. Screening of the shredded solid wastes before composting results in a more uniform composting mixture (for MSW and added liquids); this allows a more uniform rate of composting for all particles.

Screening is generally optional before composting, but is an essential step after the composting process has been completed. The post-compost screening is used primarily for separation of the noncomposted fraction from the compost, or to meet certain size requirements of compost markets.

Magnetic separation: Normally, magnetic separators are placed atop conveyors that carry the shredded wastes. The magnetic separator may be a belt-type unit or a drum-type unit. Ferrous metals removed by the magnet may either be recycled or removed to a landfill.

Moisture addition and mixing: For the composting process to proceed at a rapid rate, all environmental conditions for the microorganisms must be met. These conditions must be uniform throughout the mass of wastes being composted. The waste solids, liquids, and microorganisms must be in intimate contact with each other; the extent of this contact is determined by the amount of liquid added and thoroughness of liquids and waste mixing.

Typically, 50% to 60% moisture is considered optimum for the composting process. Solid wastes may contain between 20% and 30% moisture, and therefore will need to be supplemented with an additional moisture source.

Water is the most commonly used moisture source. Other sources may include sewage sludges (70% to 98% water) or high-moisture-containing wastes from food processing industries. These high-moisture wastes may contain plant nutrients, especially nitrogen, that are lacking in MSW.

Liquids other than water should be used only if one of the objectives of the composting operation is to dispose of these liquids, as well.

Although there may be benefits to disposing high-moisture wastes via composting, decisions to use these liquids should be approached with caution, especially with relation to pH level, salt concentrations, and the presence of high concentrations of heavy metals. These may affect the composting process, as well as compost product quality.

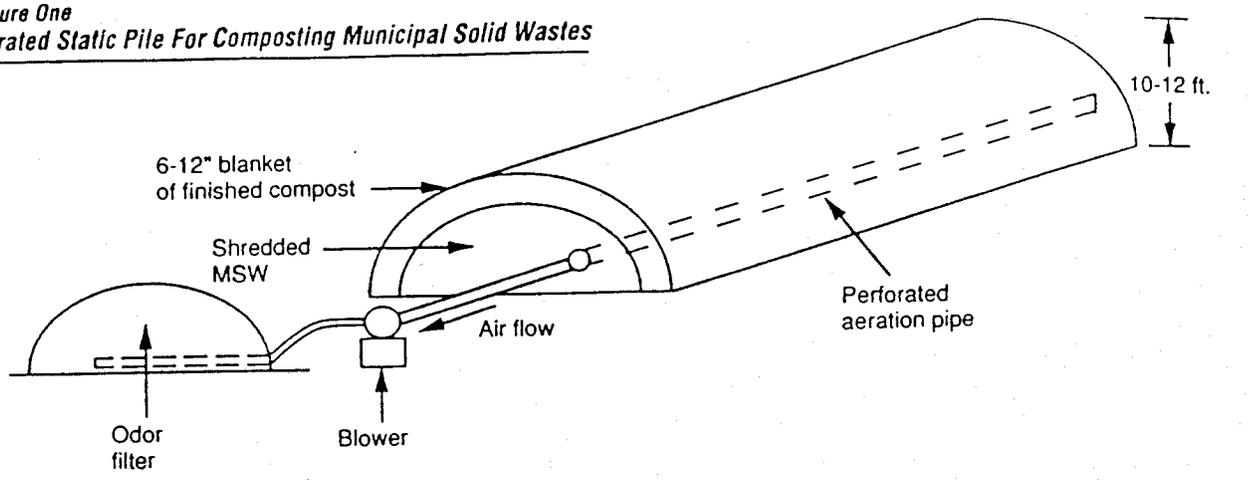
Several methods are used to mix liquids with MSW. Mixers equipped with a series of rotating paddles or augers placed in a fixed bin are most common for mixing shredded MSW. Shredded MSW can also be mixed on a flat surface, such as a concrete floor, using machines such as front-end loaders or equipment fitted with a series of rotating augers or paddles. In composting technology that uses a rotary drum, the drum serves as a shredder and a mixer.

After the moisture has been added and the mixing is complete, the mixture is ready for composting.

In some composting technologies there may be a need to add a source of acclimated microorganisms (culture) during the mixing process to get the composting process off to a rapid start. Operational composting plants may use partially or completely composted wastes as the culture source. Continuous feed in-vessel-composting plants may have enough microorganisms in the vessel to serve as a culture.

For plants in the start-up phase, the MSW should contain enough microorganisms to get the composting process started.

Figure One
Aerated Static Pile For Composting Municipal Solid Wastes



Composting technologies

Several composting technologies are available, some proprietary and some nonproprietary. Proprietary technologies may offer pre- and postprocessing as a complete composting package.

The technologies vary in the method of air supply, temperature control, mixing/turning of the mass being composted, and the time required to produce a finished product. Their capital and operating costs may vary as well. All composting technologies attempt to reduce volume, destroy pathogens and weed seeds, and stabilize the organic matter while converting it to compost.

Composting technologies can be classified into three general categories: windrow, aerated static pile, and in-vessel.

Windrow composting

A windrow is a pile, triangular in cross-section, whose length exceeds its width and height. Typically, piles 7 feet high and 14 to 16 feet wide at the base are constructed. The height of the pile and the width of the pile at its base are determined by the equipment available for turning the pile.

Turning the pile provides the primary means of active aeration, although passive aeration from the atmospheric air occurs at all times. The windrow dimensions should be such as to allow conservation of the heat generated, while allowing diffusion of air to the deeper portions of the pile.

Piles may be turned as frequently as once per week. Turning of piles also allows an opportunity for the materials at the surface of the windrow to be placed within the windrow, and, therefore, undergo composting. When piles are turned, heat is released, in the form of steam. If inner portions of the pile are subject to low-oxygen conditions, odors may also result when this portion of the pile is exposed.

Machines equipped with augers, paddles, or tines a used for turning the piles. Some windrow turners are capable of supplementing the pile with water if neces Smaller operations may choose to use front-end load

Temperature control in the windrow is more diffic comparison to other technologies. Minimum tempera of 132° F should be maintained to ensure pathogen d tion. Weed seeds are also destroyed at these temperat

Generally, the time required for composting using windrow method is longer than in other methods. Thi primarily due to the fact that the other methods keep supply and temperature within the pile at optimum le MSW composting in windrows may take two to six months. Because of the long detention times required area requirements are also high.

Windrows must be placed on a paved surface, to a ease in turning piles. Piles may be placed out-of-doo this may create free liquid runoff, or leachate, from n precipitation (although piles whose initial moisture c was within the optimum range normally do not prod leachate). The leachate/runoff must be collected and treated, or reused with a batch of incoming wastes. T avoid these problems, piles may be placed under a rc this adds to up-front costs.

Windrow composting may be used in combinatio an in-vessel composting technology. Generally, the row method is used for curing (finishing) the compo

Aerated static piles

The aerated static pile method is a nonproprietary co posting technology. It requires that the composting r (or preprocessed MSW mixed with liquids) be place piles that are mechanically aerated. See Figure One.

These piles are placed over a network of pipes, which are connected to a blower. The blower supplies air for composting; air may be supplied under positive or negative pressure.

Piles are broken up for the first time only when the composting process is nearly complete. The compost is then taken through a series of postprocessing steps.

Air-supply blowers may operate by forcing air into the pile or drawing air out of the pile. The blowers are generally controlled by a timer or a temperature feedback system similar to a home thermostat.

Air circulation in the compost piles provides the needed oxygen for the composting microbes and also prevents excessive heat buildup in the pile. Removal of excess heat and water vapor allows the pile to cool, so as to maintain optimum temperatures for microbial activity. The controlled air supply to the piles allows the construction of large-sized piles, thereby decreasing the need for large land areas.

Aerated static pile composting can be performed under a roof or in the open; composting in the open has the same disadvantages for this method as it does using a windrow.

Odors from piles are generally minimal. Odors are common when piles are being turned and the composting materials within a pile are exposed to the surrounding air. The aerated static piles are normally turned only when the composting process is nearly complete. Odor traps or filters can be used to curtail odor migration.

Temperatures in the inner portion of a pile are normally adequate to destroy a significant number of the pathogens and weed seeds. The surface of the piles, however, may not reach the desired temperatures for the destruction of pathogens (as the piles are not turned); this can be overcome by placing a layer of finished compost 6 to 12 inches thick over the compost pile. The outer layer of finished compost acts as an insulting blanket and helps maintain the needed temperatures.

Aerated static pile composting has been used extensively for sewage sludge. It has also been used successfully for composting MSW, yard wastes, and industrial organic wastes. The aerated static pile is generally less-capital-intensive than either an in-vessel system or a windrow system. However, there may be continued electrical costs to supply air to the compost piles.

The time required for composting using this technology ranges from six to 12 weeks. The land requirements for this method are lower than those of a windrow method of composting.

In-vessel composting systems

In-vessel composting involves placing the materials to be composted in a chamber or vessel in which adequate mixing, aeration, and moisture control are provided. There are several in-vessel systems available; most are proprietary.

Some in-vessel systems require minimal preprocessing of MSW; others require extensive preprocessing.

Common in-vessel systems include drums, silos, digester bins, and tunnels. These vessels may be single- or multi-compartmentalized units. In some cases the vessel rotates; in others the vessel is stationary, and a mixing/agitating mechanism moves the materials around. Most in-vessel systems are continuous-feed systems, although some operate in a batch mode. All of these systems require additional processing after the material has been discharged from the vessel.

A major advantage of in-vessel systems is that all environmental conditions can be carefully controlled, allowing for rapid composting. The materials to be composted are frequently turned and mixed to allow homogeneity in the compost and promote rapid oxygen transfer.

In-vessel systems offer the advantage of short retention times, ranging from less than one week to as much as two weeks. This reduces land needs considerably, compared to the other two systems. The vessels are generally placed in a building. These systems, if properly operated, produce minimal odors and little or no leachate.

Air supply can be precisely controlled. Some units may be equipped with oxygen sensors, and air may be preferentially supplied to that portion of the vessel that is deficient in oxygen.

Postprocessing

Postprocessing may consist of a series of steps that either improve the stability of the compost or alter the physical properties to meet market needs. Depending on the degree of preprocessing and the technology used for composting, this step may vary.

Commonly, one or two screening steps, curing of the compost, and additional grinding are used to prepare the compost for markets.

Screening: Screens are used to separate out the compost from the noncompostable fraction. During the composting operation, the compostable fraction undergoes a significant size reduction, while the noncompostable fraction undergoes little or no size reduction.

Screening can be done before or after the curing process. Depending on the initial shredding process and the size of screen used, some larger compostable particles may enter the noncompostable stream during screening. One or more screens may be used as in an initial coarse screening, followed by a fine screening step. The noncompostable fraction retained on the coarse screen is sent to the landfill;

compostable materials retained on finer screens may be returned to the beginning of the composting process.

Screened compost may contain inert particles, such as glass or plastics, that may have passed through the screen. Generally, such inert materials are present only in small quantities.

Curing: Curing allows the compost to attain a biologically stable condition. Microbial activity during curing continues, but at a slower rate than during actual composting. As the pile cures, less heat is generated by the microorganisms, and the pile begins to cool down.

Cooling of piles does not necessarily mean that the curing is complete; it is a sign of reduced microbial activity, and that could result from a lack of moisture or inadequate environmental conditions (moisture, pH, etc.).

Curing piles may be force-aerated, or may use passive aeration with occasional turning.

Curing may take from a few days to several weeks or months. The cured compost is then prepared for markets. Depending on market needs, the compost may have to pass through a shredder and an additional screening step.

Savings in landfill space

Composting MSW does not eliminate the need for landfills. However, only 30% to 40% of incoming MSW will have to be landfilled after composting; this amount could be reduced still further in communities with active recycling programs.

The amount of compost produced is 25% to 35% (by weight) of the incoming wastes. The remaining weight is lost to the atmosphere in the form of carbon dioxide gas and water.

Currently, there are at least four MSW composting facilities operational in the United States. An additional 15 facilities are said to be in the design, construction, or advanced planning stages.

Next month: Lesson Three will describe yard waste composting. ▮

Spring Relief Design Approval

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Environmental Management
512 North Salisbury Street • Raleigh, North Carolina 27604

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

George T. Everett, Ph.D.
Director

October 24, 1991

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919/395-3900

Winston-Salem
919/896-7007

M E M O R A N D U M

TO: William L. Meyer, Director
Division of Solid Waste Management

FROM: for George T. Everett

SUBJECT: Proposed Haywood County Sanitary Landfill
White Oak Site
Addendum to the Permit Application

The Division of Environmental Management has reviewed the subject addendum to Haywood County's White Oak Landfill Application and offers the following comments:

Groundwater Quality

1. The site is in a groundwater discharge area evidenced by the spring discharge down the middle of the site, and the Pigeon River bordering the downgradient side. These features should limit groundwater contamination in the event of liner failure.

2. The spring area and the stream flowing from it are to be excavated to a depth of up to 14 feet in the upper section. A drain line will be installed in the bottom of the excavation and covered with gravel to the top of the water table. The gravel will be covered with at least four feet of compacted soil, a one foot thick bentonite and soil liner mixture, a synthetic liner, and gravel. This drain could serve as a point of contaminated groundwater treatment in case of liner failure.

3. After the synthetic liner is installed, the water table on the site should decline as a result of the restricted recharge to the groundwaters. The increased separation distance to the water table should further reduce groundwater contamination potential.

4. There is very limited groundwater use in the area with no groundwater supplies being located directly downgradient.

Water Quality

1. The site of this proposed landfill cell is located entirely on the Bill Davis Property with the spring in question found mid cell (laterally) and at the beginning of the bottom third of the cell which lays on a south to north grade toward the west bank of the Pigeon River. The spring is further located approximately 600 feet from the Pigeon River and 1/4 mile north of the nearest occupied dwelling. The map attached to the addendum appears to accurately depict the cell/spring location.

2. The Tribble and Richardson proposal for segregating this stream from interference by the landfill cell appears reasonably sound as described in the addendum with proper monitoring and diversion of all remaining surface water from the proposed cell. Essentially, the spring will be relieved at the point of maximum known flow and transported via an underdrain system under the final 1/3 of the cell (with a two layered liner; clay and composite) to a manhole which can then either divert the flow to the leachate collection pond for proper treatment and disposal (if monitoring shows contamination) or to an erosion control basin for release to the Pigeon River. Collection of the spring, minimization of the recharge area (as will result from development of the upper part of the cell), and construction of an underdrain system to transport this flow from the area is an established means of handing these waters. The question which will remain unknown until actual project development is the extent (volume) of spring flow to be intercepted under the cell and the capability of the leachate collection pond of handling the entire stream flow if larger than expected volumes appear. Haywood County will need to be prepared to deal with such an occurrence as use of this landfill progresses.

3. The proposed addendum to the White Oak Landfill as means of handling spring-fed surface waters on this property (first cell development) and associated permit should include a condition that requires monitoring of parameters normal and specific to landfill wastes on a triannual basis, but not less than once per year.

If there are any questions, please advise.

GTE:ja/White.

cc: Roy Davis
Perry Nelson
Steve Tedder
Permit Files

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Environmental Management
512 North Salisbury Street • Raleigh, North Carolina 27604

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

George T. Everett, Ph.D.
Director

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November 6, 1991

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Wilmington
919/395-3900

Winston-Salem
919/896-7007

Mr. Jack Horton
Town Manager/Waynesville, NC
420 North Main Street
Waynesville, N.C. 28786

Dear Mr. Horton:

Enclosed per your request is a copy of DEHNR-Division of Environmental Management comments sent to William L. Meyer, concerning the Haywood County Landfill. If I can be of any further assistance, please contact me at 919-733-3221.

JL:ja/Horton.

Sincerely,

Jeff C. Lautier
Hydrogeologist
Groundwater Section
Permits & Compliance

Attachments.

Appendix B

Geotechnical Data

SINCE
1881

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES • ENGINEERS & CHEMISTS
"OVER ONE HUNDRED YEARS OF SERVICE"

Post Office Box 2058
Asheville, North Carolina 28802
(704) 274-0742

December 8, 1988

Haywood County Board of Commissioners
c/o Jensen Engineering
Post Office Box 1818
Asheville, North Carolina 28814

Attention: Mr. George Jensen, P.E.

Re: Preliminary Subsurface Exploration
Proposed Haywood County Landfill
White Oak Township
Haywood County, North Carolina
F&R File No. P-70-613
Report No. 1

Gentlemen:

Froehling and Robertson, Inc has performed the preliminary subsurface exploration for the referenced project as authorized verbally by Mr. Ralph Owens of Jensen Engineering and we are submitting our findings herein. The exploration was performed to evaluate subsurface conditions as they pertain to site evaluation and the design and construction of the proposed landfill facilities. This report presents a brief description of our understanding of the project, the information obtained in the subsurface exploration and our conclusions and recommendations.

PROJECT DESCRIPTION

We have discussed the project with the Mr. George Jensen of Jensen Engineering and have been furnished site boundary plan showing the survey locations prepared by Gibson Land Surveying. We understand that the project is in the conceptual stages and specific details regarding site design have not been completed.

SUBSURFACE EXPLORATION

The subsurface exploration included the performance of eight soil test borings and eleven auger probe borings at locations selected by representatives of Jensen Engineering. The boring locations were established in the field by a representative of Jensen Engineering and the approximate boring locations are presented on a plan in the Appendix. The Appendix also contains Test Boring Records presenting the information obtained in the subsurface exploration, a key to the terms used in the Test Boring Records, and a brief description of the boring procedures used. The borings were drilled with a CME 55 truck mounted drill rig and were advanced using a 6-inch hollow stem auger. Soil specimens were obtained by standard split spoon and by bulk methods.

LABORATORY TESTS

Laboratory test included the performance of classification test (ASTM D-4318, D-421, D-2487), Standard Proctor moisture-density (ASTM D-698), and permeability of remolded specimens. The tests were performed on four separate bulk soils specimens obtained in the field from the auger spoils as directed by personnel from

Jensen Engineering. Results of the laboratory tests and descriptions of the test procedures are presented in the appendix of this report.

SITE DESCRIPTION AND SUBSURFACE CONDITIONS

The site of the proposed landfill is located near Hepco in White Oak Township in Haywood County, North Carolina. The site covers an area of approximately 108.9 acres south of Waterville Lake. At the time the soil test borings were made, the site was open pasture land bordered by forest. The site consists of gently rolling hills and shallow hollows. The site lies within the Blue Ridge Belt of the Blue Ridge Physiographic Province of North Carolina. The rocks underlying this area are of sedimentary and igneous origin but have been profoundly altered by the high heat and pressure associated with deep burial and tectonic movements which have affected them since their formation in late Precambrian time. The rocks most commonly encountered in the local area are mapped as metasediments of the Ocoee Supergroup. Chemical weathering of the rocks has produced soils which normally consist of silt with variable amounts of fine sand, and minor amounts of clay and fine mica.

Weathering of the bedrock may be accelerated by the presence of joints, fractures, or zones of easily weathered minerals in the rock. For this reason, the upper surface of the rock may be irregular and isolated boulders, pinnacles, and ledges composed of the more resistant materials may be encountered above the general soil/rock contact.

In some areas, the natural surface soils may consist of alluvium which has been formed by the deposition of water borne sediments on flood plains or in stream channels. The alluvial soils may consist of organic material, boulders, gravel, sand, clay, or

silt, either singly or in any combination. Because these materials have been deposited from either flowing or quiet waters, alluvial soils may vary greatly in consistency, composition, and character in both the horizontal and vertical directions.

Moderate to very high consistency residual soils were encountered from the surface to the total depth explored in each boring. The residual soils have been formed by means of chemical weathering of the metasedimentary rocks of the Ocoee Supergroup which forms the bedrock in this portion of the Blue Ridge Physiographic Province of North Carolina. The residual soils consisted of mottled reddish brown, purple, and grey SILT which contained variable amounts of sand and traces of fine mica and of silty SAND which contained traces of fine mica. The lines on the boring logs denote color or textural changes in the residuum. However, the residual soils are laterally discontinuous with textural changes expected with short distances. The penetration resistances ("N" values) ranged from 8 blows per foot to 50 blows per 6 inches.

Laboratory classification tests performed indicated that the residual soils are relatively fine grained with 100 to 98 percent of the material fine than the U.S. No. 4 sieve and 46.5 to 83.0 percent of the material consisted of silts and clays finer than the U.S. No. 200 sieve. The liquid limits ranged from 29 to 49 and the fines are nonplastic. The soils were classified as either a ML (low plasticity silt), or a SM (silty sand) by the Unified Soil Classification System. Maximum dry density as determined by a standard Proctor ranged from 101.5 to 110.2 pounds per cubic foot with the optimum moisture contents ranging from 15.8 to 20.0 percent. Natural moisture contents ranged from 13.5 to 20 percent. Permeability tests performed on remolded specimens compacted to densities ranging from 94.9 to 101.4 percent of the individual soil specimens respective Standard Proctor maximum dry density provided averaged permeability values ranging from 2.9×10^{-7} to 5.1×10^{-7} centimeters per second. The permeabilities were determined by an average of three tests on each remolded specimen.

ROCK - Weathered bedrock was encountered in borings B-1, B-3, and B-8 and depths of 35, 26, and 35 feet, respectively. The penetration resistances ("N" values) ranged from 50 blows per six inches to 50 blow per 1 inch penetration. Unweathered rock, as defined by rock which can not be drilled with auger drilling equipment, was encountered at boring B-3 at a depth of 37 feet.

Ground Water - Ground water was not encountered at the time the soils test borings were performed and not long term ground water observations were performed.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices for the exclusive use of Haywood County Board of Commissioners and their agents in the design of the proposed Haywood County Landfill to be constructed on the south side of Waterville Lake in the White Oak Township in Haywood County, North Carolina. No other warranty, expressed or implied, is made. Our conclusions and recommendations are based upon design information furnished to us, the information obtained in the previously described subsurface exploration, and our previous experience. These conclusions and recommendations do not reflect variations in subsurface conditions which may exist between boring locations or in unexplored portions of the site. Should such variations become apparent during construction, it will be necessary to reevaluate our findings based upon on-site observation of the conditions.

In the event that changes are made in the design or location of the proposed landfill site, the recommendations presented in this report shall not be considered valid unless the changes are reviewed by our firm and the conclusions of this report modified or verified in writing. We should also be given the opportunity

to review the design, grading plans, and applicable portions of the project specifications when the design is finalized.

We recommend that this report, in its entirety, should be made available to the prospective contractors for informational purposes. The Test Boring Records should not be separated from this report.

ACKNOWLEDGMENT

Froehling and Robertson, Inc. appreciates the opportunity to work with you on this project. If there are any questions regarding the information presented in this report, please do not hesitate to contact us.

Respectfully submitted,

FROEHLING AND ROBERTSON, INC.

Richard O. Ricks, E.I.T.
Geotechnical Staff

William H. Duhling, Jr., P. E.
Geotechnical Engineer

NORTH CAROLINA PROFESSIONAL ENGINEER 7808 WILLIAM H. DUHLING, JR.

Appendix

A P P E N D I X

Laboratory Test Results

Site Plan

Test Boring Records

Proctor Test Reports

Graphs

Descriptive Terms

Procedures

F&R File No. P-70-613
Report No. 1

LABORATORY TEST RESULTS

CLASSIFICATION TESTING

Sample No.	Depth ft.	Nat. W%	Limits LL	Limits PI	Sieve #4	Sieve #10	(% finer) #40	(% finer) #200	Classification
B-5	9-14	17.6	34	NP	99.0	95.6	74.4	55.1	ML
B-6	1.5-10	14.3	34	NP	99.7	94.7	76.9	46.5	SM
B-7A	0-10	13.5	29	NP	98.0	94.3	74.4	48.7	SM
B-7B	15-25	20.0	49	NP	100.0	98.5	94.9	83.0	ML

PERMEABILITY RESULTS

SAMPLE NO. Boring B-5, 9-14' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1900.5

Moist.: 20.6% DRY DENSITY (pcf): 104.3 COMP.: 98.2

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	10,440	5.5	3.0	$3.6 * 10^{-7}$
2	21	4,500	4.1	5.0	$3.7 * 10^{-7}$
3	21	3,720	3.5	5.0	$3.8 * 10^{-7}$
				k (ave)=	$3.7 * 10^{-7}$

F&R File No. P-70-613
Report No. 1

PERMEABILITY RESULTS (Cont.)

SAMPLE NO. Boring B-6, 9-14' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1896.0

Moist.: 19.9% DRY DENSITY (pcf): 104.6 COMP.: 94.9%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	28,140	13.2	3.0	$3.2 * 10^{-7}$
2	20	5,700	2.2	3.0	$2.6 * 10^{-7}$
3	20	52,920	21.6	5.0	$2.8 * 10^{-7}$
				k (ave)=	$2.9 * 10^{-7}$

SAMPLE NO. Boring B-7A, 0-10' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1918.7

Moist.: 20.7% DRY DENSITY (pcf): 105.4 COMP.: 100.5%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	10,380	7.7	3.0	$5.0 * 10^{-7}$
2	21	1,481	1.8	5.0	$5.0 * 10^{-7}$
3	21	3,240	4.2	5.0	$5.3 * 10^{-7}$
				k (ave)=	$5.1 * 10^{-7}$

F&R File No. P-70-613
Report No. 1

PERMEABILITY RESULTS (Cont.)

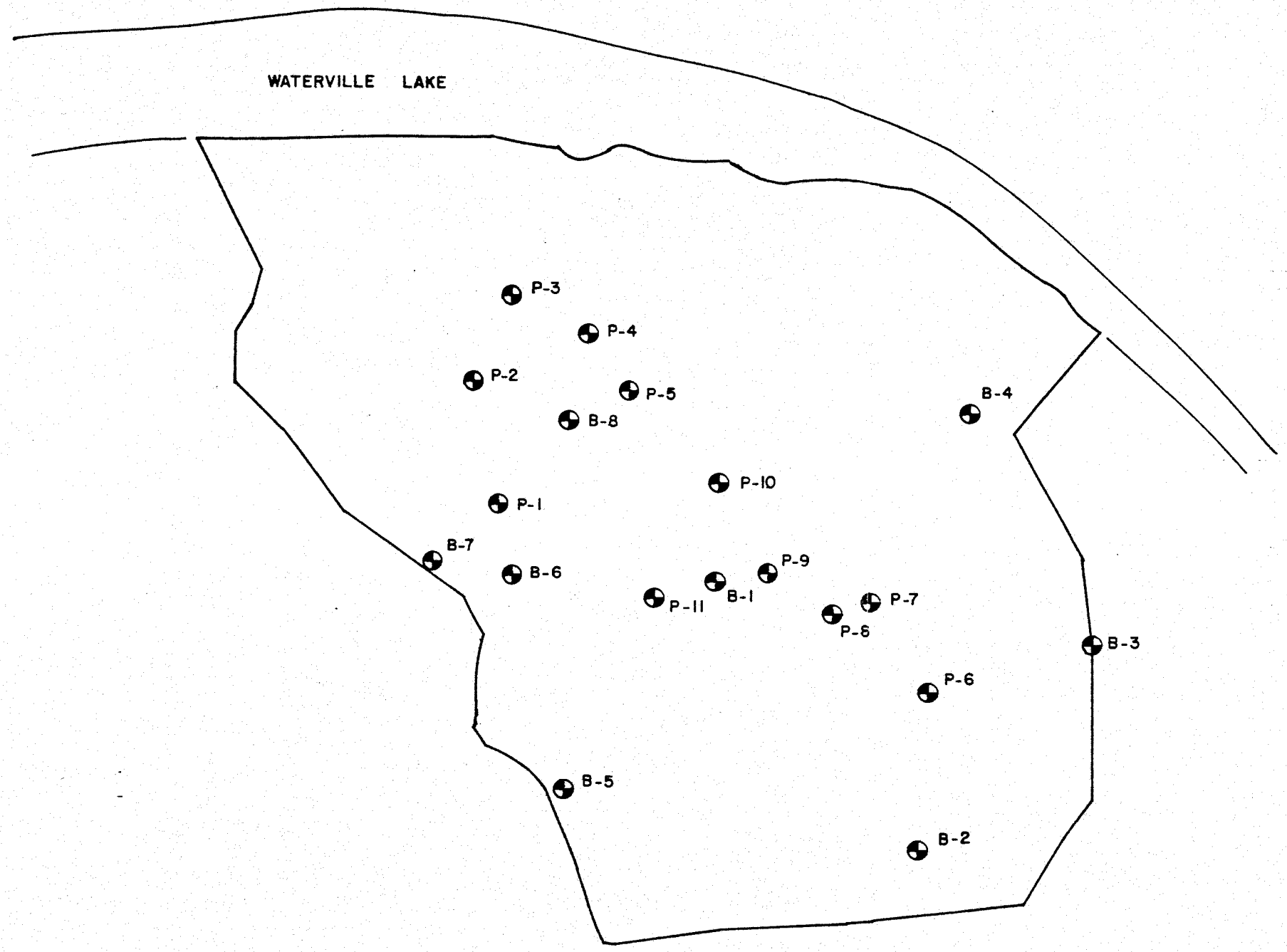
SAMPLE NO. Boring B-7B, 15-25' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1859.7

Moist.: 23.8% DRY DENSITY (pcf): 99.4 COMP.: 97.9%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	22,260	15.6	3.0	$3.8 * 10^{-7}$
2	20	5,820	3.3	3.0	$3.9 * 10^{-7}$
3	20	53,040	27.4	3.0	$3.5 * 10^{-7}$
				k (ave)=	$3.7 * 10^{-7}$



NORTH
(approx.)

LEGEND

B -() - LOCATION OF BORINGS
P -() - LOCATION OF PROBES

APPROXIMATE LOCATIONS OF SOIL TEST BORINGS

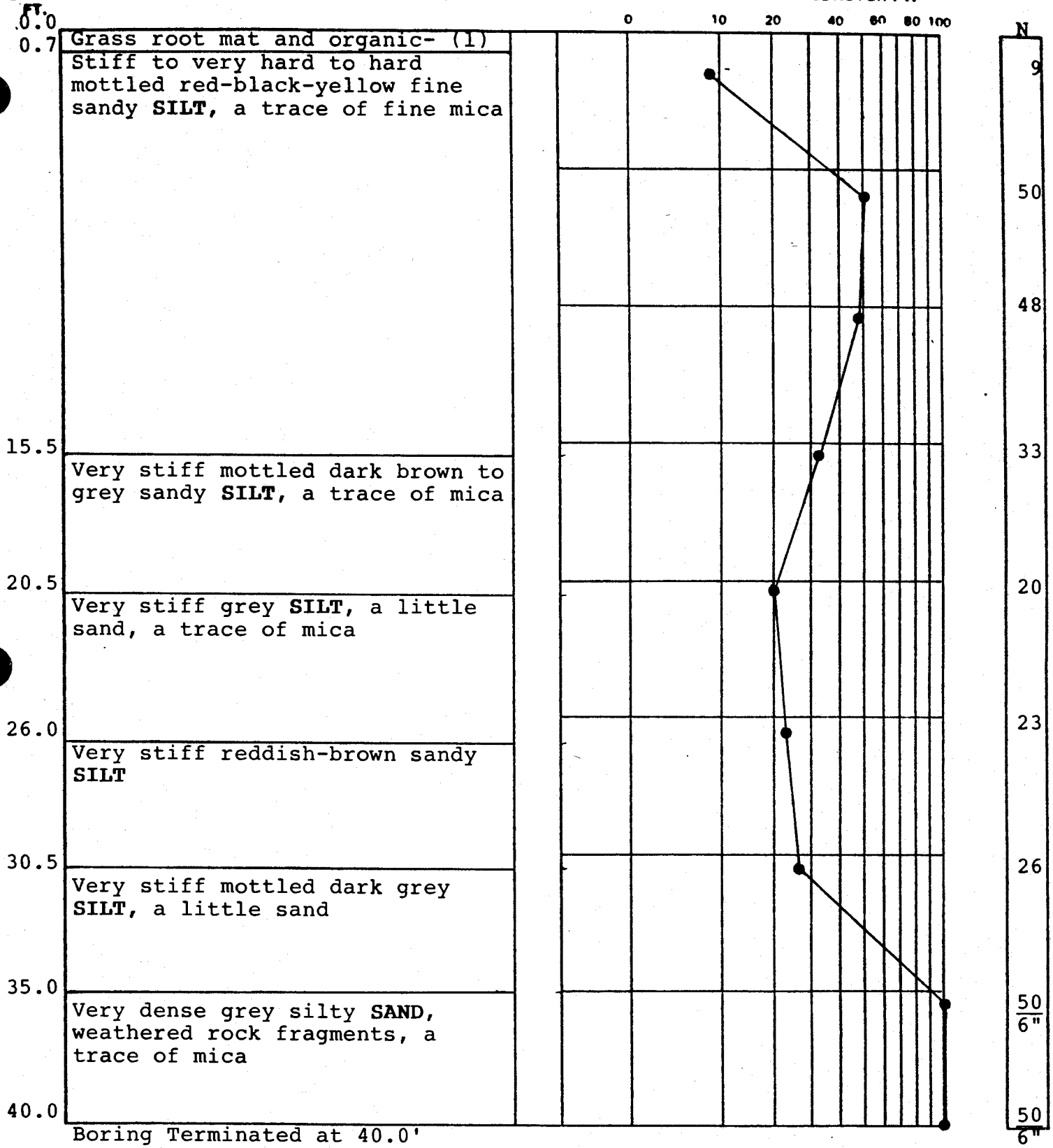
Made for: HAYWOOD COUNTY BOARD OF COMMISSIONERS
c/o JENSEN ENGINEERING

Project: PROPOSED HAYWOOD COUNTY LANDFILL
WHITE OAK TOWNSHIP
HAYWOOD COUNTY, NC

Scale: 1"= 400' (approx.) December 6, 1988

FROEHLING & ROBERTSON, INC.
ASHEVILLE, NC

NOTE: locations obtain from survey by others. P-70-613



Boring Terminated at 40.0'
Weathered rock at 35'
No water at completion

(1)- laden soil

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

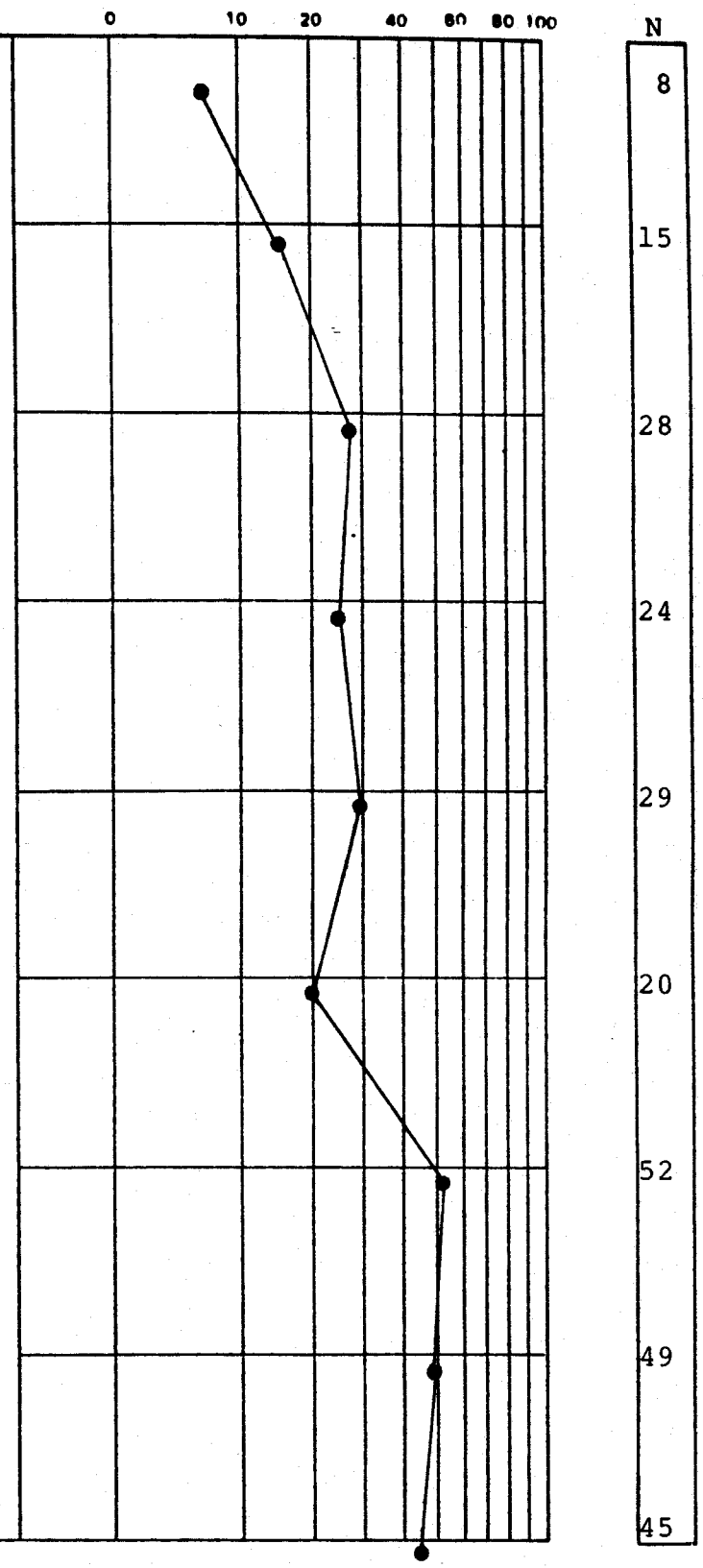
WATER TABLE, 1 HR.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-1
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV
0.0		
0.7	Grass root mat and organic- (1)	
	Firm to very stiff light brown **SILT**, a trace to a little sand	
14.0		
	Very stiff to very hard to hard grey **SILT**, a little fine sand, a trace of mica	
40.5		
	Boring Terminated at 40.5'	
	No rock encountered	
	No water at completion	
	(1)- laden soil	



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-2

DATE DRILLED 11-4-88

LAB NO.

JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100	N
0.0				
0.7	Grass root mat and organic-(1)			
	Stiff reddish-brown **SILT**, traces of clay and very fine sand			11
4.5				
	Stiff to very stiff brown fine sandy **SILT**, a trace of mica			23 31
14.0				
	Very stiff to very hard grey fine sandy **SILT**, a trace of mica			27 64 50/1" 50/4"
34.0				
	Boring Terminated at 34.0' Auger Refusal at 37' Rock encountered at 37' No water at completion			50/1"
	(1)- laden soil			

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

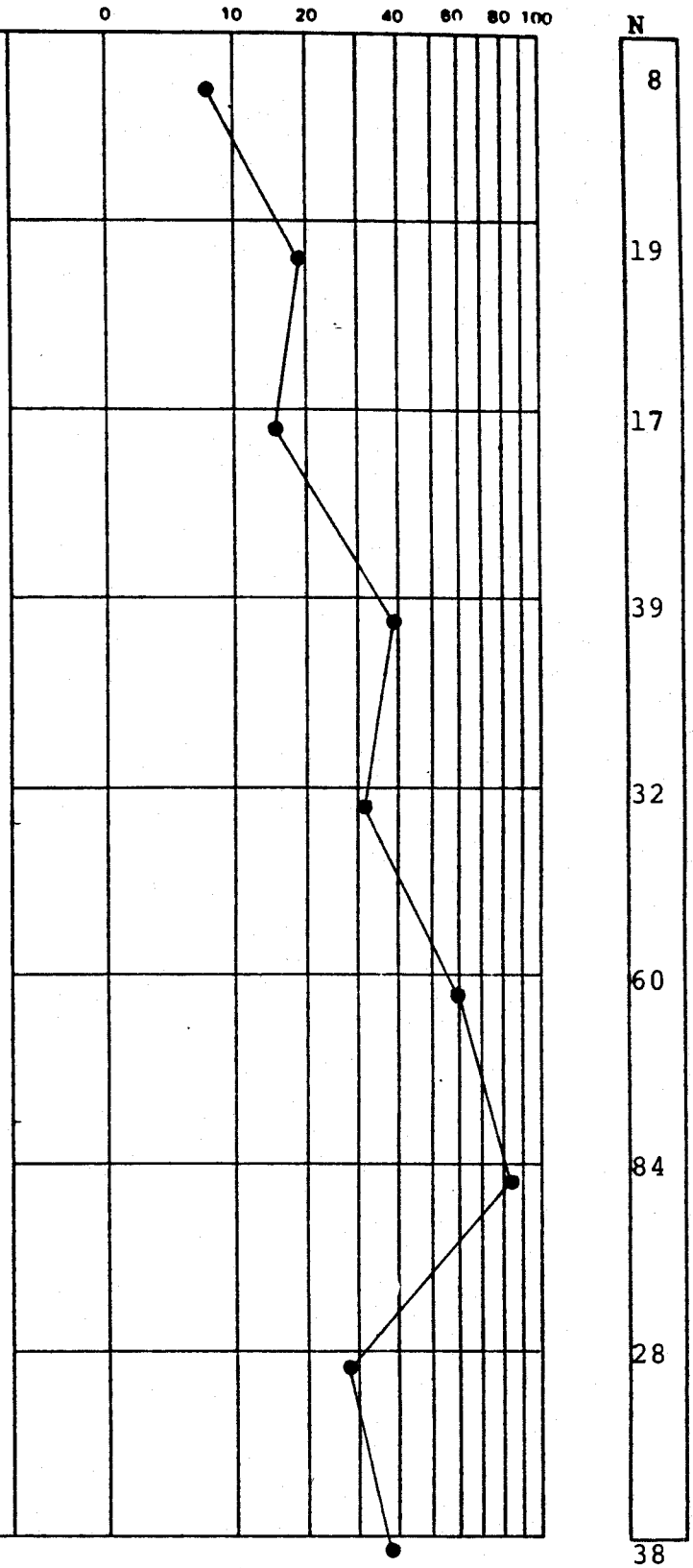
WATER TABLE, 24 HR.
WATER TABLE, 1 HR.
◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-3
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV
0.0		
0.7	Grass root mat and organic-(1)	
	Firm mottled reddish-brown and black fine sandy **SILT**, a trace of mica	
4.0		
	Very stiff reddish-brown sandy **SILT**, traces of rock fragments	
6.0		
	Very stiff to hard grey **SILT**, traces of fine sand and mica	
21.0		
	Very hard mottled yellow and black sandy **SILT**, a trace of mica	
29.0		
	Very hard to very stiff to hard grey **SILT**, traces of fine sand and mica	
40.5		

PENETRATION–BLOWS PER FT.



Boring Terminated at 40.5'
No rock fragments
No water at completion
(1)- laden soil

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

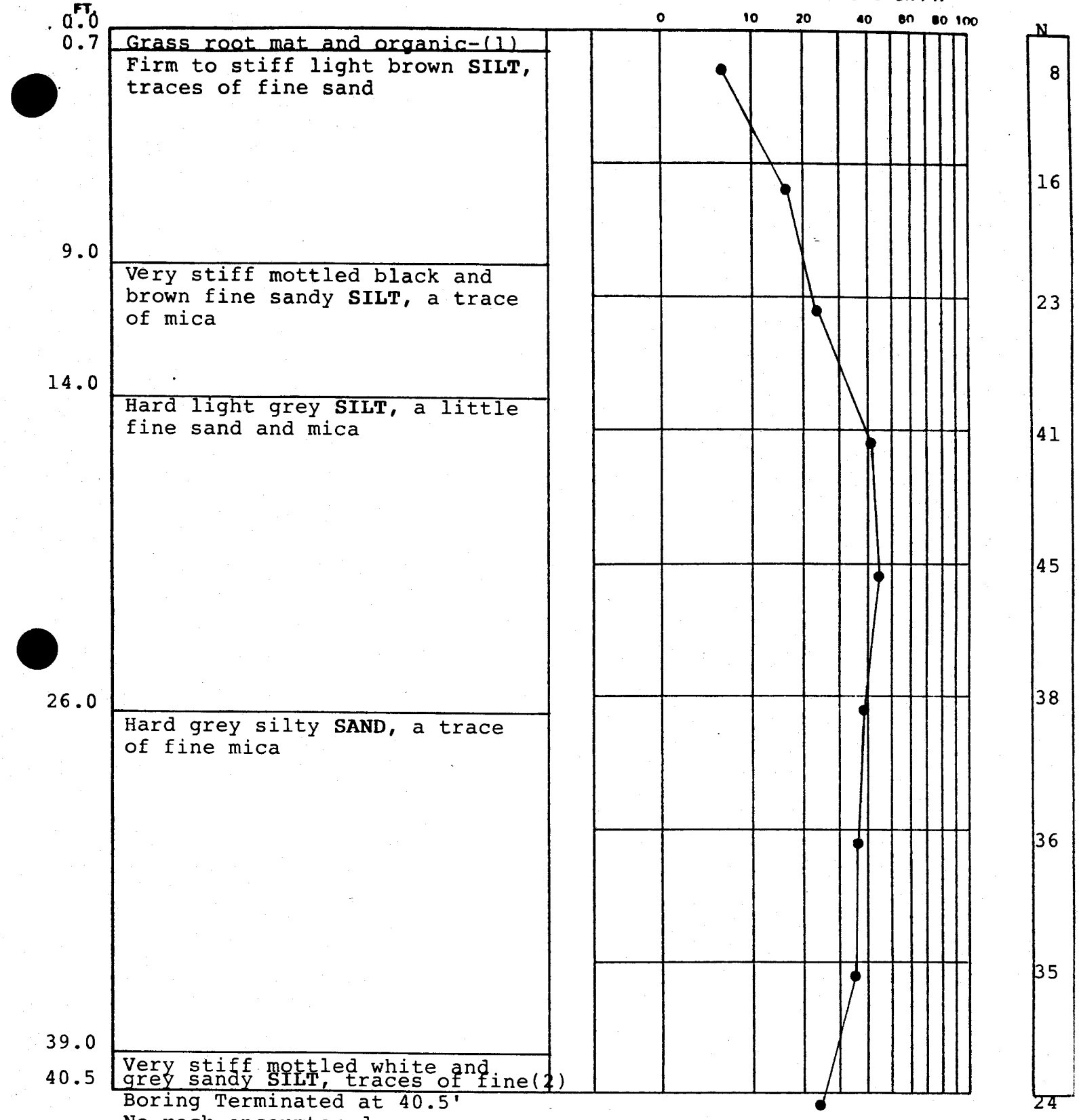
WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-4
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-5

DATE DRILLED 11-7-88

LAB NO. _____

JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100	N
0.0	Grass root mat and organic-(1)			
0.7	Stiff brown sandy **SILT**, a trace(2)			
1.5	Stiff mottled grey and brown to grey sandy **SILT**, a trace of mica			10
				16
10.0	Very stiff to very hard grey **SILT**, a little sand, a trace of fine mica			13
				23
				24
				57
29.0	Hard grey **SILT**, a little sand, a trace of mica			49
				49
39.0				
40.0	Very hard mottled grey sandy **SILT** (3)			50/6"

Boring Terminated at 40.0'
No water at completion
(1)- laden soil
(2)- of mica
(3)- a trace of mica and rock fragments

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

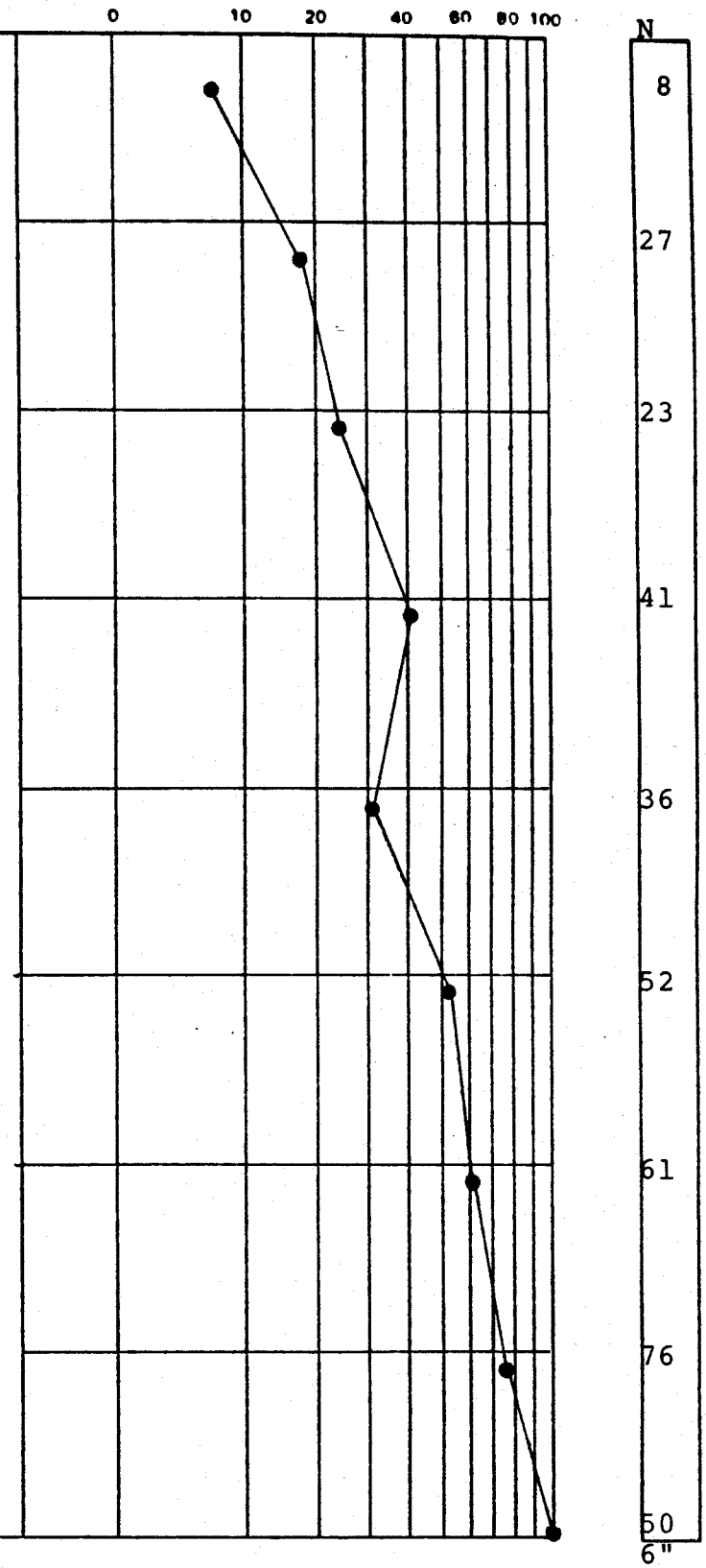
WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-6
DATE DRILLED 11-5-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV
0.0		
0.7	Grass root mat and organic- (1)	
	Very stiff to hard red to mottled purple **SILT**, a little fine sand, a trace of mica	
25.0		
	Hard grey **SILT**, a little sand, a trace of mica	
30.0		
	Very hard light brown **SILT**, a little fine sand	
40.0		



Boring Terminated at 40'
No rock encountered
No water at completion

(1)- laden soil

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-7
DATE DRILLED 11-5-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV
0.0		
0.7	Grass root mat and organic- (1).	
1.5	Very stiff brown sandy **SILT**, (2)	
	Very dense to dense to very dense mottled brown silty **SAND**, a few rock fragments	
54.0		
35.0	Very hard dark brown sandy **SILT**, a trace of mica	
	Very dense brown **SAND**, a few rock fragments, a trace of mica	
40.0		
	Boring Terminated at 40.0'	

PENETRATION–BLOWS PER FT.

	0	10	20	40	60	80	100	N
	●							18
							●	50/6"
				●				50
				●				49
					●			36
							●	50/6"
					●			62
							●	50/6"

No water at completion

(1)- laden soil
(2)- a trace of mica

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

■ UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-8
DATE DRILLED 11-4-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-1
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Small rock fragments from 5 to 10'		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-2
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

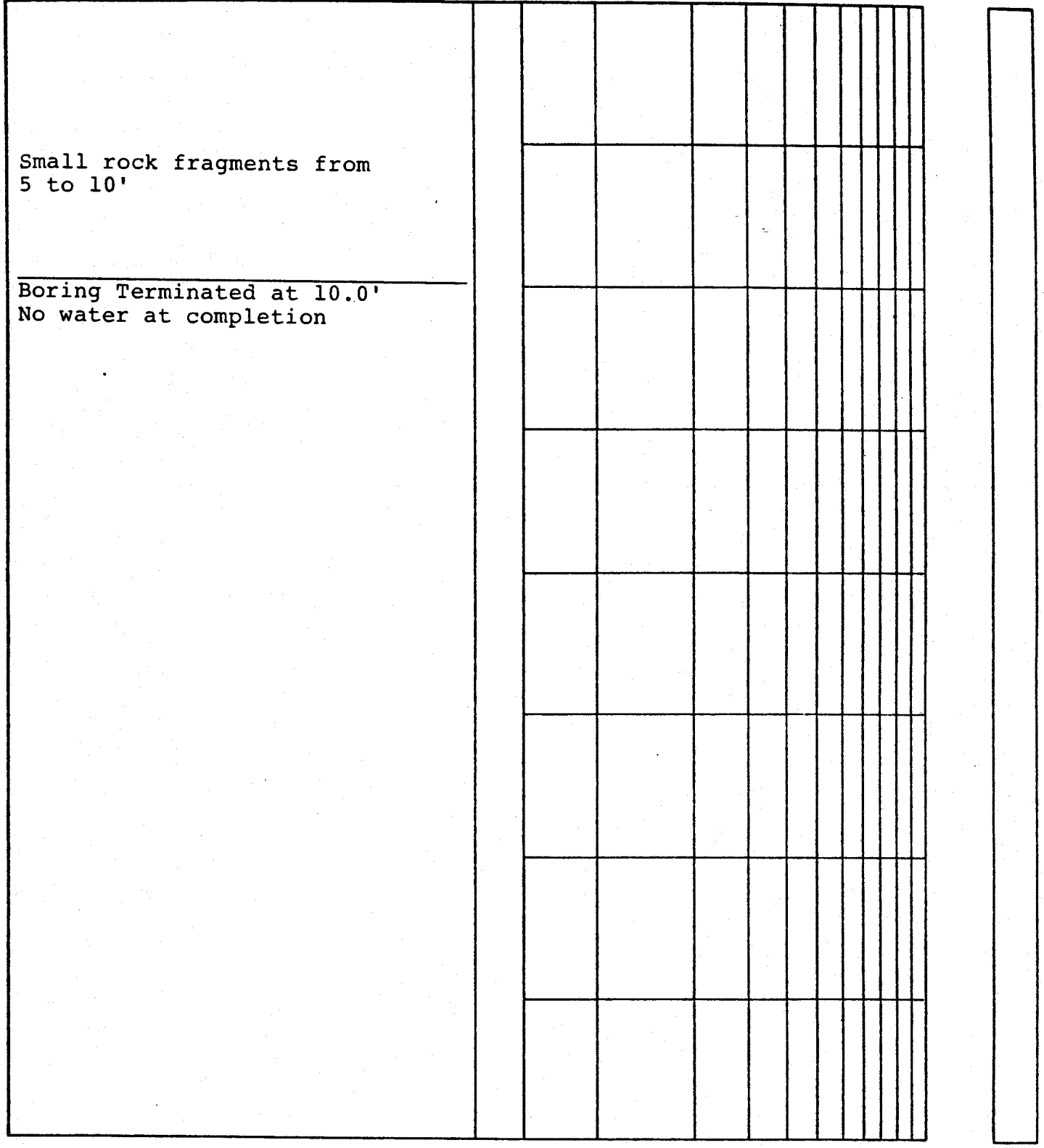
WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-3
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Small rock fragments from 5 to 10'		
10.0	Boring Terminated at 10.0' No water at completion		



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

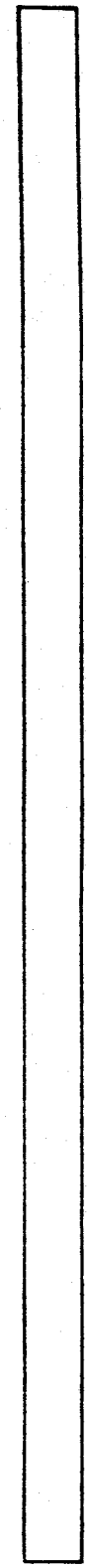
WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-4
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Rock fragments from 5 to 10'		
10.0	Boring Terminated at 10.0' No water at completion		



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.
WATER TABLE, 1 HR.
◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-5
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Small rock fragments from the surface to a depth of 10'		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-6
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

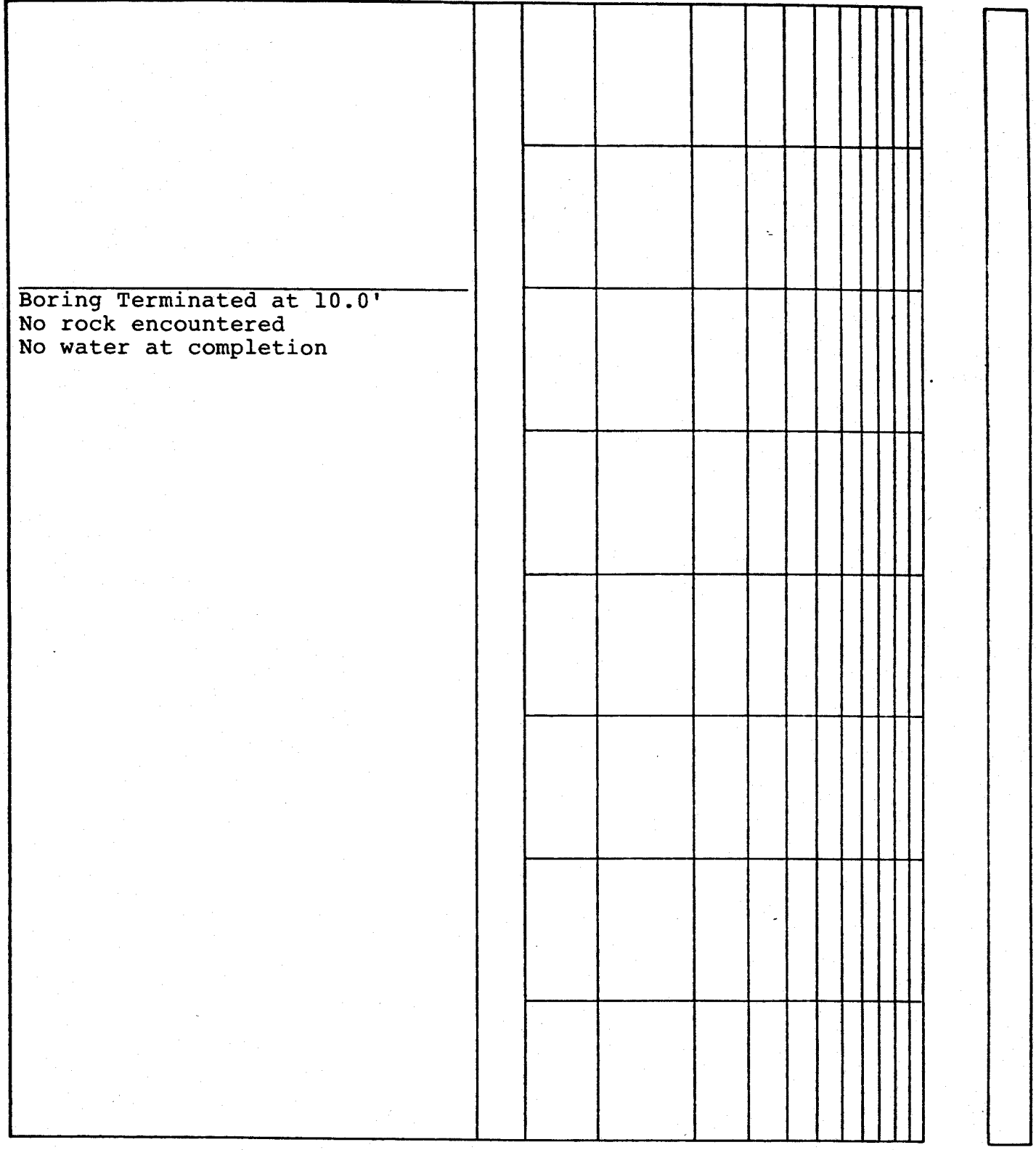
WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-7
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

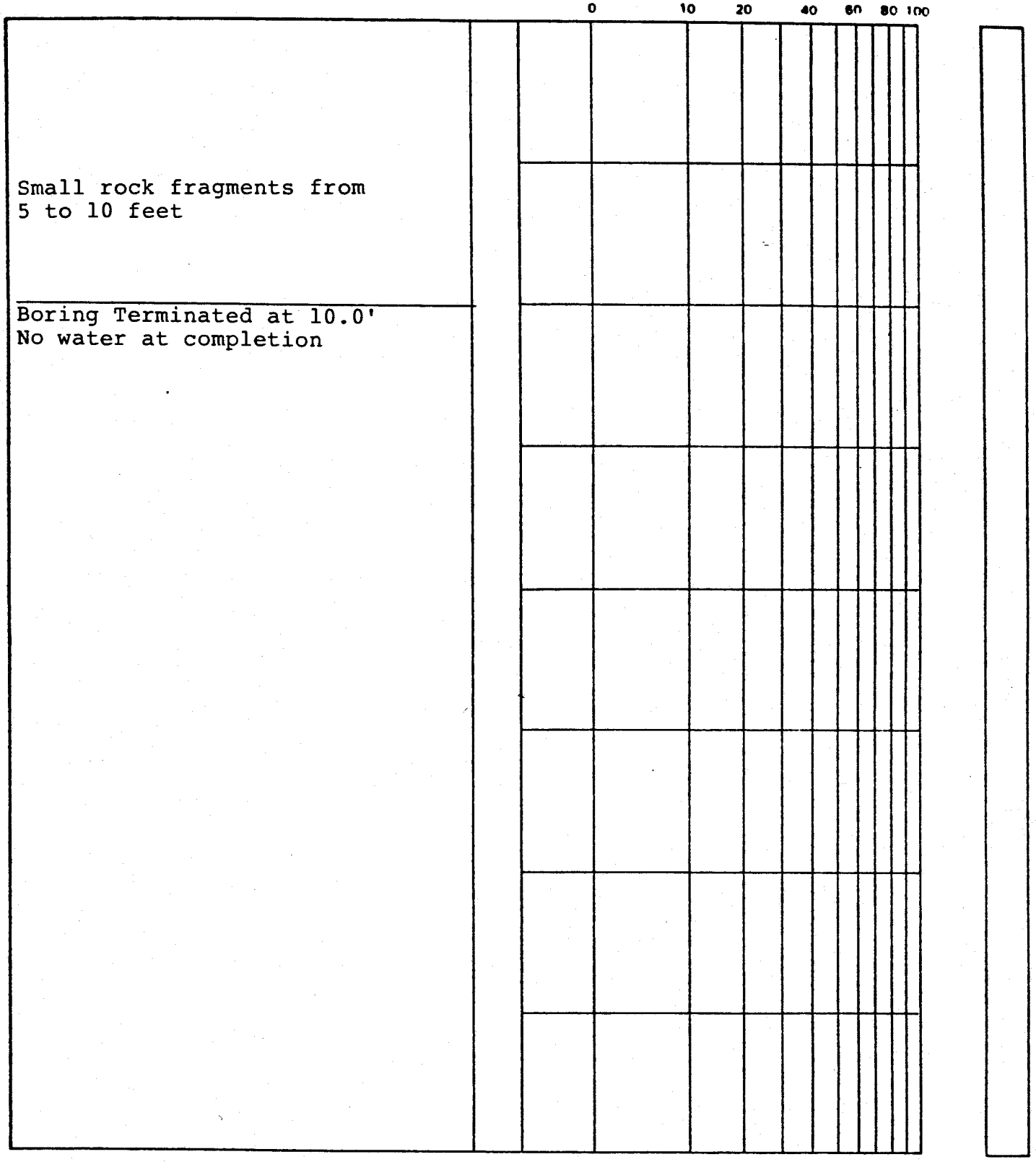
WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-8
DATE DRILLED 11-7-88
LAB NO. _____
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
	Small rock fragments from 5 to 10 feet		
10.0	Boring Terminated at 10.0' No water at completion		



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

■ UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-9

DATE DRILLED 11-7-88

LAB NO.

JOB NO. P-70-561

DEPTH	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0 FT			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-10
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

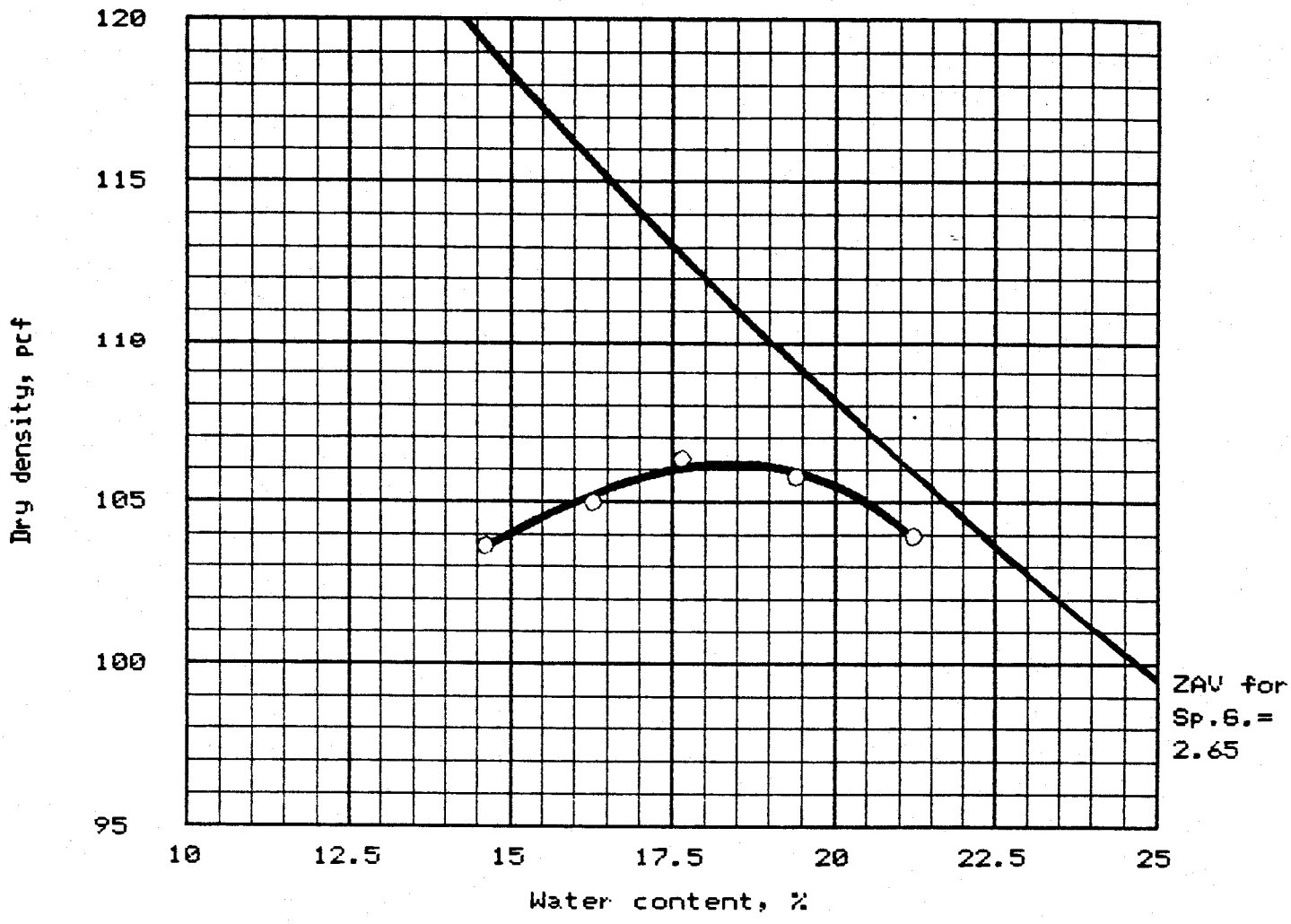
WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-11-
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

PROCTOR TEST REPORT



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
9-14'	ML	A-4	17.6 %		34	NP	1.0 %	55.1 %

TEST RESULTS

Optimum moisture = 18.4 %
Maximum dry density = 106.2 pcf

MATERIAL DESCRIPTION

Brown sandy SILT,
a trace of mica

Project No.: 613 (1)
Project: HAYWOOD COUNTY LANDFILL
Location: Boring B-5

Date: 12-04-1988

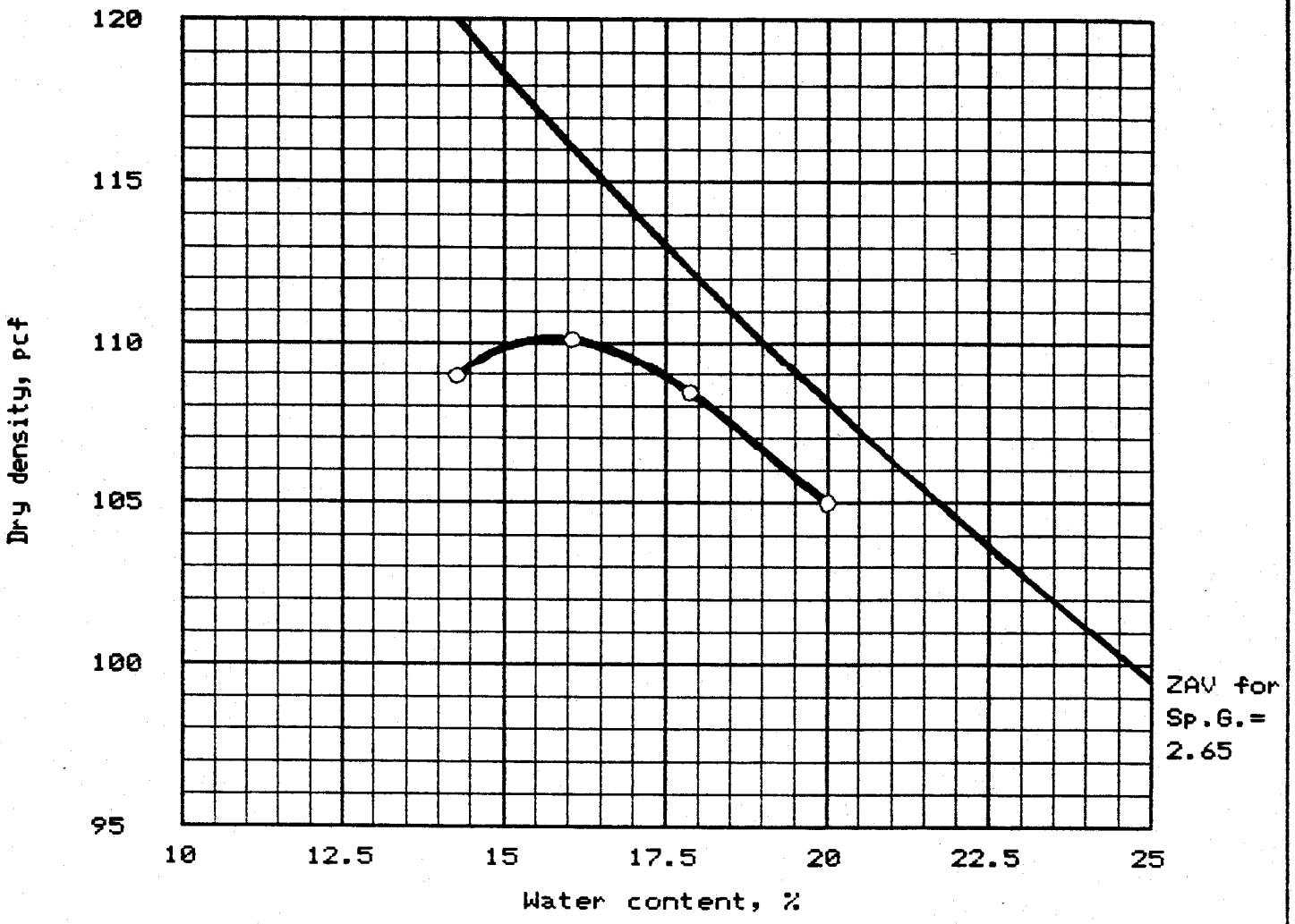
Remarks:
Bulk Auger Specimen

PROCTOR TEST REPORT

FROEHLING & ROBERTSON, INC.

Fig. No. _____

PROCTOR TEST REPORT



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
1.5-10	SM	A-4	14.3 %		34	NP	00.3 %	46.5 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 15.8 % Maximum dry density = 110.2 pcf	Brown sandy SILT, a trace of mica

Project No.: 613 (2)
Project: HAYWOOD COUNTY LANDFILL
Location: Boring B-6

Date: 12-04-1988

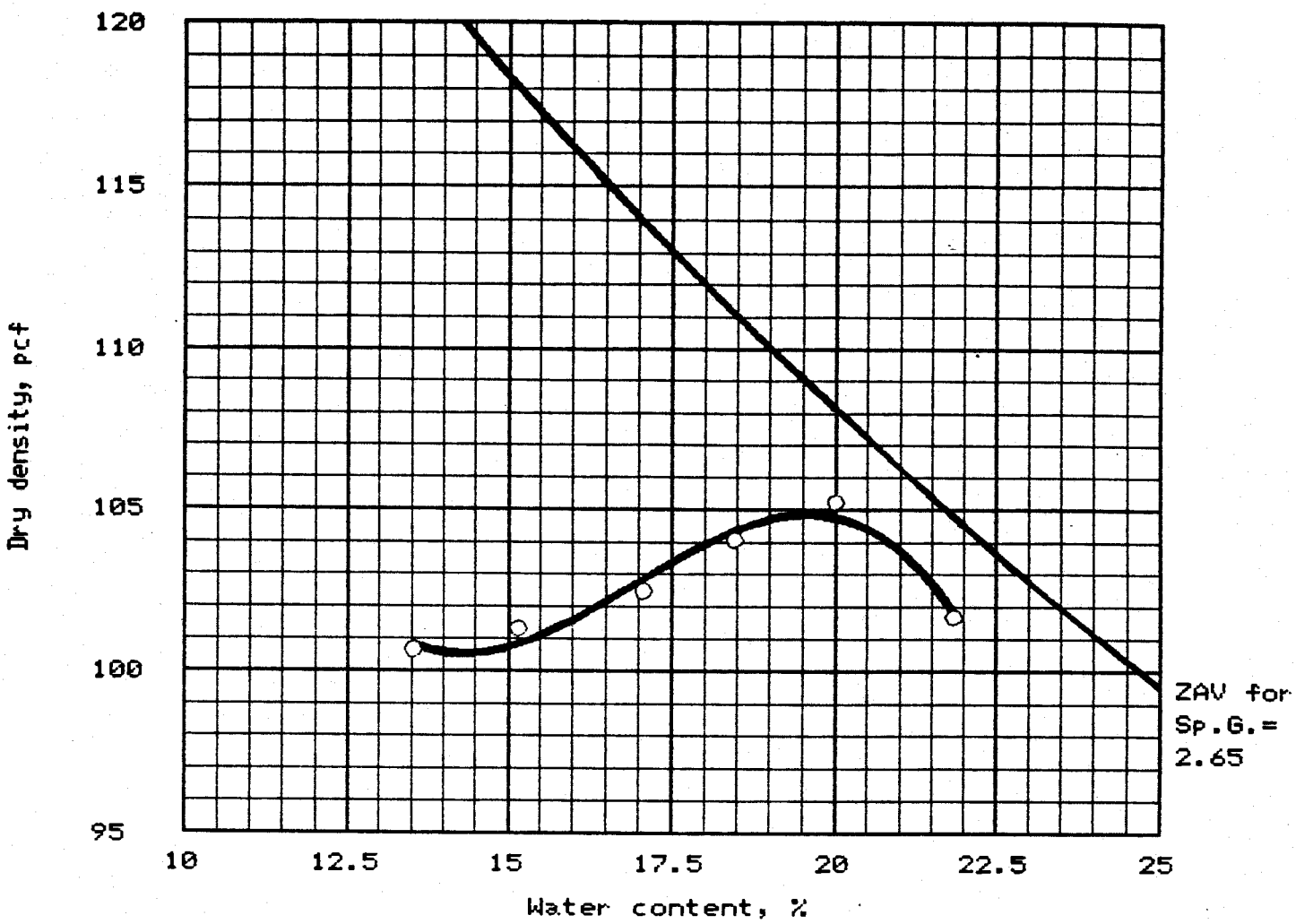
Remarks:
Bulk Auger Specimen

PROCTOR TEST REPORT

FROEHLING & ROBERTSON, INC.

Fig. No. _____

PROCTOR TEST REPORT



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
0-10'	SM	A-4	13.5 %		29	NP	2.0 %	48.7 %

TEST RESULTS

Optimum moisture = 19.6 %
Maximum dry density = 104.9 pcf

MATERIAL DESCRIPTION

Brown silty SAND,
a trace of mica

Project No.: 613 (3)
Project: HAYWOOD COUNTY LANDFILL
Location: Boring B-7
Sample A
Date: 12-04-1988

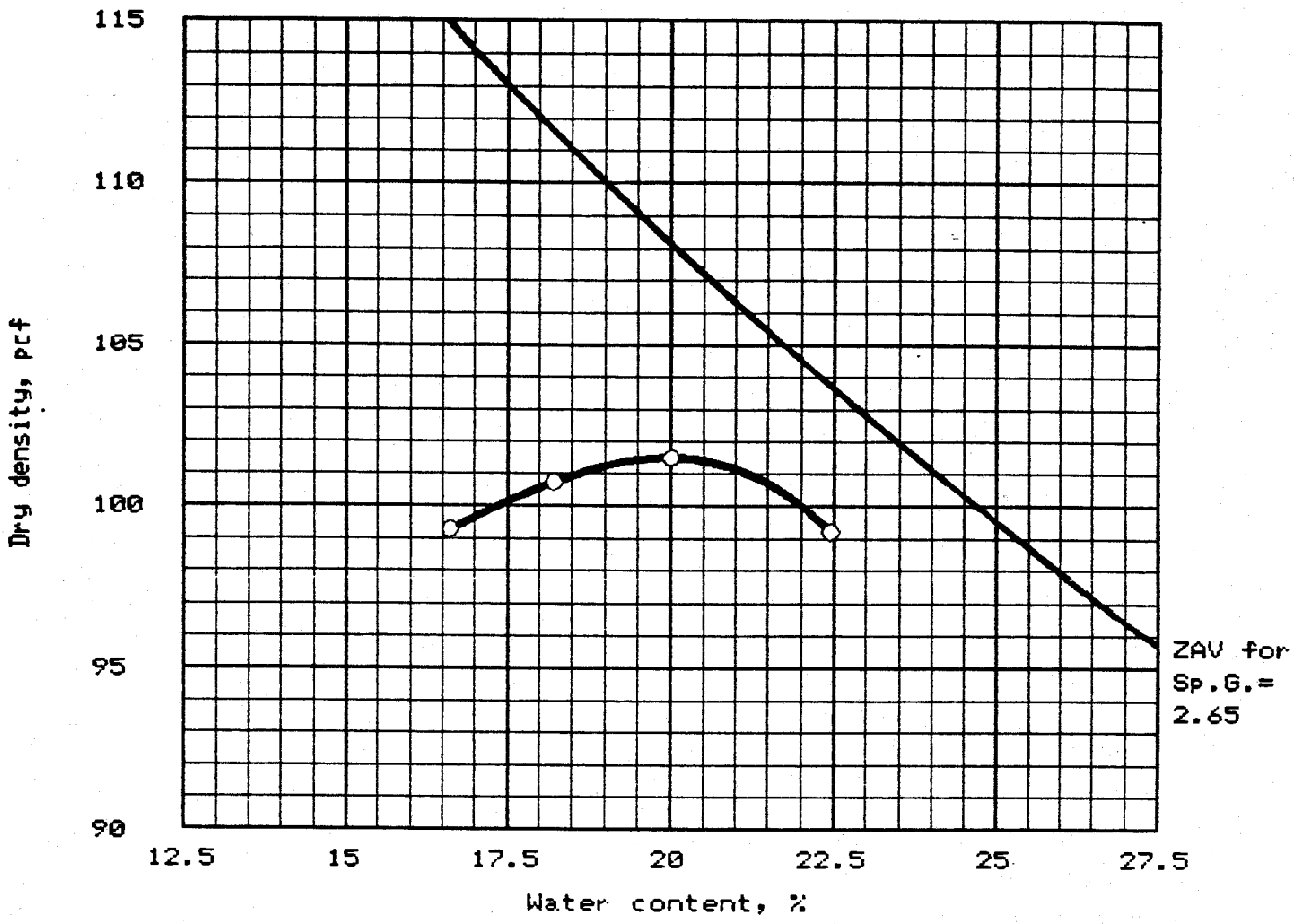
Remarks:
Bulk Auger Specimen

PROCTOR TEST REPORT

FROEHLING & ROBERTSON, INC.

Fig. No. _____

PROCTOR TEST REPORT



"Standard" Proctor, ASTM D 698, Method A

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > No.4	% < No.200
	USCS	AASHTO						
15-25'	ML	A-5 (5)	20.0 %		49	NP	0.0 %	83.0 %

TEST RESULTS	MATERIAL DESCRIPTION
Optimum moisture = 20.0 % Maximum dry density = 101.5 pcf	Reddish brown sandy SILT

Project No.: 613 (4)
Project: HAYWOOD COUNTY LANDFILL
Location: Boring B-7
Sample B
Date: 12-04-1988

Remarks:
Bulk Auger Specimen

PROCTOR TEST REPORT

FROEHLING & ROBERTSON, INC.

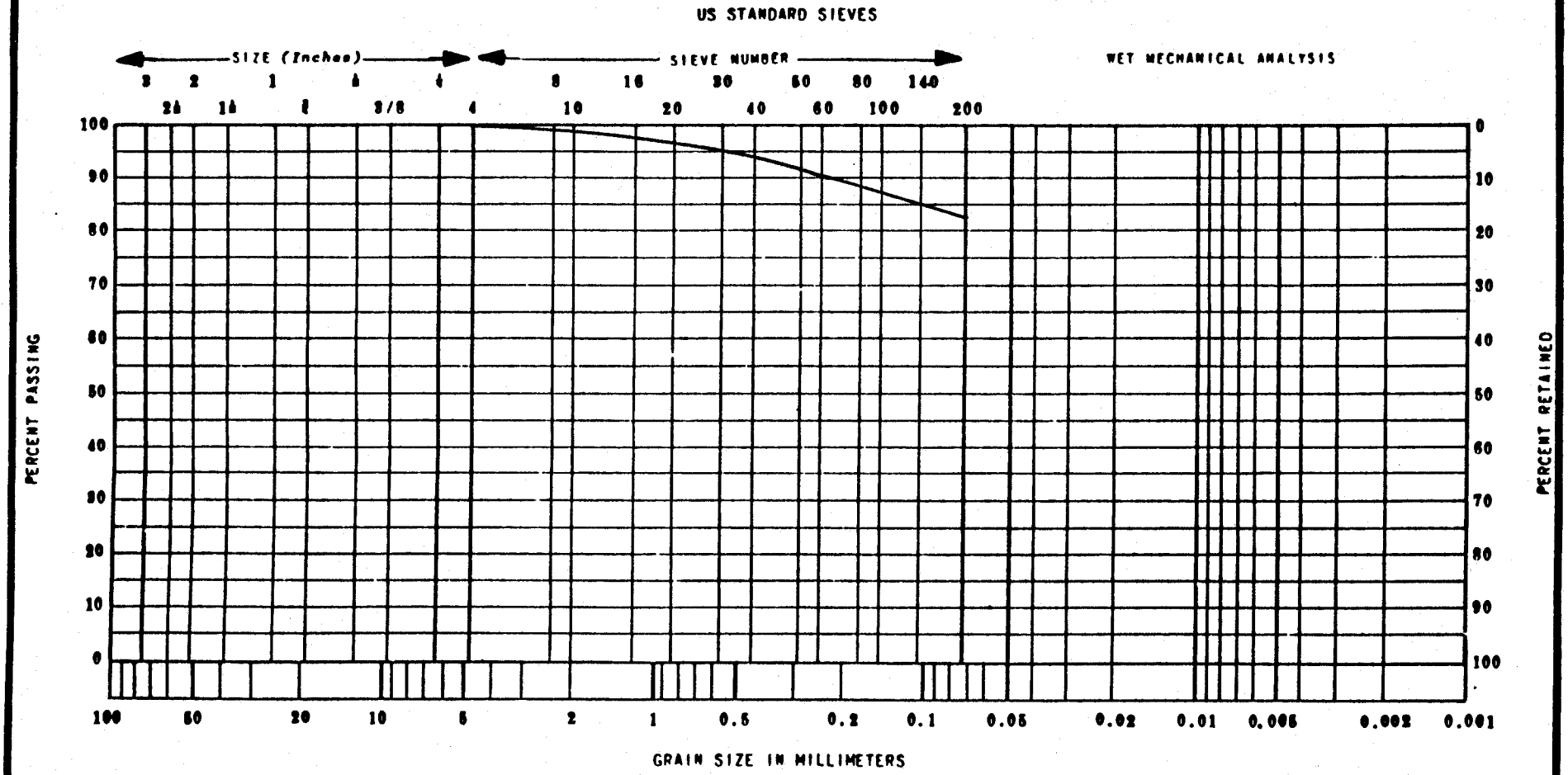
Fig. No. _____

FROEHLING & ROBERTSON, INC.
FULL SERVICE LABORATORIES ● ENGINEERS & CHEMISTS

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADING CHART

DATE 12-5-88

PROJECT
Proposed Haywood County Landfill, White Oak Township, Haywood Co., NC



EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL % MOISTURE	w_L	w_P	I_P	CLASSIFICATION	REMARKS
B-7B	15-25	20.0	49	NP		ML	

TECHNICIAN (Signature)

PLOTTED BY (Signature)

CHECKED BY (Signature)

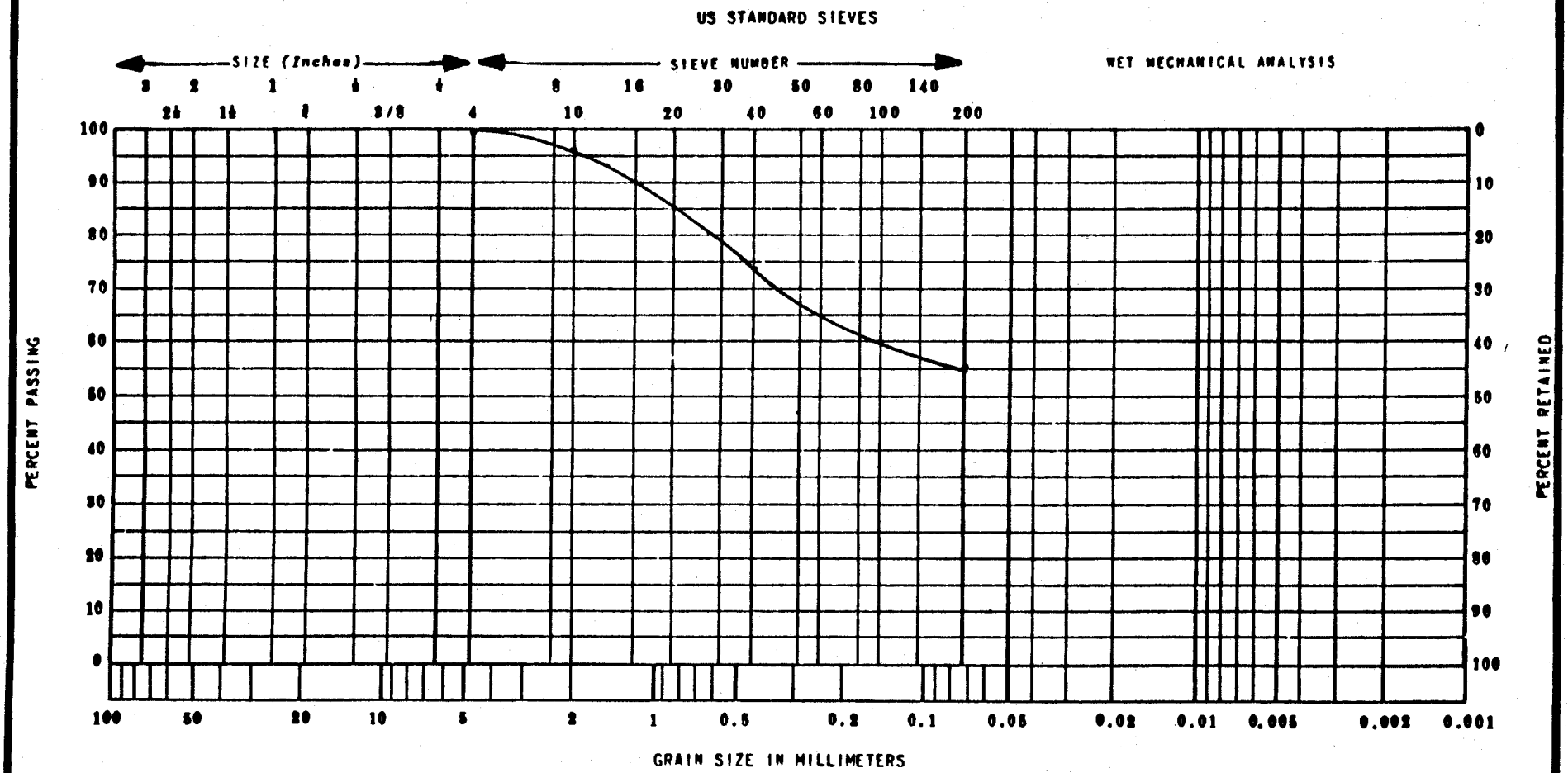
Form No. 110

FROE[illegible] & RC[illegible]ON, I[illegible]
FULL SERVICE LABORATORIES ● ENGINEERS & CHEMISTS

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADING CHART

DATE 12-5-88

PROJECT
Haywood County Landfill, White Oak Township, Haywood County, NC



EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL % MOISTURE	w_L	w_P	I_P	CLASSIFICATION	REMARKS
B-5	9-14	17.6	34	NP		ML	

TECHNICIAN (Signature)

PLOTTED BY (Signature)

CHECKED BY (Signature)

Form No: 110

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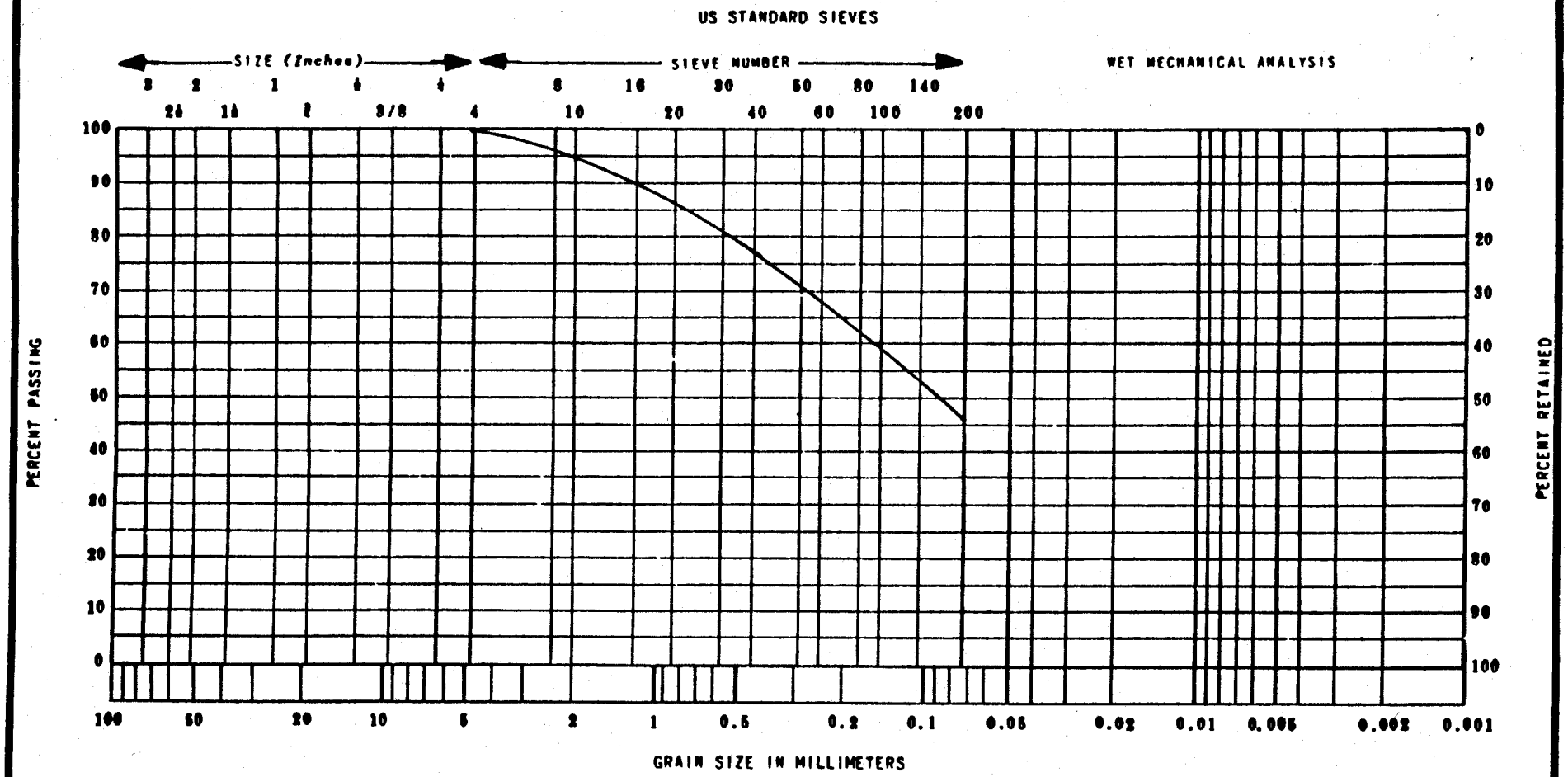
FULL SERVICE LABORATORIES • ENGINEERS & CHEMISTS

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADING CHART

DATE 12-5-88

PROJECT
Proposed Haywood County Landfill, White Oak Township, Haywood Co., NC



EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL % MOISTURE	w_L	w_P	I_P	CLASSIFICATION	REMARKS
B-6	1.5-10	14.3	34	NP		SM	

TECHNICIAN (Signature) | PLOTTED BY (Signature) | CHECKED BY (Signature)

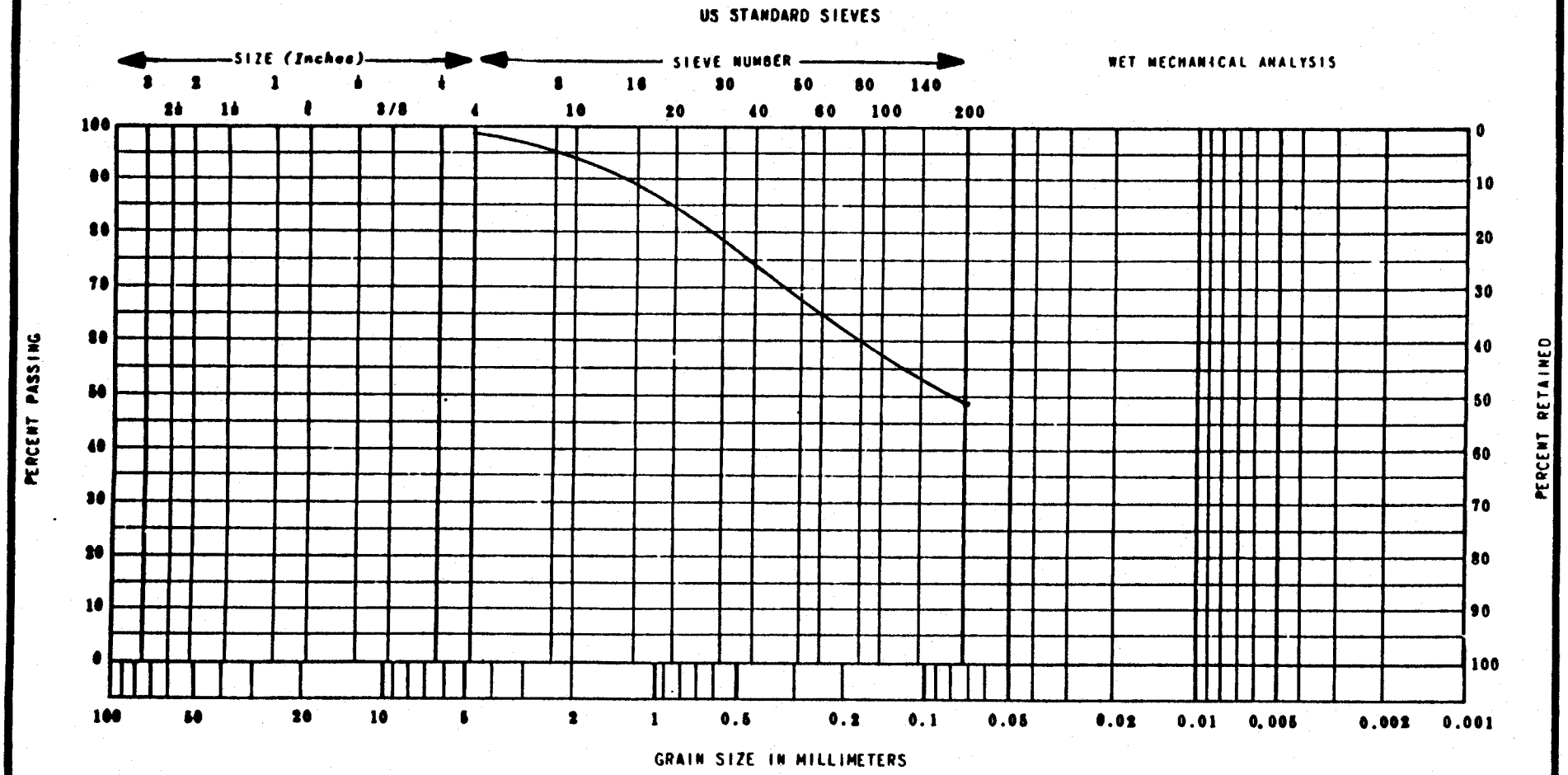
Form No: 110

FRE[illegible]G & ROBERTSON, INC.
FULL SERVICE LABORATORIES ● ENGINEERS & CHEMISTS

GRAIN SIZE DISTRIBUTION GRAPH - AGGREGATE GRADING CHART

DATE: 12-5-88

PROJECT: Proposed Haywood County Landfill, White Oak Township, Haywood Co., N.C.



EXCAVATION NUMBER	SAMPLE NUMBER	NATURAL % MOISTURE	w_L	w_P	I_P	CLASSIFICATION	REMARKS
B-7A	0-10	13.5	29	NP		SM	

TECHNICIAN (Signature)

PLOTTED BY (Signature)

CHECKED BY (Signature)

SINCE F&R 1881

KEY TO SOIL CLASSIFICATIONS AND UNDERSTANDING BORING LOGS

DESCRIPTIVE ADJECTIVES

TRACE	0 - 10%
LITTLE	11 - 20%
SOME	21 - 35%
AND	> 50%

Predominant soil type CAPITALIZED on boring logs.

COMPACTNESS - Coarse-grained soils and non-plastic fines

Descriptive Terms	Std. Pene. blows/ft.
Very loose	< 4
Loose	4 - 10
Medium dense	11 - 30
Dense	31 - 50
Very dense	> 50

Should use chart to adjust for overburden.

CONSISTENCY - Fine-grained soils with some plasticity

Descriptive Terms	Std. Pene. blows/ft
Very soft	< 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 16
Very stiff	17 - 30
Hard	31 - 50
Very hard	> 50

SINCE
F&R
1881

SOIL TEST BORINGS

Soil samples were obtained using the procedures described in ASTM Specification D 1586-74. The borings were advanced by mechanically rotating continuous flight, hollow-stem augers into the ground. At regular intervals, soil samples were obtained with a standard 1.4 inch ID, 2 inch OD split tube sampler through the hollow stem of the augers. The sampler was first seated 6 inches and then driven an additional 12 inches with blows of a 140 pound hammer falling 30 inches. The number of blows required to drive the sampler the final 12 inches is designated the "standard penetration resistance" and provides an indication of the soil consistency and strength.

The soil samples thus obtained were enclosed in glass jars and transported to the laboratory where they were examined and classified by a Geotechnical Engineer. Soil classifications and penetration resistances are shown on the attached Test Boring Records.

RESPOND TO 40 CFR PARTS 258.13 & 258.14:

Part 258.13: Fault Areas

- Per Subtitle "D" Regulations, a new MSWLF unit shall not be located within 200 feet (60 meters) of a fault that has had displacement in Halocene time (recent epoch of the Quaternary period) unless the owner demonstrates to the Director of an approved State that an alternate setback distance of less than 200 feet will prevent damage to the structural integrity of the MSWLF unit and will be protective of the human health and environment.

- As documented by Law Engineering, Inc. in the "Final Report of Hydrogeological Study" in Section 4.7 Seismic Considerations, that Halocene Faults were not observed in the immediate vicinity of the proposed landfill site nor were they shown on any published maps or discussed in the literature reviewed.

Part 258.14: Seismic Impact Zones

- Per Subtitle "D" Regulations, a new MSWLF unit shall not be located in seismic impact zones, unless the owner demonstrates to the Director of an approved State, that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earthen material for the site.

  Seismic Impact Zones: an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earthen material, expressed as a percentage of the earth's gravitational pull, will **exceed** 0.10g in 250 years.

- As indicated by Law Engineering, Inc. in the previously mentioned study and section, and as documented by the U.S. Geological Survey in Open-File Report 82-1033, the probable acceleration in rock in the area of the proposed landfill site with a 90 percent probability of not being exceeded in a 250 year period is **less** than 0.10g.

  In light of this, the site should not be subjected to this design requirement. The slope stability calculations indicate that the design of the MSWLF unit is sound.

July 29, 1991

LAW ENGINEERING

GEOTECHNICAL, ENVIRONMENTAL
& CONSTRUCTION MATERIALS
CONSULTANTS

Dr. Richard Rust
Tribble & Richardson, Inc.
4020 West Chase Boulevard, Suite 515
Raleigh, North Carolina 27067

SUBJECT: Final Report of Hydrogeological Study
Proposed White Oak Sanitary Landfill
Haywood County, North Carolina
Law Engineering Project No. 57400142.01

Dear Dr. Rust:

Law Engineering, Inc. is pleased to submit this final report of our hydrogeological study performed at the subject site. This report supercedes all previous reports and supplements including our original "Report of Hydrogeological Study", dated May 22, 1990 and incorporates supplemental field data obtained during the past 14 months. This report also addresses a number of comments and questions raised by the state relative to specific hydrogeological conditions within the site.

The purpose of this study was to evaluate the site's suitability for development as a sanitary landfill relative to hydrogeological considerations. The work was conducted to meet the requirements for landfill site acceptability permitting outlined in the North Carolina Rules for Solid Waste Management as amended through March 1, 1989, Section .0504 relative to geological and hydrological studies. The initial work was performed substantially as outlined in our proposal No. 574-89253, dated December 7, 1989. Additional data acquisition was conducted in response to specific state requests.

This report briefly discusses our understanding of the project, describes our exploratory procedures and presents our findings and conclusions. We appreciate the opportunity of working with you on this project and look forward to our continued association. Please contact us if any questions arise or if we may be of further service in any way.

Very truly yours,

LAW ENGINEERING, INC.

M. Whitt Walker

M. Whitt Walker, P.G.
Principal Geologist

James W. Niehoff, P.E.
Principal Engineer

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1.0 INTRODUCTION

This report was prepared by Law Engineering, Inc. and presents our understanding and interpretation of site hydrogeological conditions. The purpose of the study was to obtain sufficient surface and subsurface data to allow for the evaluation of the site for suitability relative to its future development potential as a sanitary landfill.

The work and test procedures utilized in the study consisted of: 1) a review of published geological, water resources and agronomic literature and maps, 2) a site reconnaissance, 3) a subsurface exploration program, 4) a stream flow analysis, and 5) selected physical and chemical laboratory analyses.

In preparing this report, numerous sources of published data were consulted and utilized. Although not referenced at the point of use in most cases, the authors acknowledge the fact that much of this report is based on work performed by others. The bibliography lists those sources of information.

2.0 PROJECT INFORMATION

Haywood County, North Carolina currently operates a sanitary landfill which is nearing capacity. In order to meet future solid waste disposal requirements, the subject site was selected as a potential location for a future landfill. This site was the subject of an earlier (1988), limited subsurface exploration performed by Froehling & Robertson, Inc. Although this study obtained information relative to overburden soil conditions within the parcel, it was not of sufficient scope to define the ground-water flow patterns or the nature of the underlying rock. The present study was designed to supplement existing information to provide sufficient data to evaluate the site for landfill permitting under current regulations.

3.0 GENERAL SITE AREA

3.1 DESCRIPTION OF GENERAL SITE AREA

The subject site consists of approximately 109 acres located in the White Oak Community of rural Haywood County, approximately 20 miles north of Waynesville (see Figure 1 - Site Location Map). The general site area is characterized by sparse development consisting of single family houses and small farms.

Currently, the subject property is undeveloped. The major portion of the site, which includes the southern two-thirds, primarily consists of pasture land. The remaining portion of the site, adjacent to the Pigeon River, is wooded.

Topographically, the site is dominated by four major ridgelines trending in a north-south direction. The property line generally follows the crests of the easternmost and westernmost ridges, the Pigeon River to the north and a local high point to the south. A number of small springheads are located within the lower portions of the swales between the ridgelines. According to our observations and those of local residents, the number and location of the springheads changes seasonally and with variations in precipitation activity. The springs ultimately join to form a small perennial stream within the northern third of the parcel. Overall, site grades generally fall moderately, then more steeply northward toward the Pigeon River at the northern property boundary.

The site is located approximately 2000 feet west of the Fines Creek exit on the south side of Interstate 40. Site access is presently gained from a road which exits White Oak Road south of the site.

No airports are present within 10,000 feet of the site in any direction.

3.2 PROXIMITY TO PUBLIC AND DOMESTIC WATER WELLS

A survey of residences located within a radius of approximately 2 miles was performed by Johanna Wood and Mary Henigbaum who work for the Haywood County Board of Commissioners. Approximately 100 people from the White Oak and Shelton Laurel communities were interviewed as to the source or sources of drinking water at their homes or businesses. The majority of the people interviewed obtain their drinking water from surface springs or wells. A copy of the information obtained is attached in the Appendix.

3.3 PROXIMITY TO STREAMS

As noted previously, the only on-site water courses consist of several small springs which join to form a perennial stream. The nearest significant surface water body is the Pigeon River, referred to as Walters Lake in the site area. Two relatively small streams, Messer Branch and Rocky Branch, are located south and west of the site approximately 2000 and 3000 feet from the site, respectively.

4.0 SURFACE AND SUBSURFACE INVESTIGATION

4.1 TOPOGRAPHIC DESCRIPTION

The site is characterized by 4 major ridgelines which are dissected by swales occupied by wet weather springs (Figure 2). The ridgelines are oriented generally in a north-south pattern. Ridgeline and valley elevations differ by as much as 100 to 125 feet across the site. The overall or general slope of the site is toward the north and northwest with increasing steepness as the site nears the Pigeon River. The highest point within the site is located along the southern property line at approximate elevation 2651 feet (msl). The lowest point topographically is around elevation 2260 feet along the northern property boundary.

4.2 BORING AND SAMPLING PROGRAM

Nineteen borings were drilled in 1988 by Froehling & Robertson, Inc. Twenty-seven borings were drilled during the Law Engineering, Inc. study in early 1990. An additional 7 borings were drilled by LAW in April of 1991. All boring locations conducted for this study are shown on Figure 3 in the Appendix.

Law Engineering Borings B-101 through B-115 were drilled in general accordance with the procedures delineated in ASTM D-1586. Hollow-stem augers were used to advance each soil boring to refusal depths. Split spoon soil samples were obtained every five feet and their standard penetration test resistance (N-value) recorded. The soil samples obtained in the split spoon sampler are adequate for classification purposes, but are not sufficiently undisturbed for tests of physical properties. Consequently, undisturbed soil samples were obtained by the Shelby tube method (ASTM D-1587) of representative strata in borings B-103, B-111A, and B-113A for further laboratory testing.

As the availability of adequate cover fill material is a major issue in landfill siting, bulk samples of soil were obtained from auger cuttings at depths of 0 to 10 feet and 0 to 15 feet in borings B-111 and B-112, respectively for evaluation.

In borings B-105, B-109A, and B-111A, and 113A, materials below refusal elevations were sampled by means of diamond coring to permit an evaluation of the composition and continuity of the rock. Packer tests to evaluate in-situ hydraulic conductivity were conducted at selected levels within the cored holes in borings B-109A, and B-113A. The results of the tests are presented in Table 1 in the Appendix.

Ground water was present in each of the borings except B-106, B-107, B-112, and B-114 which are located atop ridge lines (see Figure 3). To evaluate ground-water elevations in these areas, an air percussion drilling rig (air track) was utilized to advance borings through the soil and rock. These fifteen borings, designated AT-1 through AT-15, were drilled atop ridgelines and in areas where ground water was not encountered during the initial boring phase.

After drilling, three-quarter-inch PVC casing with the lower ten feet slotted, was installed in 28 of the auger and air-track borings for the purpose of obtaining stabilized water table readings. The remaining borings (B-108, B-109, B-109A, B-111A, B-113, and B-113A) were converted into 2-inch Type-I monitoring wells. Slug tests (in-situ hydraulic conductivity) were run on each of the Type-I wells, including those screened below the bedrock/soil interface.

It should be noted that work on this project was interupted several times by local residents and legal challenges to our right of access. As a result, it was not possible to obtain water level readings at intervals of 24 hours and 7 days in all cases. However, over the course of the project, water level readings have been obtained in most boreholes over an extended period of time which allows for a thorough evaluation of normal water level fluctuations. Based upon our review of ground-water elevations in monitoring wells in nearby Canton, it appears that seasonal high ground-water levels generally occur in mid to late spring, the general time during which water levels were obtained within this site. Also, it should be noted that this study was conducted during an extended period of higher than normal rainfall. As a result, we believe that the water table elevations measured in our boreholes represent a seasonal high for the area.

Our original report presented water level readings made on May 21, 1990, which were obtained by untrained county personnel. Several of these readings appear to be inconsistent with measurements made before and after this date. Consequently, this data is considered suspect and possibly erroneous. It has thus been disregarded as a basis for the evaluations made in this report.

4.3 LABORATORY TESTING PROGRAM

A number of laboratory tests were performed on the soil samples to evaluate various physical properties. Among these were falling head permeability tests, Standard Proctor density tests, and classification tests including grain size analyses and atterberg limits tests. In addition, cation exchange capacity tests were performed on selected samples to evaluate the ability of the soil to adsorb leachate ions. The laboratory test results are appended and

are summarized in Table 1.

4.4 DESCRIPTION OF GEOLOGY, SOILS AND ROCKS

4.4.1 Regional Geologic Setting

The site and immediate vicinity are located in the eastern Blue Ridge Mountains, an area underlain by metamorphic rocks of Pre-Cambrian age. The rock units present include the Pre-Cambrian Basement Complex (which directly underlies the site), the Thunderhead Sandstone of the Great Smoky Group (which is in fault contact with the basement) and the Wading Branch Formation and the Longarm Quartzite of the Snowbird Group which unconformably overlies the basement a short distance west of the site. The Snowbird and Great Smoky Groups are part of the Ocoee Series.

4.4.2 Lithology

The lithologic descriptions which follow were taken from Hadley and Goldsmith (1963).

The basement is comprised of a complex assemblage of plutonic rocks and layered gneiss (Hadley and Goldsmith,1963). The plutonic rocks include massive augen gneiss, granitoid gneiss, and little foliated granitic rocks. The layered rocks are paragneiss derived from ancient sedimentary and possibly volcanic rocks and are defined throughout the Blue Ridge and Piedmont as the Carolina Gneiss.

The Wading Branch formation is the lower-most unit of the Snowbird Group and unconformably overlies the basement rocks. The type area is Wading Branch Ridge northwest of Walters Lake and consists of a 1500 foot interval of dark fine to coarse-grained poorly sorted clastic rocks ranging from sandy slate to very coarse pebbly sandstone. The Longarm Quartzite conformably overlies the Wading Branch formation and is named for Longarm Mountain in the core of the Cataloochee Anticlinorium a few miles northwest of the site. The formation consists of several thousand feet of clean feldspathic quartzite and arkose. Being the most resistant unit within the Snowbird Group, the Longarm Quartzite

forms several major ridges in the area including Longarm and Whiteoak Mountains.

The other prominent rock unit in the area is the Thunderhead Sandstone of the Great Smoky Group. The formation is named for Thunderhead Mountain on the crest of the Great Smoky Mountains west of the study area. The Thunderhead consists of 6,000 to 12,000 feet of medium-to coarse-grained feldspathic sandstone or arkose but is interbedded with various amounts of arkosic pebble conglomerate, finer-grained feldspathic sandstone, argillaceous metasandstone, dark-gray slate. Within the study area the Thunderhead is apparently in fault contact with the basement complex.

4.4.3 Structure

The major structural features present in the vicinity are the Cataloochee Anticlinorium a short distance west of the site and the Greenbrier Fault which bounds the eastern edge of the Cataloochee Anticlinorium. A smaller fault is present about a half mile east of the Greenbrier.

Regional foliation trends are oriented northeast with southeast dips which is sub-parallel to the regional structural features. Joints are oriented northwest and northeast and are generally very steeply dipping. Regional joint patterns can be inferred from stream patterns which are often controlled by bedrock fractures.

4.4.4 Site Geology

A geologic reconnaissance was made by Robert D. Hatcher in December, 1989 (report appended). The reconnaissance concentrated on observing and recording measurements of geologic structures and the character of the bedrock exposed within the immediate site vicinity. According to Hatcher, the bedrock underlying the site consists of a coarse to very coarse foliated granitic gneiss cut by veins of pegmatite and quartz. Premetamorphic mylonitic gneiss formed by ductile faulting was observed at one locality (Location 6 of Hatcher's report). The rocks observed by Hatcher apparently correlate with the plutonic basement rocks of Hadley and Goldsmith (1963).

Rock outcrops observed by Law Engineering geologists in areas adjacent to the site are shown on Figure 4. Local foliation strikes between 10 to 70 degrees to the northeast with dips of 30 to 65 degrees to the southeast. Measurements are presented on Table 2. Deeply weathered outcrops of gneiss, monzonite, and pegmatite occur within the site.

4.4.5 Soil Conditions

The soils mantling the site are a result of in-place chemical and physical weathering of the parent bedrock. Consequently, the soil mineralogy reflects that of the source rock. The profile of the overburden soil includes a surficial stratum of slightly clayey sandy silt or silty sand, underlain by more coarsely grained sandy silts with depth. Soil consistency tends to increase with depth in inverse proportion to the degree of weathering. In general, the overburden soils represent the upper 30 to 50 feet of the subsurface profile. Cross sections representing typical subsurface conditions within the site are presented on Figures 7 through 9 in the Appendix. Due to the general similarity of soil types within the overburden layer, the profiles do not include strata breaks indicative of differences in soil type. Conditions at specific boring locations are presented on the individual Test Boring Records, also in the Appendix.

In-situ and laboratory tests indicate that hydraulic conductivity values for the undisturbed soil ranged from 2.3×10^{-4} to 8×10^{-5} cm/sec. When remolded in accordance with ASTM D-698, a maximum dry density ranging from 109 to 116 pounds per cubic foot was determined. Compacted fill soils from this site typically have hydraulic conductivities ranging from 3×10^{-7} cm/sec to 5×10^{-7} cm/sec, according to the tests conducted by Froehling and Robertson, Inc. in their 1988 study.

Six of the soil samples obtained from the field were submitted for cation exchange capacity testing to provide data upon which to estimate the sorptive capacity of the site soils. The laboratory tests results indicate the soils have a relatively low potential for adsorbing leachate ions.

Near the interface of intact bedrock, a transitional material known as partially weathered

rock is often encountered. This material can be penetrated by soil augers, yet exhibits standard penetration values of greater than 100 blows per foot. In general, partially weathered rock was found to be less than 5 feet in thickness, where encountered.

4.4.6 Rock

Rock cores were obtained from 4 of the borings on-site. The rock was determined to consist primarily of a biotite gneiss with some segments consisting primarily of quartz. The rock is described as being slightly to moderately weathered and fractured with RQD (rock quality designation) values ranging from 0 to 100 percent, typically a function of core depth. Some vertical jointing was noted in boring B-111A between a depth of about 29 to 33.5 feet.

Pressure testing was performed on borings B-109A, B-111A, and B-113A at depth intervals of 25 to 30 feet, 32 to 44 feet, and 22 to 27 feet, respectively. The rock interval tested in B-111A did not take water. The estimated hydraulic conductivities obtained in the rock within borings B-109A and B113A are 8×10^{-5} and 8×10^{-4} centimeters per second (cm/sec), respectively. Slug tests were also conducted in these rock core borings to provide an estimate of the hydraulic conductivity of the overall formation. This procedure produced results similar to those obtained in the pressure tests. It should be noted that larger, open fractures in the bedrock likely have significantly higher conductivities.

4.5 DESCRIPTION AND OCCURRENCE OF SURFACE WATER

Three primary springs were observed on-site which originate within the swales. The locations of the stream heads at the time of our site work are shown on Figure 5 in the Appendix. A V-notch weir was constructed at each of the streams at two locations each (see Figure 5) to evaluate the flow rate at the time of our study. From this data, we estimated the flow rates for the small streams to range from about 6 to 22 gallons per minute. A summary of measurements of stream flows and calculations are appended.

4.6 DESCRIPTION OF UNCONFINED AQUIFERS

Ground water at the site occurs under water table conditions. The phreatic surface may be affected by fluctuations in barometric pressure, surface water systems, aquifer pumping, a lack of recharge, and other manmade and/or natural occurrences.

Within the site area, ground-water recharge primarily results from rain water which filters down through the soil overburden until it reaches the phreatic surface. The borings suggest that the water table within the site generally flows along or near the top of the rock surface. However, in some locations along the crests of ridgelines, the phreatic surface is within the bedrock. The springs generally represent areas where the upper surface of the ground-water table intercepts the ground surface. In some areas, however, it appears that springs may exit the soil atop localized zones of low-permeability soil of rock above the general ground-water level. A water table map has been constructed from measurements of surface water and water levels in boreholes. This map is presented as Figure 5 in the Appendix. The water table elevation noted on the plan is considered to represent a near seasonal long term high. However, as noted on Table 1, water levels in some isolated areas were noted to range up to 5 feet higher during the study period. Well records researched for the area indicate that higher water elevations typically occur in the late spring and early summer months during the time frame when readings were made. Precipitation during study period is considered to be above normal.

The water table, as shown, follows the general topography of the site with most flows trending toward the swales, then to the north and the Pigeon River. One area which represents an exception to this general trend is located near the southeastern corner of the site limits. In this location, a saddle point is present in the ridgeline and ground-water flows in an easterly direction toward a bend in the Pigeon River.

In an effort to determine if a separate ground-water regime exists within the bedrock, cluster wells, extending into both the overburden soil and underlying bedrock, were installed at four locations. The ground-water elevations measured in each of the cluster wells were similar (generally within 1 to 2 feet). Over time, the direction of the head difference was found to

reverse in some instances (see Table 4 in the Appendix). Most of the nested wells are located in the lower portions of the site either in or adjacent to swales. Such areas would be expected to serve as both recharge or discharge zones, depending upon rainfall patterns. Potentiometric heads would be expected to fluctuate at various elevations within the subsurface profile as the shape of the ground-water flow net responds to recharge and discharge conditions. The readings obtained appear to be consistent with this general pattern. In any event, the magnitude of the gradients measured in the nested wells is relatively minor and does not indicate significant flow in either direction. This, coupled with the lack of a confining layer between the two subsurface strata, are indicative of a single ground-water regime. Ground water present in the soil overburden and the underlying bedrock appear to act as one unconfined aquifer system.

4.6.1 Water Bearing Characteristics of Bedrock

Well records were obtained for five domestic wells located within a 1 to 2 mile radius of the site to estimate the typical water bearing characteristics or properties for the bedrock. The information was obtained from Mr. Don Link of the North Carolina Department of Environment, Health, and Natural Resources. The information is listed in Table 5 in the Appendix. In general, the five wells surveyed were installed at depths which range from 245 to 375 feet. The static water levels for the wells range from 15 to 105 feet and typical well yields range from 1 to 25 gallons per minute.

Water derived from wells located in the bedrock is the primary source of drinking water in the general site area. Although no deep wells were installed at the site, the bedrock underlying the site would most likely yield sufficient quantities of water to support domestic supplies.

4.7 SEISMIC CONSIDERATIONS

Holocene faults were not observed in the immediate vicinity nor were they shown on published maps or discussed in the literature reveiwed.

Seismicity in the project area has been studied and assessed by the U.S. Geological Survey and the results of their studies have been published as Open-File Report 82-1033 (Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States, 1982). According to this document, the maximum probable acceleration in rock with a 90 percent probability of not being exceeded in a 250 year period is less than 0.1 g.

5.0 PATHWAY ANALYSIS

5.1 GENERAL

Based upon the results of water level measurements in the boreholes and observations of surface waters, the predominant ground-water flow direction is toward the north and the Pigeon River. Although not specifically detected by our borings, flows through more pervious joints in the rock could be oriented in a somewhat different direction in the vicinity of the joints.

5.2 CALCULATED GROUND-WATER FLOW VELOCITIES

Figure 5 shows the interpreted hydraulic gradient at the site which generally trends downward from areas of higher topographic elevation to lower elevation. Typical gradients range from about 0.22 in the central portion of the site to about 0.15 in the saddle area in the southeastern corner. Using a typical hydraulic conductivity of 2×10^{-4} cm/sec, and a conservative value of effective porosity of 0.25, and applying it to Darcy's Law (assuming steady state laminar flow), ground-water flow velocities at this site should be on the order of 130 to 180 feet per year. Higher flow velocities likely occur at the northern boundary of the site, where grades fall sharply toward the Pigeon River. Our flow velocity calculations are attached in the Appendix.

6.0 EVALUATION/RECOMMENDATIONS

In general, given the proper engineering controls, the proposed White Oak site appears to be suitable for development as a municipal solid waste landfill. The parcel is hydrologically down-gradient or cross-gradient of adjacent properties, has a moderate depth to ground-water in most areas, and is topographically favorable for the disposal of large quantities of waste.

Based upon the results of our study, we believe the most favorable part of the site for waste disposal includes that portion above elevation 2400. Parts of the site below this elevation are characterized by relatively steep slopes, and a high hydraulic gradient. Within the upper elevations, the lower portions of the swales are presently considered restricted for waste disposal due to the presence of springs. However, these springs are of relatively low volume and may be captured in a series of filtered drains. Once properly intercepted in this manner, the lower portions of swales may be filled with controlled, compacted fill to provide adequate separation between the waste and the ground water.

A minimum buffer of at least 4 feet should be maintained between the waste and the long term high ground-water elevation. As noted previously, the Phreatic Surface Map appended to this report portrays the near seasonal high ground-water elevation. However, in some areas, water levels were recorded during the course of our study at higher elevations than are reflected on this map. The design should consider the highest ground-water elevations recorded during the course of this study.

The installation of an engineered liner and leachate collection system is central to acceptance of the site for development as a sanitary landfill. Although not specifically addressed in the currently published North Carolina Rules for Solid Waste Management, liners and leachate collection systems are being required by the State for all newly proposed sanitary landfill sites.

Subsurface water presently flows toward the northern portion of the site and the river. A properly designed groundwater monitoring system should be incorporated into the overall

landfill design. Downgradient wells will typically need to be located along the northern side of the landfill cells. Additional wells should also be sited in the saddle area near the southeastern corner of the parcel where some ground-water apparently flows to the east. A well should also be included on the downgradient side of the leachate pond. It is anticipated that the upgradient well will be located within the south central portion of the site. Details relative to ground-water monitoring will be evaluated concurrent with the design of the landfill and will be included on the final plans.

Although the site is not in a particularly active area geologically, a reasonable design should consider the possibility of ground motion from tectonic activity. In consideration of recently published risk maps, we recommend that waste cells and liner systems be designed to be stable under a lateral earthquake acceleration of 0.1 g.

Based upon our laboratory tests, the on-site soils appear to be suitable for use as daily cover material and, potentially, for a landfill cap.

It is important that geotechnical engineers and geologists remain involved during the design phase of this project to address these important considerations.

7.0 REFERENCES CITED/METHODS

Hadley, J.B., and Goldsmith, R., 1963, "Geology of the Eastern Great Smoky Mountains North Carolina and Tennessee", U.S. Geological Survey Professional Paper 349-B, 118 pgs.

Marsh, Owen T., 1966, "Reconnaissance of the Ground-water Resources in the Waynesville Area, North Carolina", U.S. Geological Survey, Ground-water Bulletin No. 8, 108 pgs.

U.S. Geological Survey, 1967, Cove Creek Gap, North Carolina 7-1/2 minute quadrangle, scale 1:24,000.

U.S. Geological Survey, 1967, Fines Creek, North Carolina 7-1/2 minute quadrangle, scale 1:24,000.

Goldsmith, Richard, 1989, Professional Opinion Letter, 1 pg.

Butler, James Robert, 1989, Professional Opinion Letter, 1 pg.

Hatcher, Robert D., 1989, "Summary of Geologic Observations at the Proposed White Oak Landfill Site, Haywood County, North Carolina", 7 pgs.

The North Carolina Geological Survey, 1985, "Geologic Map of North Carolina".

Bouwer, H., and Rice, R.C., 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", Water Resources Research. v 12, pp 423-428.

Bouwer, H., and Rice, R.C., 1988, "The Bouwer and Rice Slug Test - An Update", Ground Water Vol. 27, No. 3, pp 304-309.

Froehling and Robertson, Inc., 1988, "Preliminary Subsurface Exploration - Proposed Haywood County Landfill".

United States Department of Agriculture, "Soil Survey for Haywood County, North Carolina".

King, P.B., Neuman, R.B., and Hadley, J.B., 1968, "Geology of the Great Smoky Mountains National Park, Tennessee and North Carolina", U.S. Geological Professional Paper 587, 23 pgs.

Streeter, V.L., and Wylie, E.B., 1975, "Fluid Mechanics", pgs 473-481.

APPENDICES

TABLE 1
SUMMARY OF PHYSICAL AND CHEMICAL PROPERTIES OF SOILS
PROPOSED HAYWOOD COUNTY LANDFILL SITE
Law Engineering, Inc. Project Number 57400142.01

HYDRAULIC CONDUCTIVITY

Laboratory Falling Head Tests

Boring	Depth (ft)	Permeability (cm/sec)	Material Type	Porosity(%)
B-5	9 - 14	3.7×10^{-7}	Sandy silt	37.7
B-6	1.5 - 10	2.9×10^{-7}	Silty sand	37.4
B-7A	0 - 10	5.1×10^{-7}	Silty sand	37.0
B-7B	15 - 25	3.7×10^{-7}	Sandy silt	40.6
B-103	15 - 17	2.3×10^{-4}	Sandy silt	41.5
B-113	5 - 7	4.4×10^{-5}	Sandy silt	35.6

Field In-situ Slug Tests

Boring	Depth (ft)	Permeability (cm/sec)	Material Type
B-108	6.6 - 16.6	2.0×10^{-4}	Sandy silt/partially weathered rock
B-109	11.5 - 16.5	8.0×10^{-5}	Sandy silt
B-109A	25.0 - 30.0	9.0×10^{-5}	Bedrock
B-111A	39.0 - 44.0	5.0×10^{-4}	Bedrock
B-113	16.0 - 21.0	2.0×10^{-4}	Sandy silt
B-113A	27.5 - 32.5	2.0×10^{-4}	Bedrock

Packer Tests

Boring	Depth (ft)	Permeability (cm/sec)	ROD (%)	Rec(%)
B-109A	25.0 - 30.0	8.0×10^{-5}	83	83
B-111A	32.0 - 44.0	No Take	63	100
B-113A	22.0 - 27.0	8.0×10^{-4}	81	94

CHEMICAL PROPERTIES

Cation Exchange Capacity (CEC)

Boring	Depth (ft)	Measured Value (meq/100gm)
B-101	15	14
B-104	15	19
B-106	15	25
B-110	5	26
B-112	15	19
B-115	10	21

TABLE 2
SUMMARY OF OUTCROP MEASUREMENTS
PROPOSED HAYWOOD COUNTY LANDFILL SITE
Law Project Number 57400142.01

Outcrop Number	Designation	Strike/Dip (degrees)
1	Foliation	N60E/65SE
	Foliation	N70E/62SE
	Foliation	N70E/63SE
	Joint	N75W/80SW
2	Foliation	N10E/38SE
	Foliation	N12E/30SE
	Foliation	N58E/78SE
	Fault	N15E/90
3	Foliation	N33E/52SE
	Joint	N20E/26SE
4	Foliation	N38E/48SE
	Joint	N15E/48SE
	Joint	N55W/75SW
	Fault	N40E/35SE
5	Foliation	N22E/48SE
	Foliation	N34E/58SE
	Fault	N30W/7SW
	Fault	N30E/90

TABLE 3
SUMMARY OF WATER ELEVATION DATA
HAYWOOD COUNTY LANDFILL
LAW ENGINEERING PROJECT NUMBER 57400142.01

BORING	TOP OF GROUND	DATE DRILLED	GROUND-WATER ELEVATION (FT-MSL) T.O.B.	3-29-90	4-23-90	4-24-90	4-27-90	4-12-91	4-18-91
B-101	2538.46	2-20-90	2517.96	2518.06	2519.16	2519.16	N/A	N/A	N/A
B-102	2516.16	2-27-90	2508.16	2511.36	2512.56	2512.56	N/A	N/A	2512.30
B-103	2509.03	3-28-90	2487.03	2464.33	N/A	N/A	N/A	N/A	2463.53
B-104	2543.65	3-28-90	DRY	DRY	2524.35	2524.45	N/A	N/A	2519.02
B-105	2555.75	2-21-90	*	2538.95	2539.55	2539.62	N/A	N/A	2539.78
B-105A	2555.63	2-23-90	N/A	2539.53	2538.73	2538.78	N/A	N/A	2538.95
B-106	2632.63	2-24-90	DRY	DRY	DRY	DRY	N/A	N/A	N/A
B-107	2579.57	2-24-90	DRY	2566.97	DRY	DRY	N/A	N/A	N/A
B-108	2513.50	2-22-90	2499.10	2507.00	2506.78	2506.8	N/A	N/A	2506.65
B-109	2441.50	3-27-90	2438.50	2439.80	2439.72	N/A	N/A	N/A	2442.00
B-109A	2442.12	3-27-90	*	2440.12	2439.70	2439.55	N/A	N/A	2439.12
B-110	2517.57	2-19-90	2508.57	2512.37	2512.02	2511.97	N/A	N/A	N/A
B-111	2491.96	2-20-90	2483.96	N/A	2490.46	2490.29	N/A	N/A	2490.46
B-111A	2491.33	3-29-90	2489.33	N/A	2490.98	2490.91	N/A	N/A	2491.63
B-112	2506.50	2-21-90	DRY	DRY	DRY	DRY	N/A	N/A	2477.92
B-113	2542.95	3-28-90	2534.45	2540.75	2540.40	2540.37	N/A	N/A	2540.20
B-113A	2541.83	3-28-90	N/A	2538.83	2538.50	2538.5	N/A	N/A	2538.33
B-114	2619.68	2-23-90	DRY	DRY	DRY	DRY	N/A	N/A	N/A
B-115	2649.17	2-23-90	DRY	DRY	**	DRY	N/A	N/A	N/A
AT-1	2544.72	4-24-90	N/A			N/A	2501.32	N/A	2500.95
AT-2	2615.07	4-24-90	N/A			N/A	2556.81	N/A	2556.12
AT-3	2620.18	4-23-90	N/A			2561.53	2561.63	N/A	2559.78
AT-4	2593.16	4-23-90	2521.16			2525.49	2525.29	N/A	N/A
AT-5	2630.63	4-23-90	N/A			N/A	DRY	N/A	N/A
AT-6	2567.03	4-23-90	2495.03			2513.33	2513.48	N/A	2510.47
AT-7	2527.29	4-24-90	N/A			N/A	2483.45	N/A	2481.06
AT-8	2509.19	4-24-90	N/A			N/A	2465.56	N/A	2470.53
AT-9	2541.91	4-11-91	DRY					2527.54	2527.43
AT-10	2512.23	4-11-91	2489.46					2493.96	2493.13
AT-11	2553.57	4-11-91	2534.89					2535.69	2535.37
AT-12	2517.40	4-11-91	DRY					DRY	DRY
AT-13	2525.32	4-11-91	2513.28					2515.48	2516.81
AT-14	2631.84	4-11-91	2564.02					2560.48	2560.06
AT-15	2644.04	4-11-91	2564.19					2580.92	2581.54

NOTES: * Indicates rock core boring - borehole filled with water at completion
** False indicator signal at elevation 2566.97

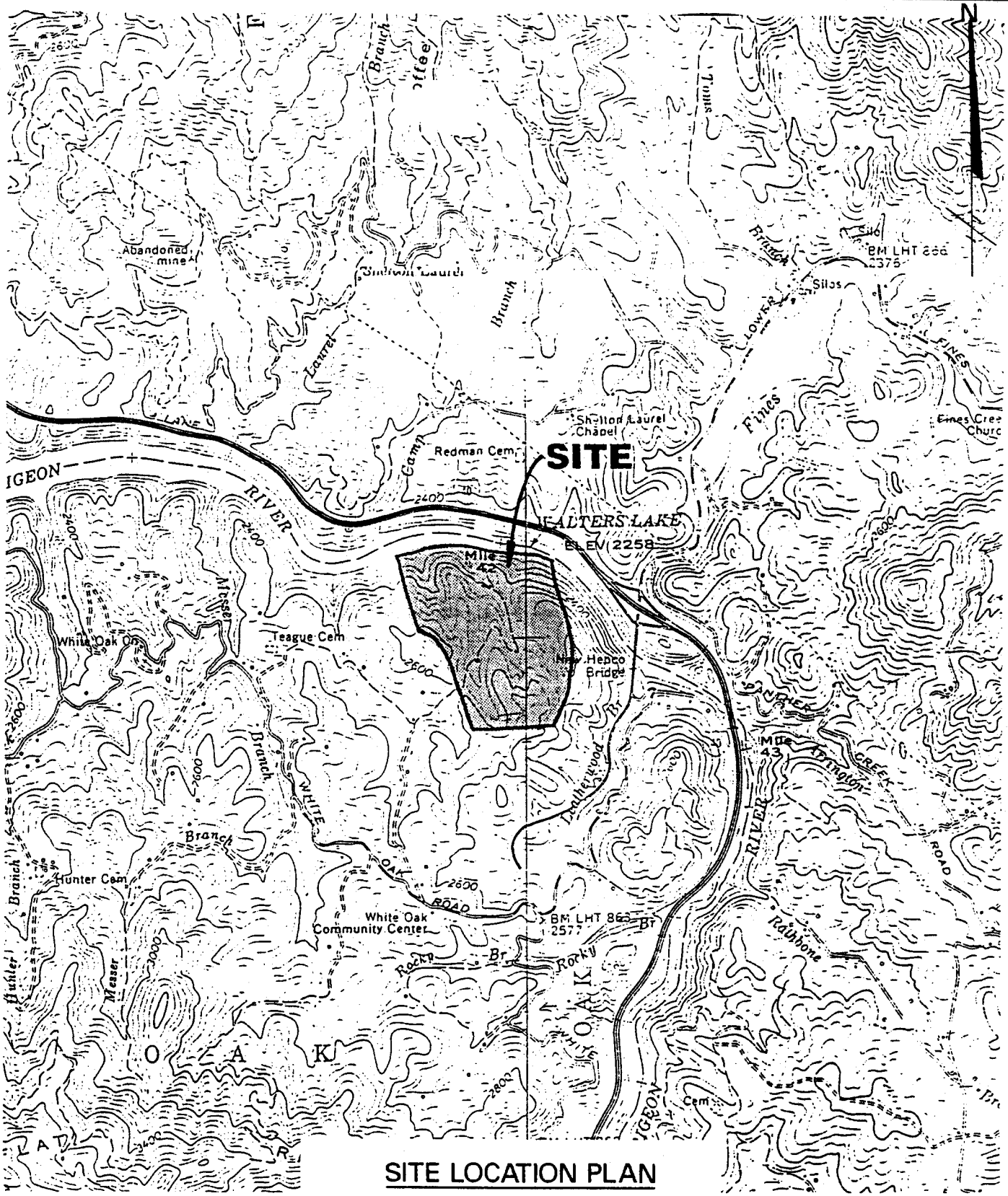
TABLE 4
SUMMARY OF NESTED WELL WATER LEVEL VARIATIONS
PROPOSED HAYWOOD COUNTY LANDFILL SITE
Law Engineering Project Number 57400142.01

Boring Number	3-29-90	Delta/ Direction	4-23-90	Delta/ Direction	4-18-91	Delta/ Direction
B-105 (38.1)	2538.95		2539.55		2539.78	
B-105A (23.5)	2539.53	.58 dn	2538.73	.82 up	2538.95	.83 up
B-109 (16.5)	2439.80		2439.72		2442.00	
B-109A (30.0)	2440.12	.32 up	2439.70	.02 dn	2439.12	2.88 dn
B-111 (34.3)	N/A		2490.46		2490.46	
B-111A (44.0)	N/A		2490.98	.52 up	2491.63	1.17 up
B-113 (21.0)	2540.75		2540.40		2540.20	
B-113A (32.5)	2538.83	1.92 dn	2538.50	1.90 dn	2538.33	1.87 dn

Notes: Numbers in parenthesis indicate boring depths

TABLE 5
WATER BEARING CHARACTERISTICS OF NEARBY WATER WELLS
PROPOSED HAYWOOD COUNTY LANDFILL SITE
Law Engineering Project Number 57400142.01

Owner/Address	Depth (feet)	Static Water Level (ft)	Casing (ft)	Yield (gpm)
Mike Mendenhal State Road 1347 P.O. Box 467 Silver City 27344	375	105	30	1
Von Bramitt, Jr. 1021 Nottingham Ln. Crystal Lake	305	40	189	10
Claude Woody State Road 1346 Rt. 4, Box 200A Waynesville 28786	365	75	24	8
William Higgins State Road 1338 P.O. Box 891 Maggie	245	15	32	25
William Carver State Road 1338 Rt. 3 Waynesville 28786	245	50	42	2



SITE LOCATION PLAN

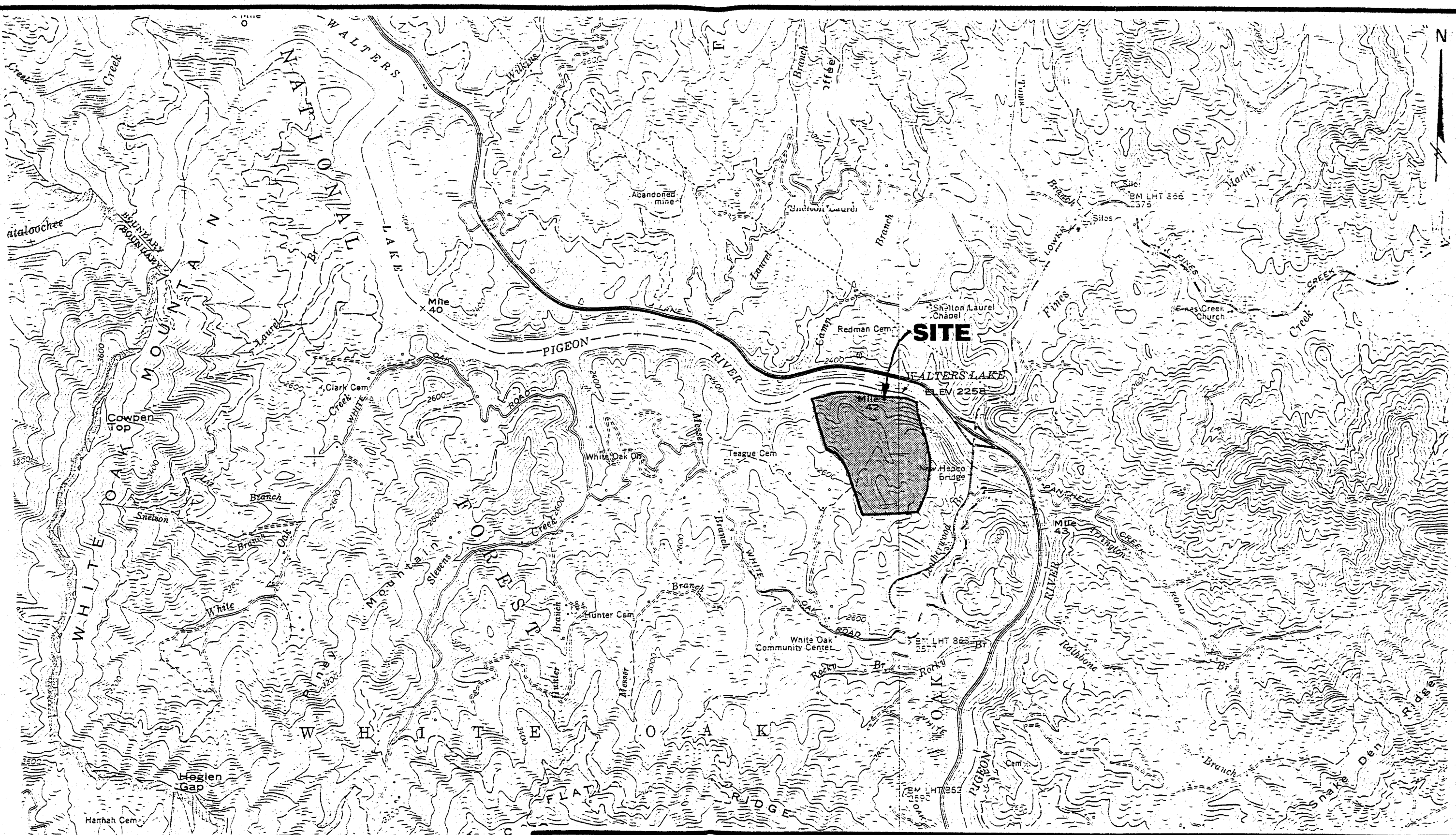
Law Engineering
Atlanta, Georgia

Geotechnical, Materials & Environmental Consultants

PROPOSED WHITE OAK LANDFILL
HAYWOOD COUNTY, NORTH CAROLINA

FIG. 1

Job Number	Scale
57400142.01	1"= 2000'



Law Engineering

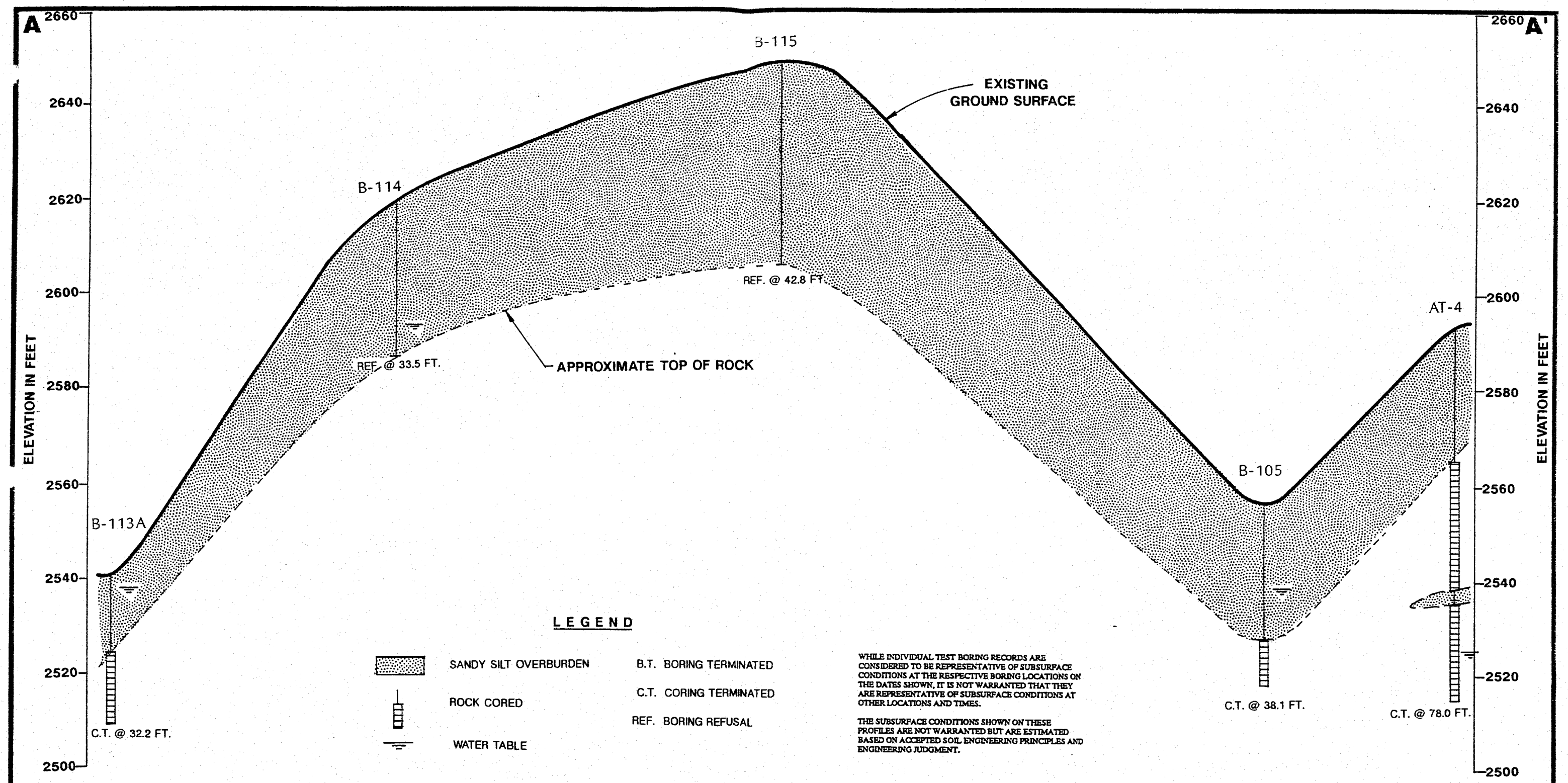
Geotechnical and Materials Engineers

PROPOSED WHITE OAK LANDFILL
HAYWOOD COUNTY, NORTH CAROLINA

JOB NUMBER 57400142.01

SCALE 1"= 2000'

FIGURE 2
SITE TOPOGRAPHIC PLAN



LEGEND

SANDY SILT OVERBURDEN

ROCK CORED

WATER TABLE

B.T. BORING TERMINATED

C.T. CORING TERMINATED

REF. BORING REFUSAL

WHILE INDIVIDUAL TEST BORING RECORDS ARE CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS ON THE DATES SHOWN, IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

THE SUBSURFACE CONDITIONS SHOWN ON THESE PROFILES ARE NOT WARRANTED BUT ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND ENGINEERING JUDGMENT.

LAW ENGINEERING
Atlanta, Georgia
Geotechnical, Materials & Environmental Consultants

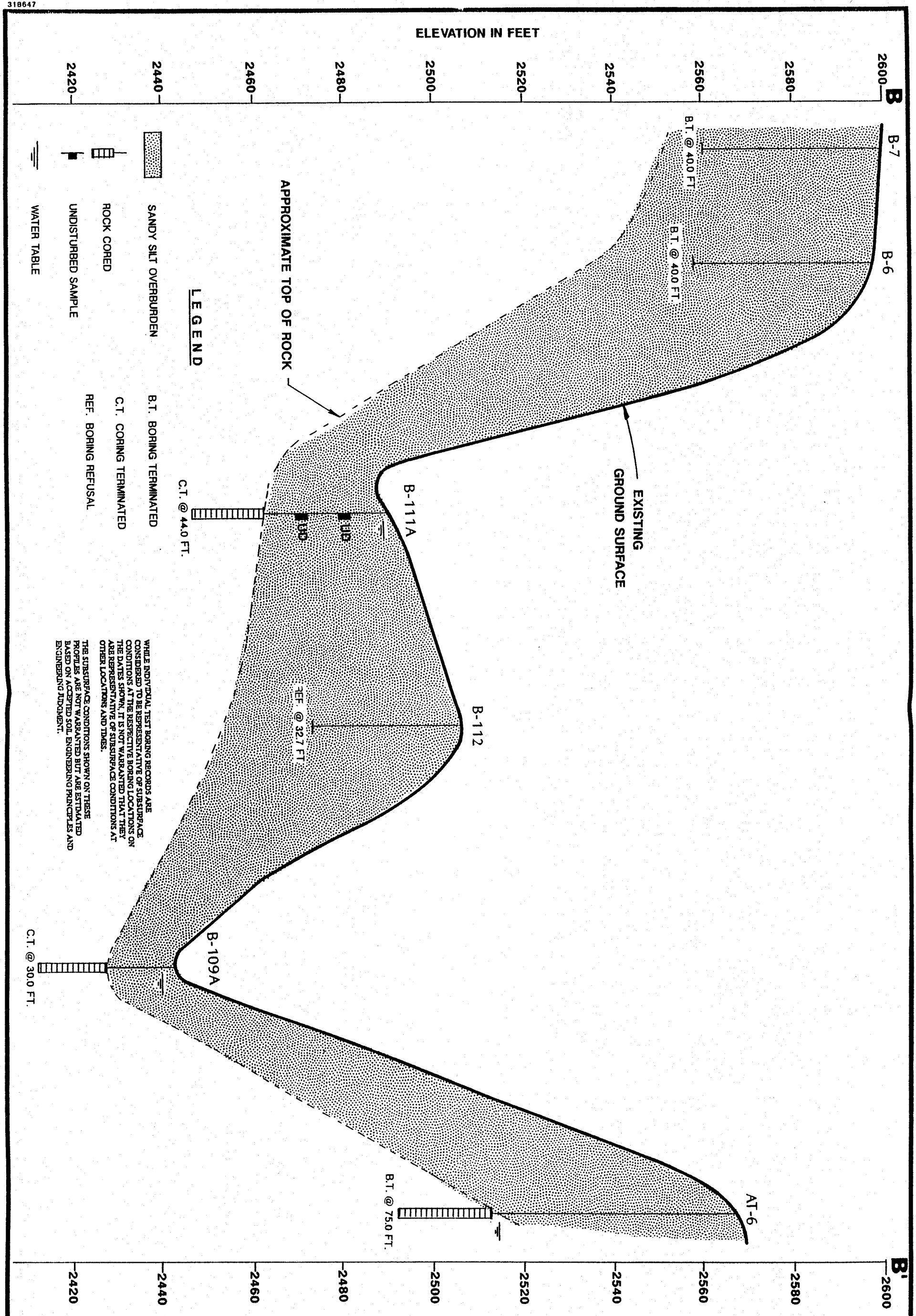
PROPOSED WHITE OAK LANDFILL
HAYWOOD COUNTY, NORTH CAROLINA

SCALE	PROJECT NO.	DATE
1"=100'(H) 1"=20'(V)	57400142.01	REVISED 10/19/90

FIGURE 7
GENERALIZED SUBSURFACE PROFILE A - A'

318647

318647

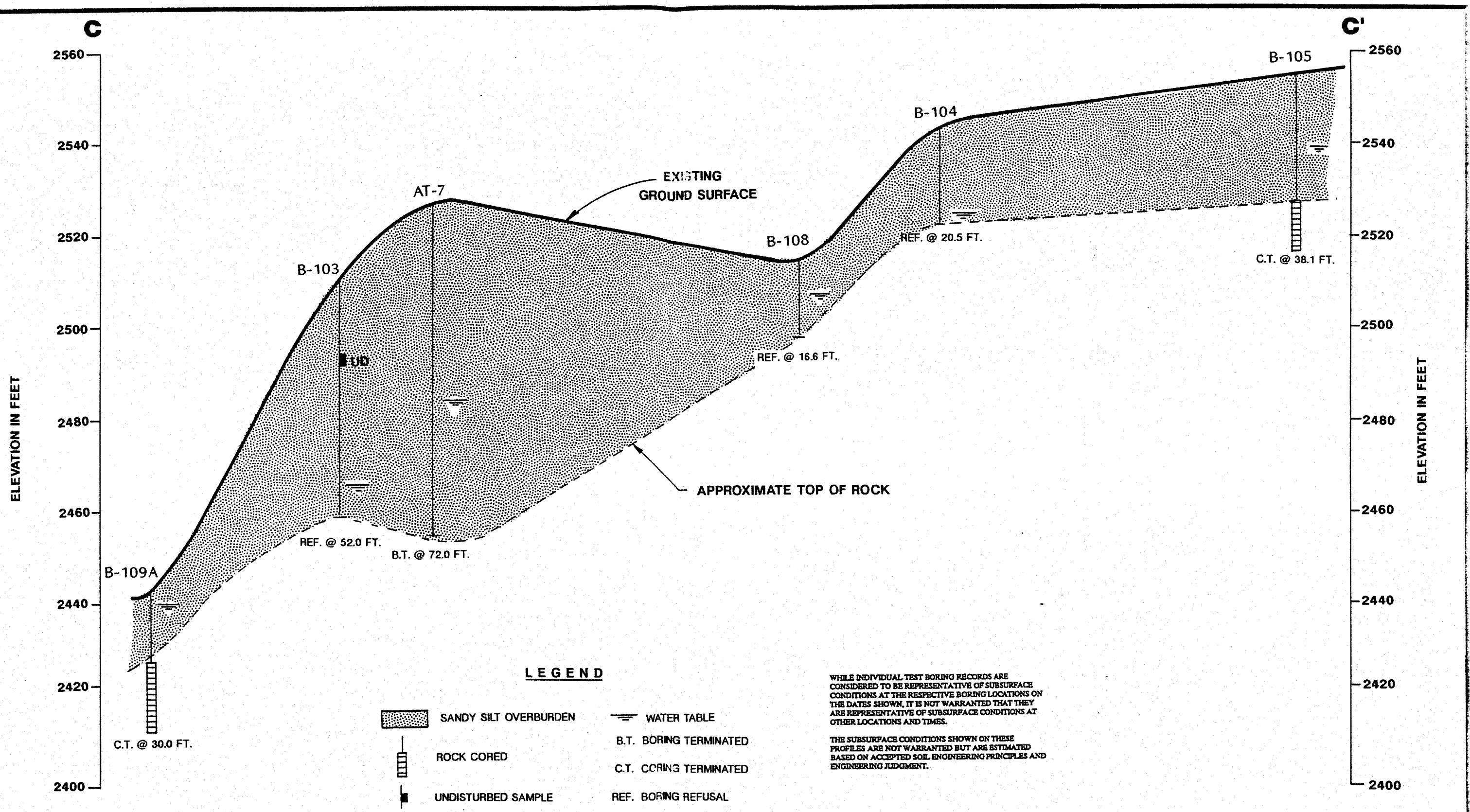


LAW ENGINEERING
Atlanta, Georgia
Geotechnical, Materials & Environmental Consultants

PROPOSED WHITE OAK LANDFILL
HAYWOOD COUNTY, NORTH CAROLINA

SCALE	PROJECT NO.	DATE
1"=100'(H) 1"=20'(V)	57400142.01	REVISED 10/19/90

FIGURE 8
GENERALIZED SUBSURFACE PROFILE B - B'



LEGEND

- SANDY SILT OVERBURDEN
- ROCK CORED
- UNDISTURBED SAMPLE
- WATER TABLE
- B.T. BORING TERMINATED
- C.T. CORING TERMINATED
- REF. BORING REFUSAL

WHILE INDIVIDUAL TEST BORING RECORDS ARE CONSIDERED TO BE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THE RESPECTIVE BORING LOCATIONS ON THE DATES SHOWN, IT IS NOT WARRANTED THAT THEY ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT OTHER LOCATIONS AND TIMES.

THE SUBSURFACE CONDITIONS SHOWN ON THESE PROFILES ARE NOT WARRANTED BUT ARE ESTIMATED BASED ON ACCEPTED SOIL ENGINEERING PRINCIPLES AND ENGINEERING JUDGMENT.

LAW ENGINEERING
Atlanta, Georgia
Geotechnical, Materials & Environmental Consultants

PROPOSED WHITE OAK LANDFILL
HAYWOOD COUNTY, NORTH CAROLINA

SCALE	PROJECT NO.	DATE
1"=100'(H) 1"=20'(V)	57400142.01	REVISED 10/19/90

FIGURE 9
GENERALIZED SUBSURFACE PROFILE C - C'

316647

CORRELATION OF PENETRATION RESISTANCE WITH RELATIVE DENSITY AND CONSISTENCY

	NO. OF BLOWS, N	RELATIVE DENSITY
SANDS:	0-4	Very Loose
	5-10	Loose
	11-30	Firm
	31-50	Dense
	OVER 50	Very Dense

		CONSISTENCY
SILTS & CLAYS:	0-2	Very Soft
	3-4	Soft
	5-8	Firm
	9-15	Stiff
	16-30	Very stiff
	31-50	Hard
	OVER 50	Very Hard

PARTICLE SIZE IDENTIFICATION

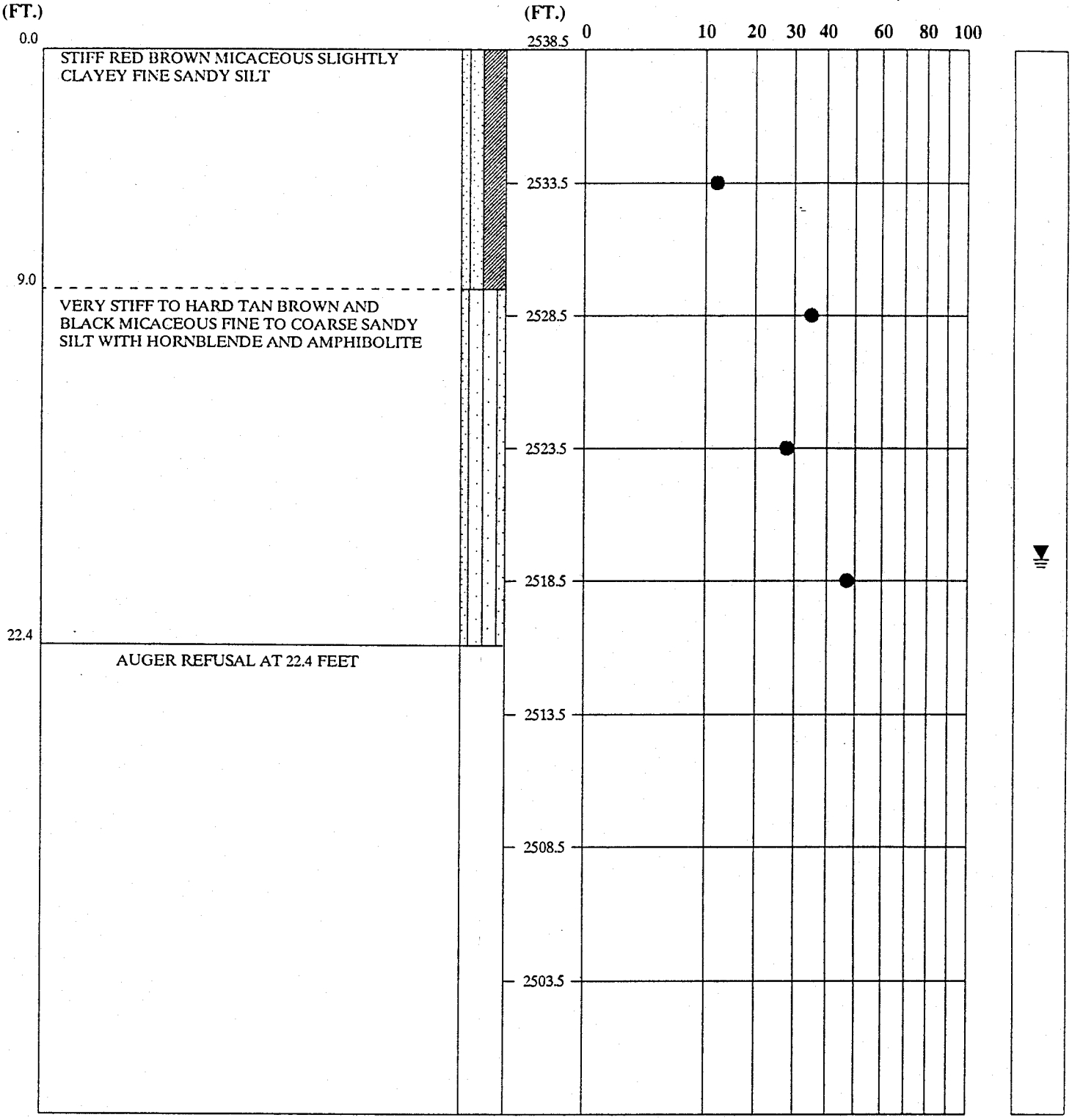
BOULDERS:		12 inches OR GREATER
COBBLES:		3 inches to 12 inches
GRAVEL:	Coarse -	3/4 inches to 3 inches
	Fine -	NO. 4 to 3/4 inches
SANDS:	Coarse -	NO. 10 to NO. 4
	Medium -	NO. 40 to NO. 10
	Fine -	NO. 200 to NO. 40
SILTS & CLAYS:		PASSING NO. 200

KEY TO DRILLING SYMBOLS

- Undisturbed Sample
- Split Spoon Sample
- Water Table After 24 Hours
- Water Table at Time of Drilling

KEY TO SOIL CLASSIFICATIONS

- SILTY CLAY
- SILT
- CLAYEY SILT
- SANDY SILT
- SAND
- SILTY SAND
- CLAYEY SAND
- PARTIALLY WEATHERED ROCK - A transitional material between soil and rock which retains the relic structure of the parent rock.
- **ASPHALT**
- **CONCRETE**
- **GRAVEL**
- **TOPSOIL**
- **FILL**
- **ALLUVIUM**
- ROCK



REMARKS:

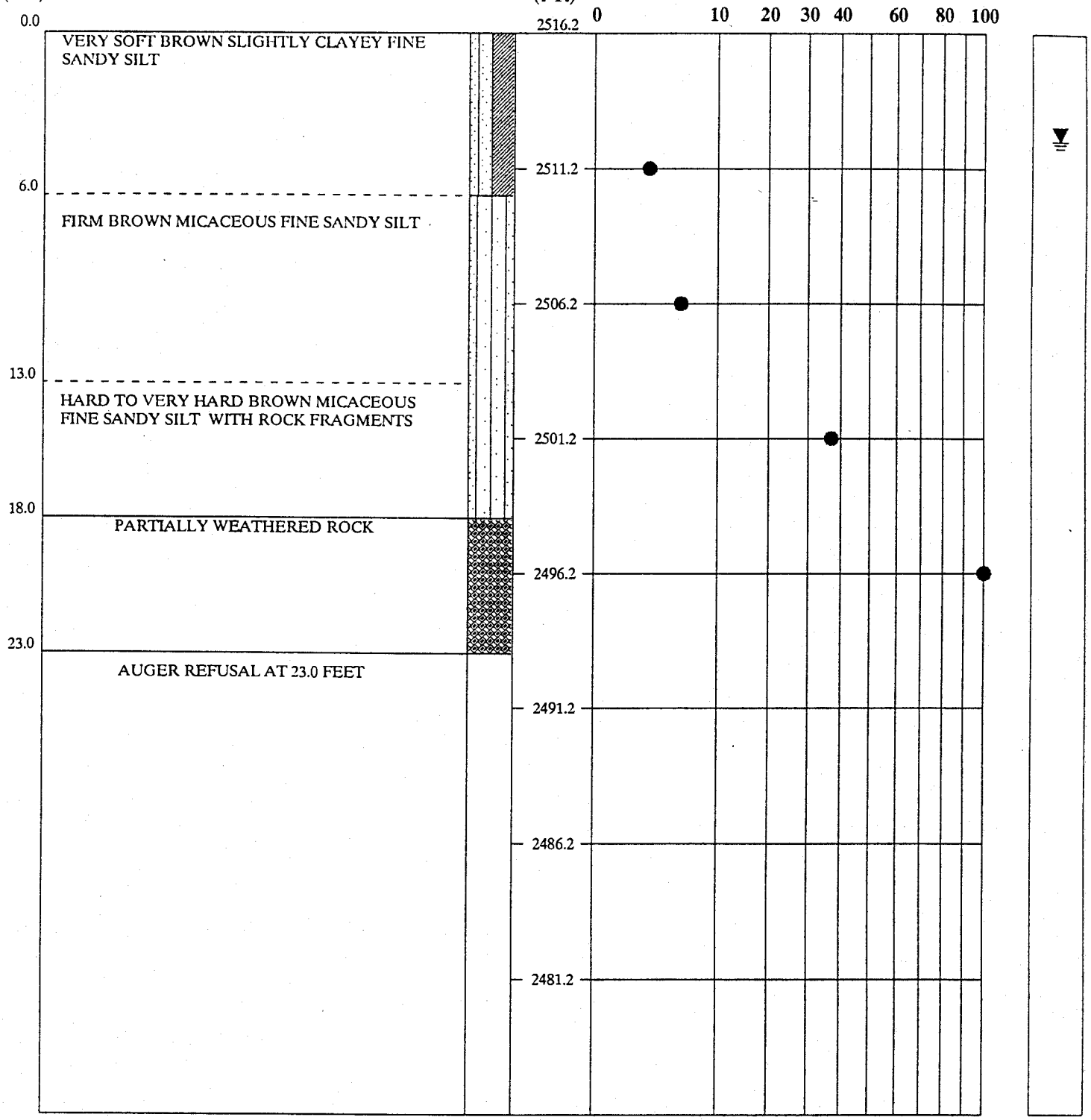
GROUND WATER MEASURED AT 19.2 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-101
DATE DRILLED	February 20, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

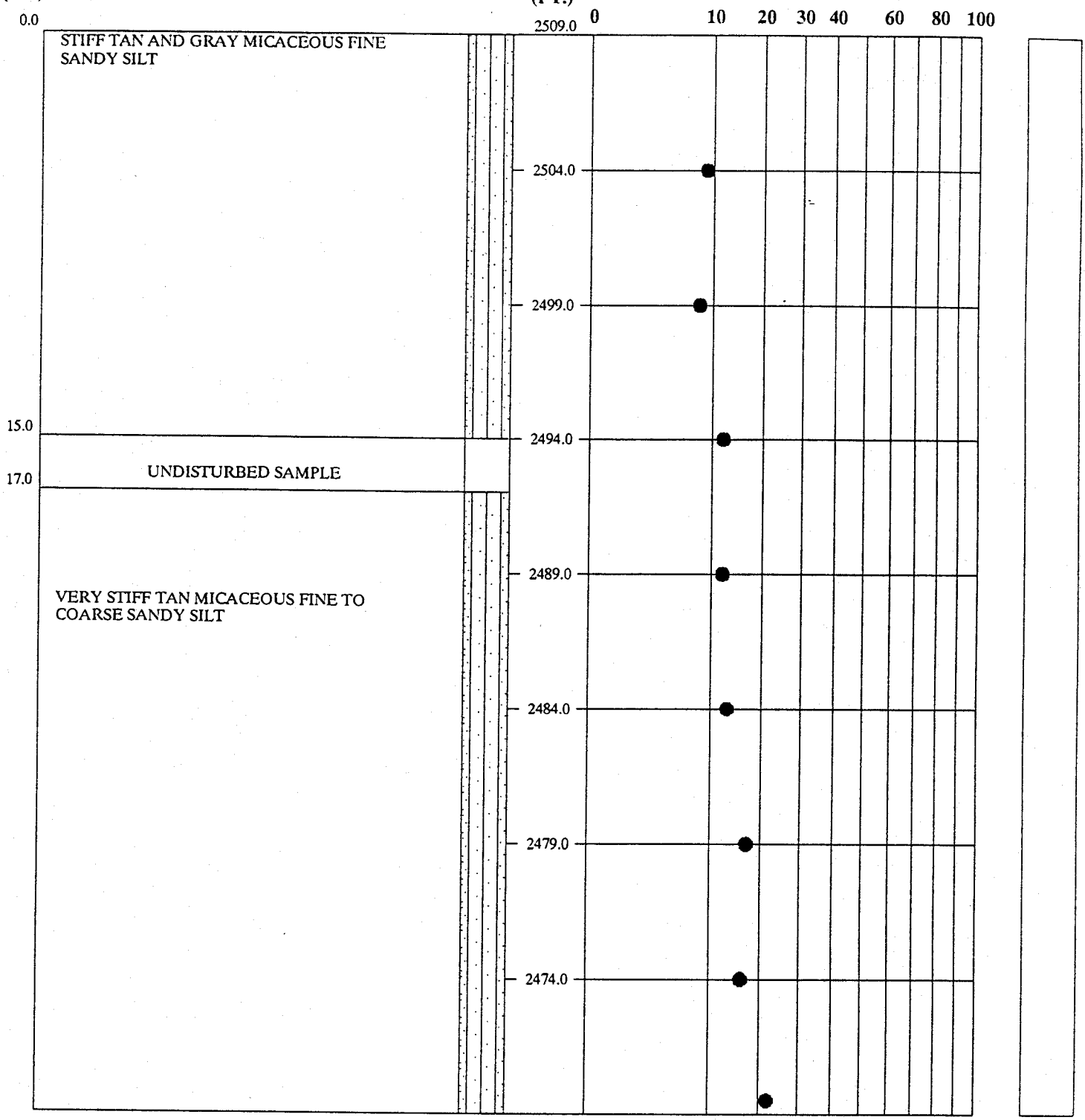
GROUND WATER MEASURED AT 4.0 ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-102
DATE DRILLED	March 27, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

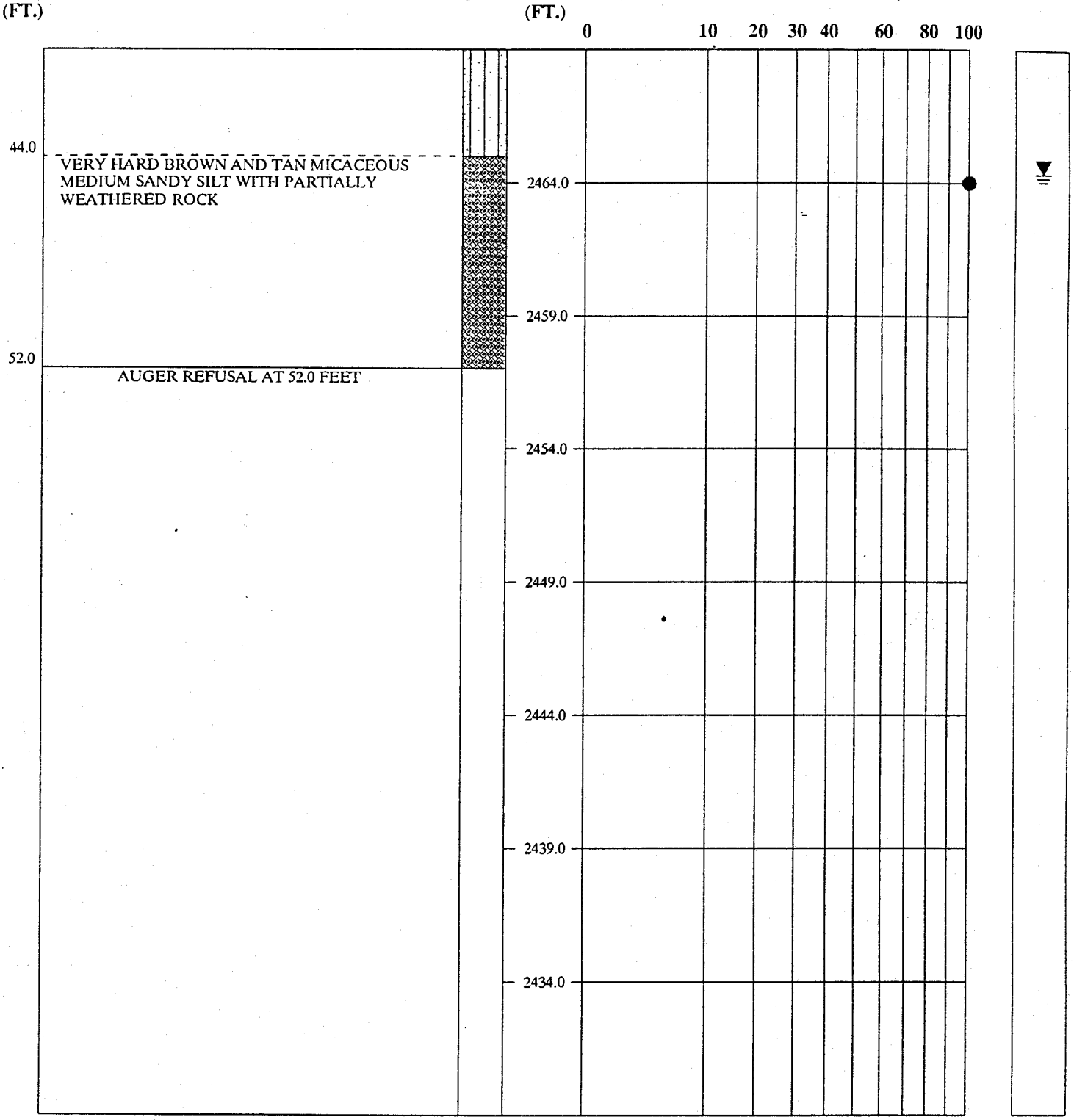
GROUND WATER MEASURED AT 44.7 FEET ON 4-23-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-103
DATE DRILLED	March 28, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 2	

LAW ENGINEERING



REMARKS:

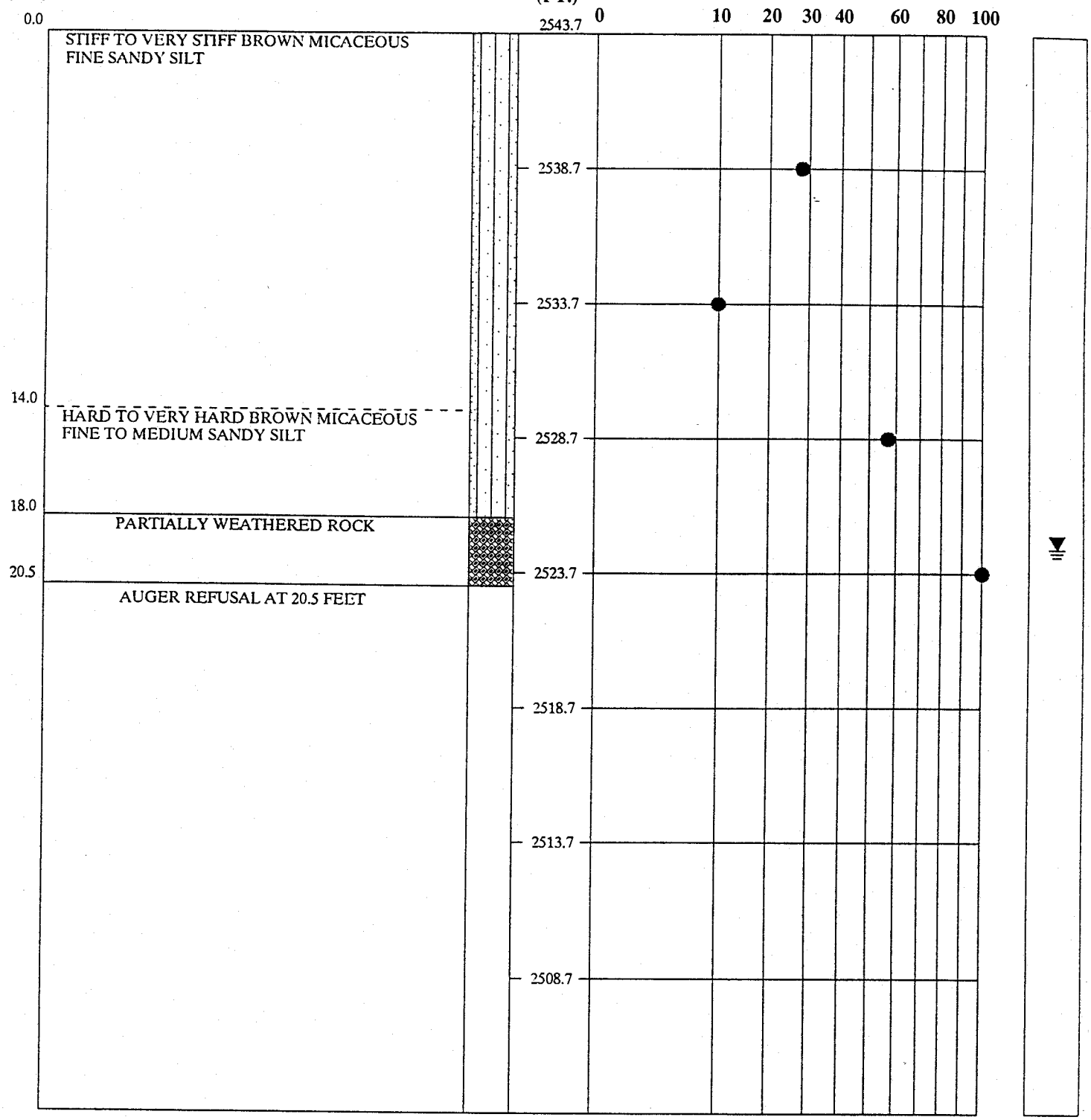
GROUND WATER MEASURED AT 44.7 FEET ON 4-23-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-103
DATE DRILLED	March 28, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING



REMARKS:

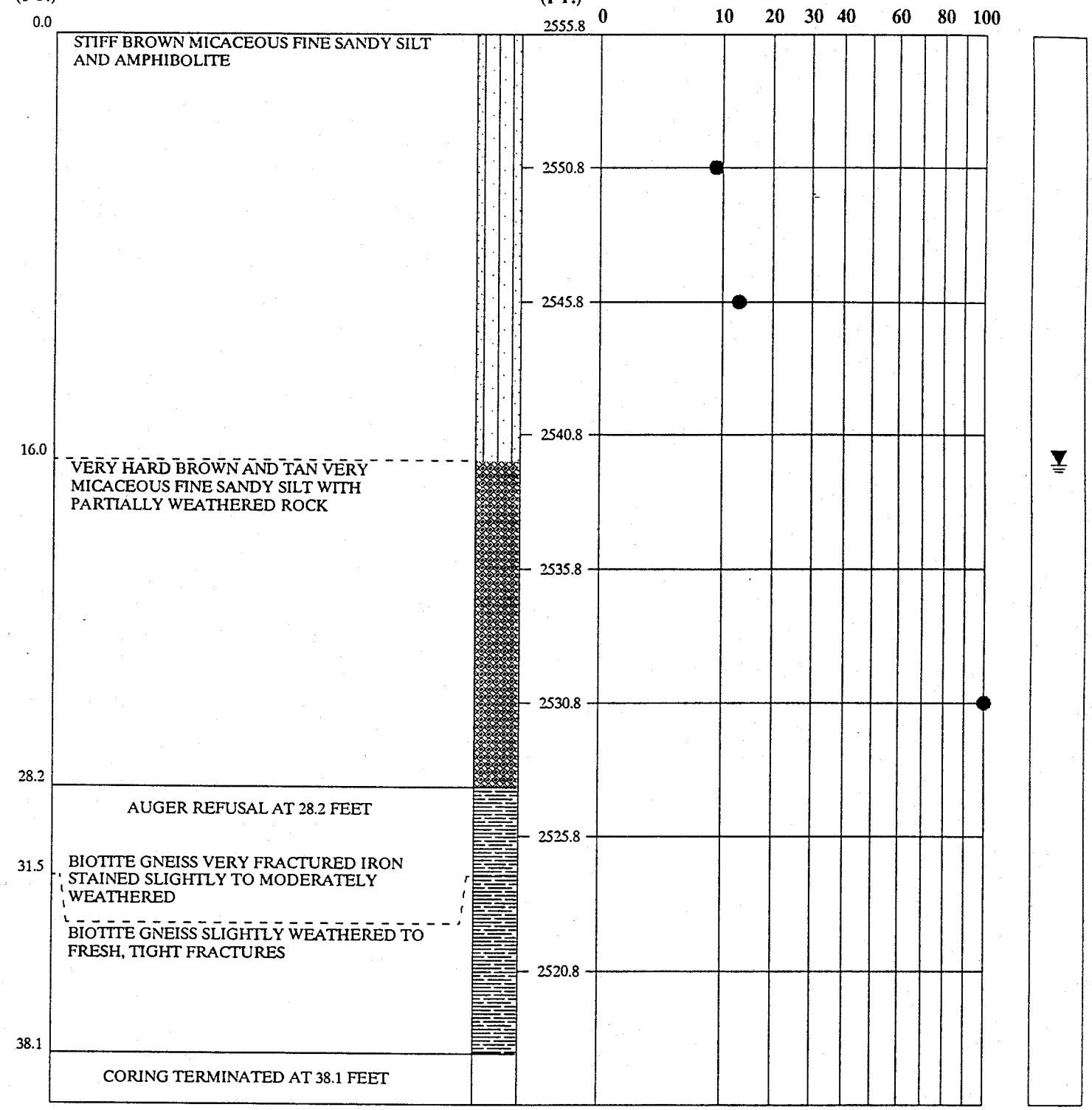
GROUND WATER MEASURED AT 19.1 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-104
DATE DRILLED	March 28, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 16.1 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-105
DATE DRILLED	February 21, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100
	* REC. 100% RQD. 0% ** REC. 50% RQD. 0% *** REC. 114% RQD. 84% **** REC. 83% RQD. 100%	2510.8 2505.8 2500.8 2495.8 2490.8 2485.8 2480.8	

REMARKS:

GROUND WATER MEASURED AT 16.1 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

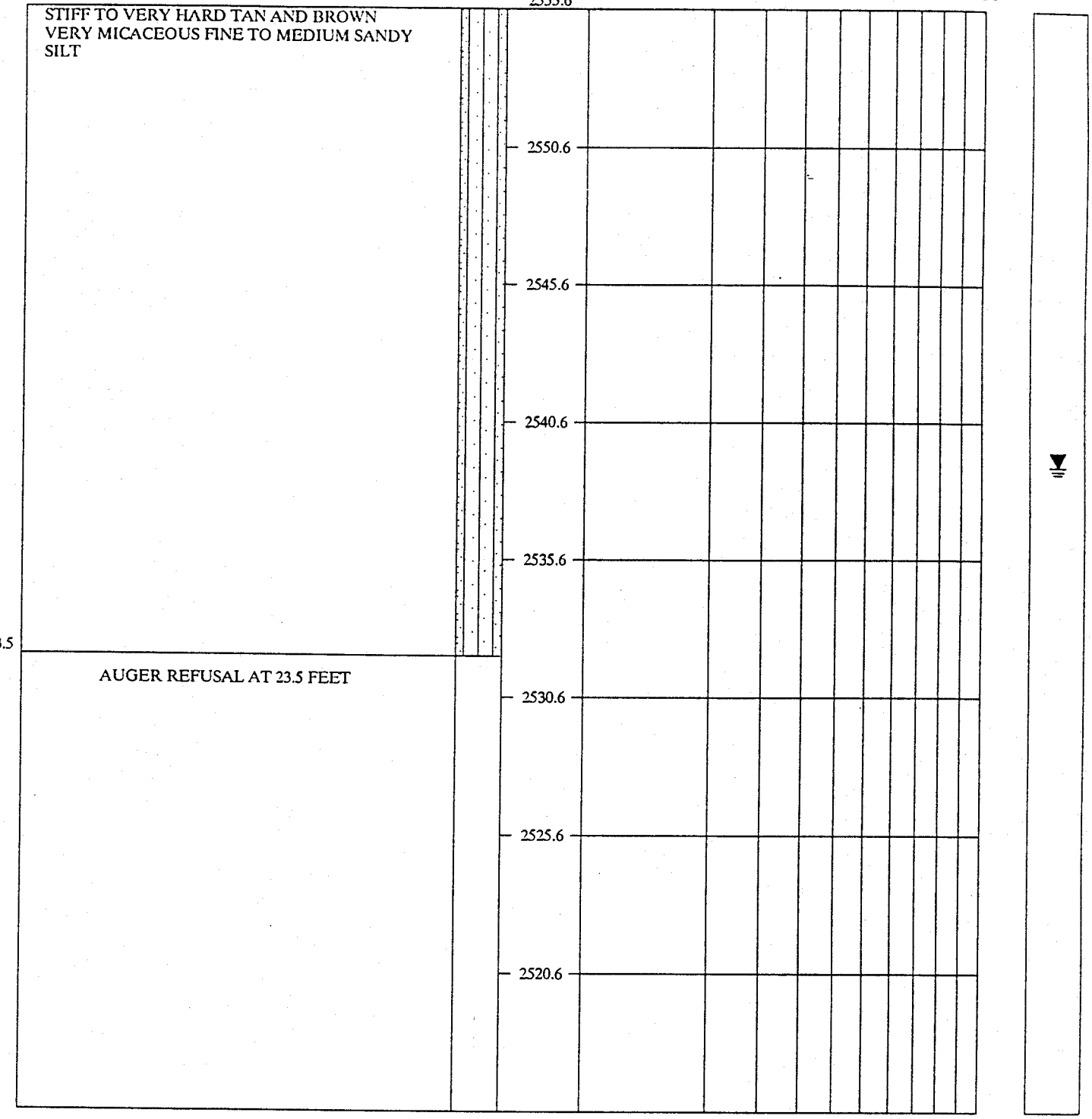
BORING NUMBER	B-105
DATE DRILLED	February 21, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
0.0	STIFF TO VERY HARD TAN AND BROWN VERY MICACEOUS FINE TO MEDIUM SANDY SILT	2555.6
23.5	AUGER REFUSAL AT 23.5 FEET	2550.6, 2545.6, 2540.6, 2535.6, 2530.6, 2525.6, 2520.6

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

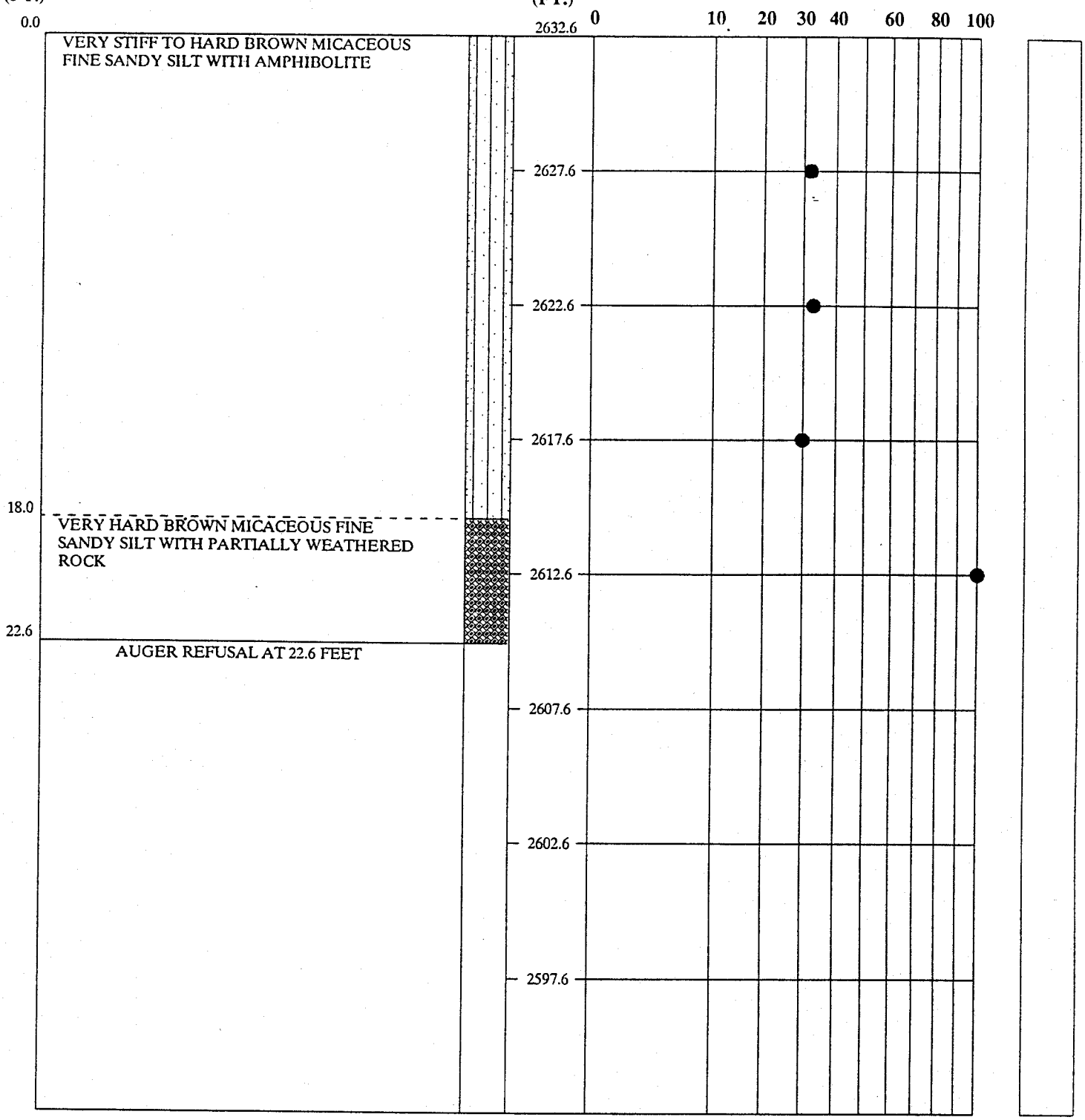
NO SAMPLES TAKEN, SOIL DESCRIPTIONS BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 16.6 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-105A
DATE DRILLED	February 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

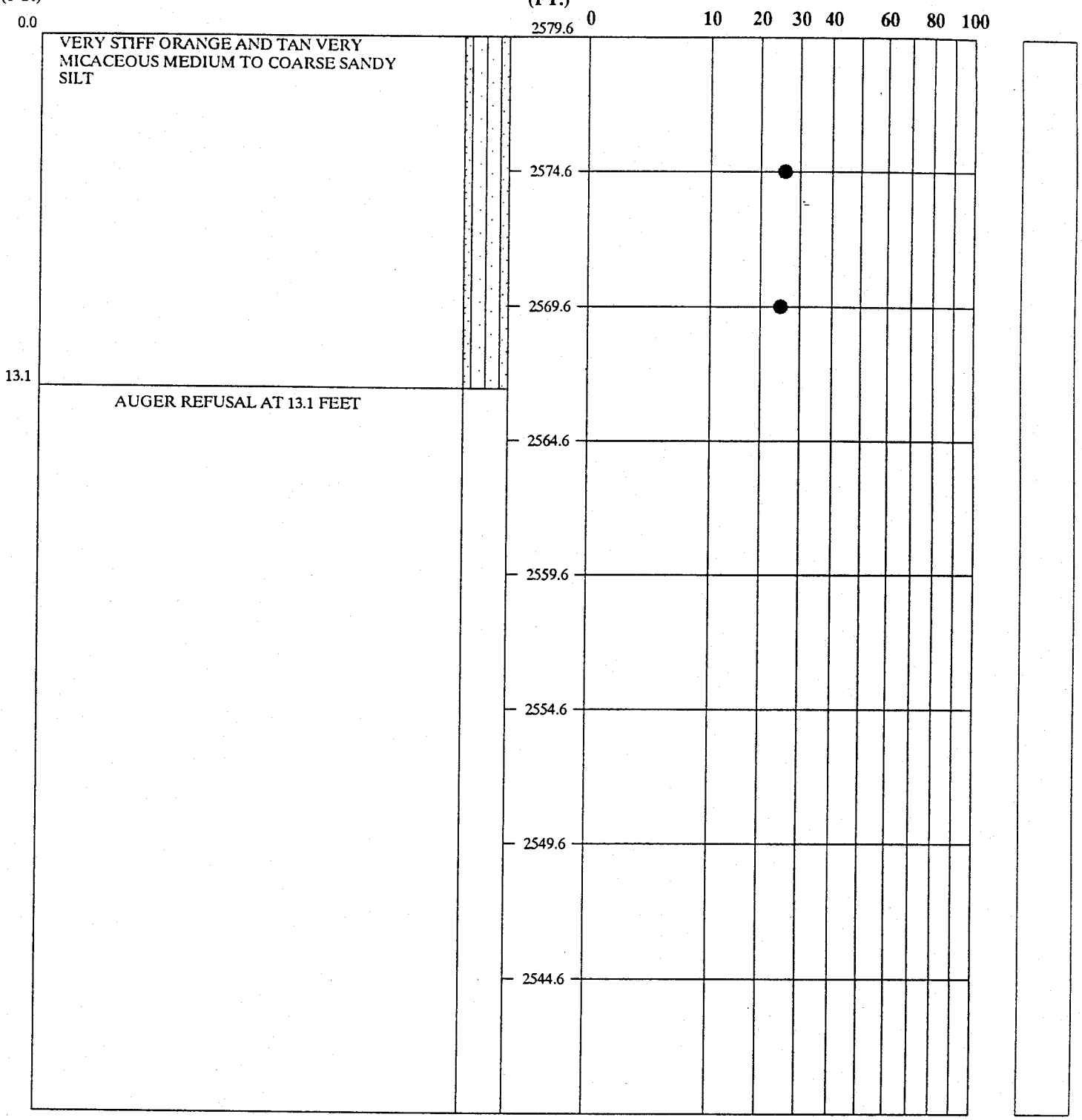
NO GROUND WATER ENCOUNTERED AS OF 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-106
DATE DRILLED	February 24, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

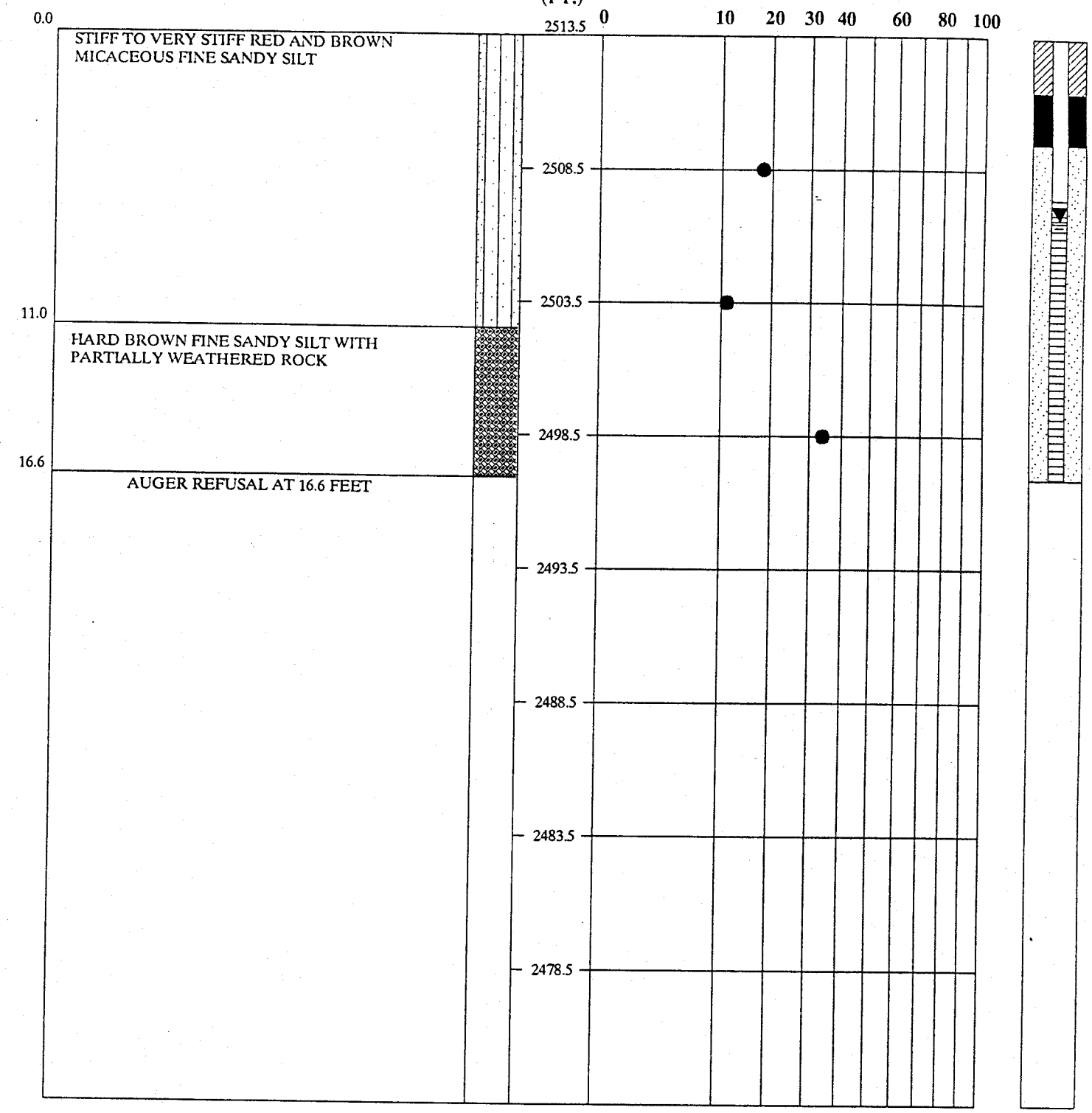
NO GROUND WATER ENCOUNTERED AS OF 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-107
DATE DRILLED	February 24, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

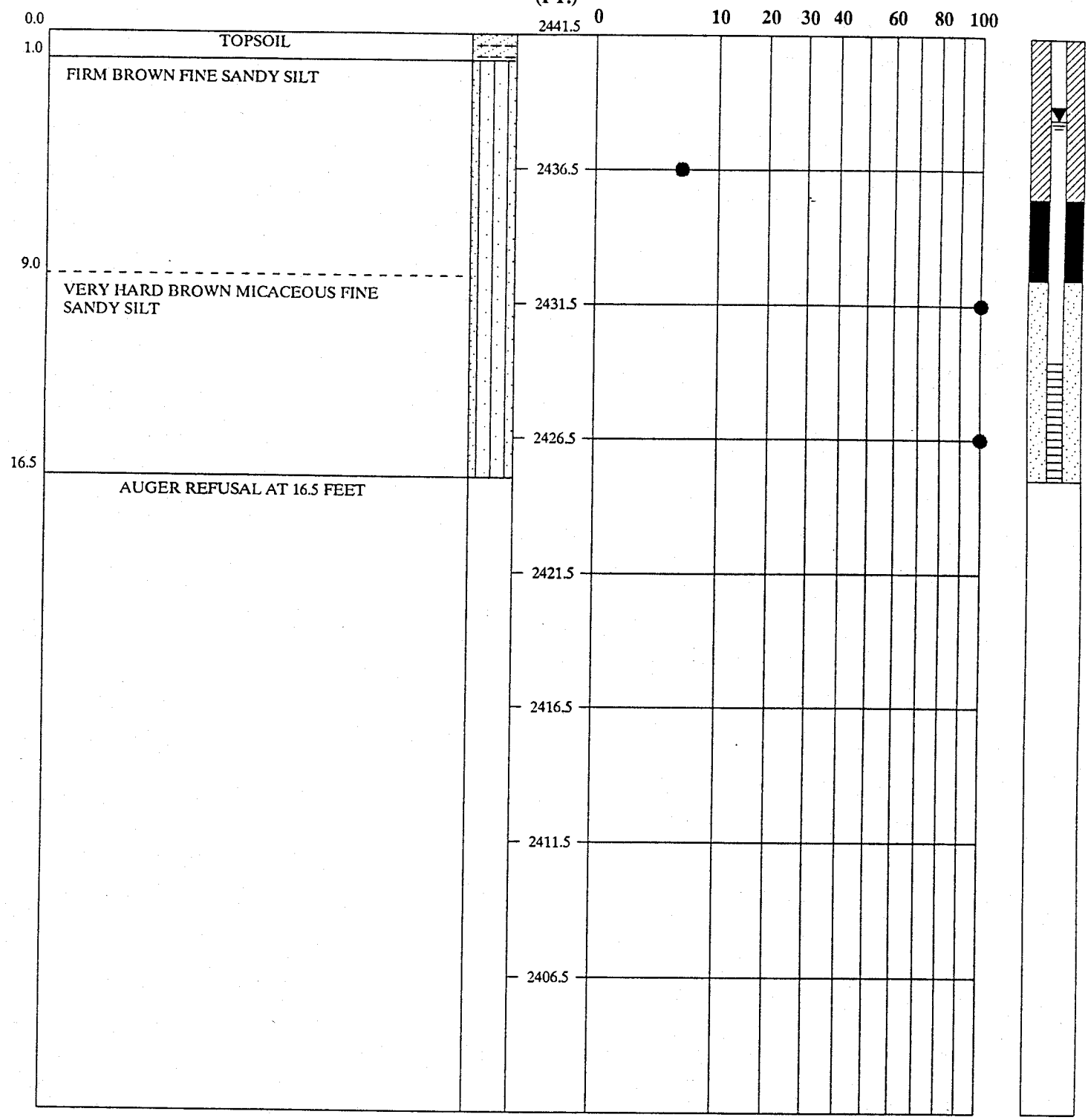
GROUND WATER MEASURED AT 6.8 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-108
DATE DRILLED	February 22, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

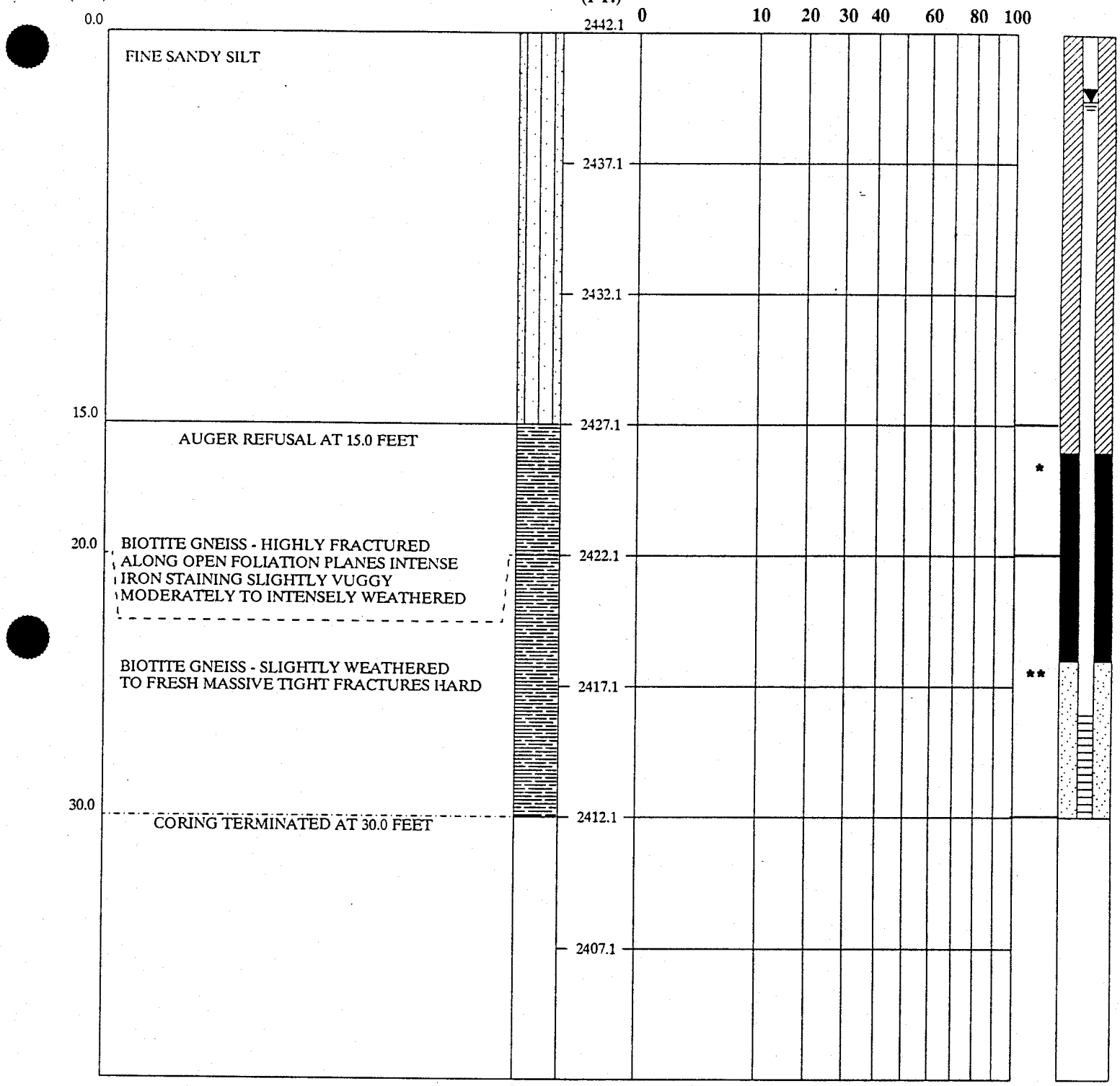
GROUND WATER MEASURED AT 3.1 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-109
DATE DRILLED	March 27, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING



REMARKS:

NO SAMPLE TAKEN. SOIL DESCRIPTIONS BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 2.6 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-109A
DATE DRILLED	March 27, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100
	* REC. 90% RQD. 14% ** REC. 83% RQD. 83%	2397.1	
		2392.1	
		2387.1	
		2382.1	
		2377.1	
		2372.1	
		2367.1	

REMARKS:

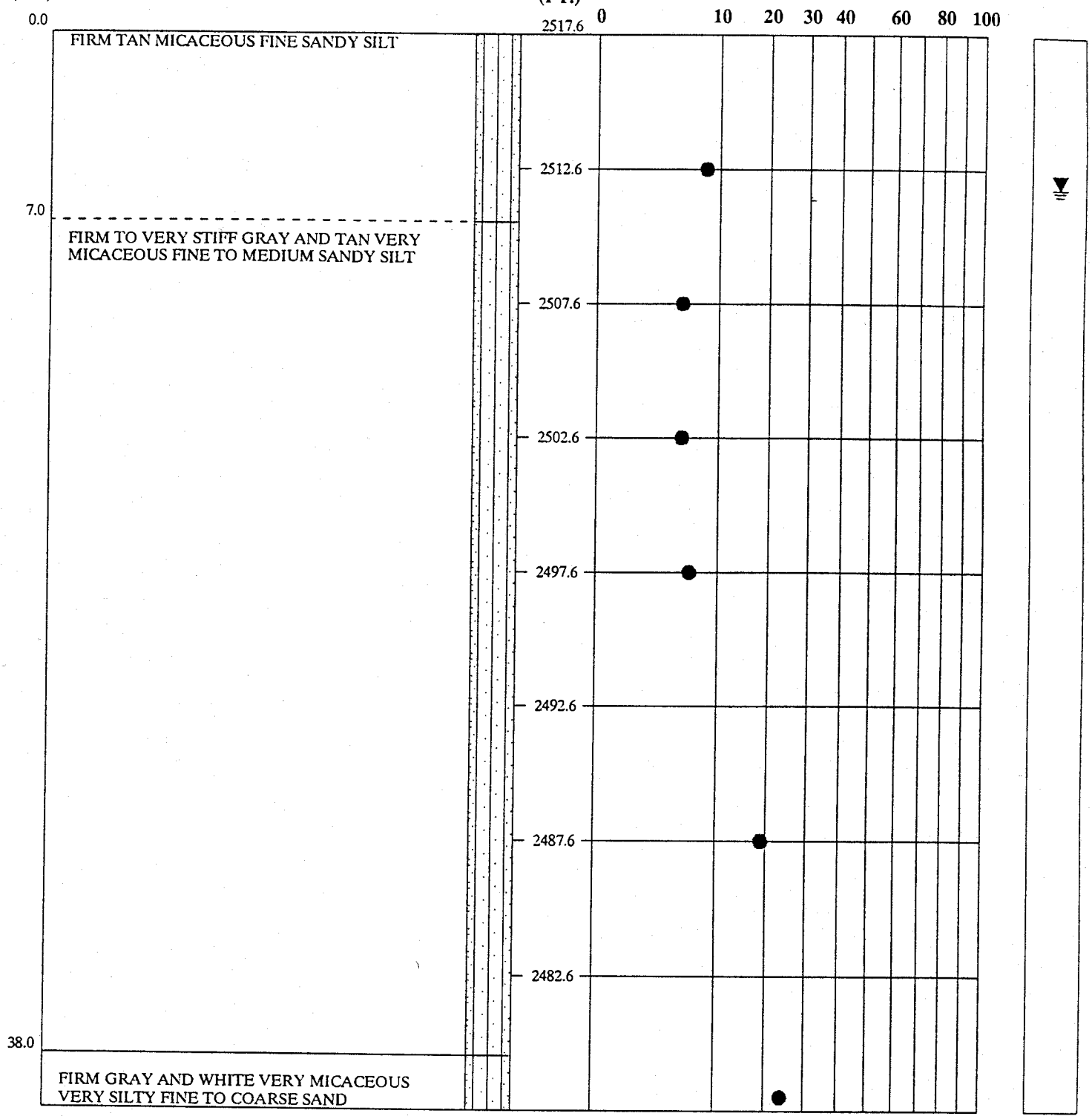
NO SAMPLE TAKEN. SOIL DESCRIPTIONS BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 2.6 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-109A
DATE DRILLED	March 27, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 5.7 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-110
DATE DRILLED	February 19, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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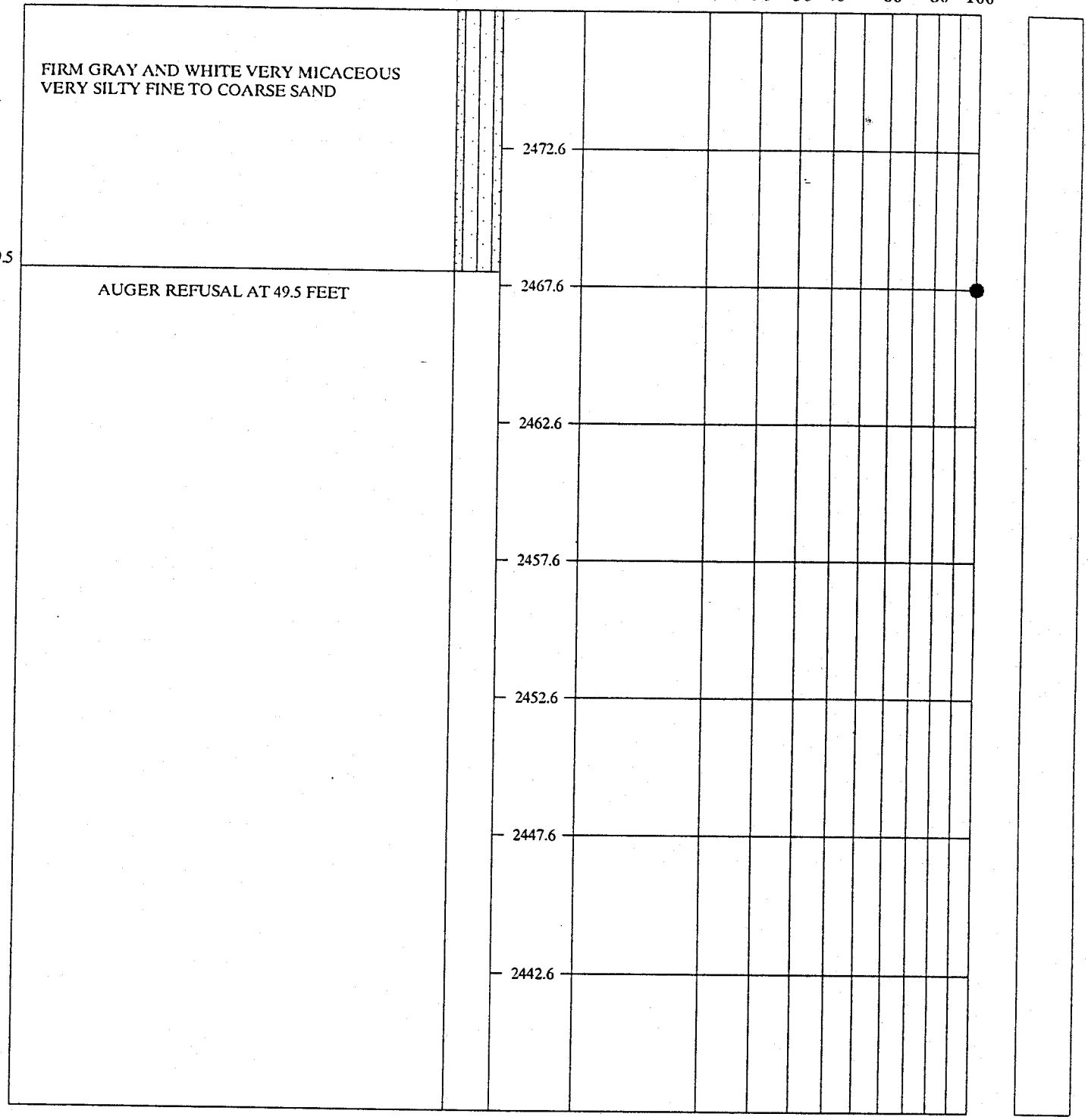
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
	FIRM GRAY AND WHITE VERY MICACEOUS VERY SILTY FINE TO COARSE SAND	2472.6
49.5	AUGER REFUSAL AT 49.5 FEET	2467.6
		2462.6
		2457.6
		2452.6
		2447.6
		2442.6

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

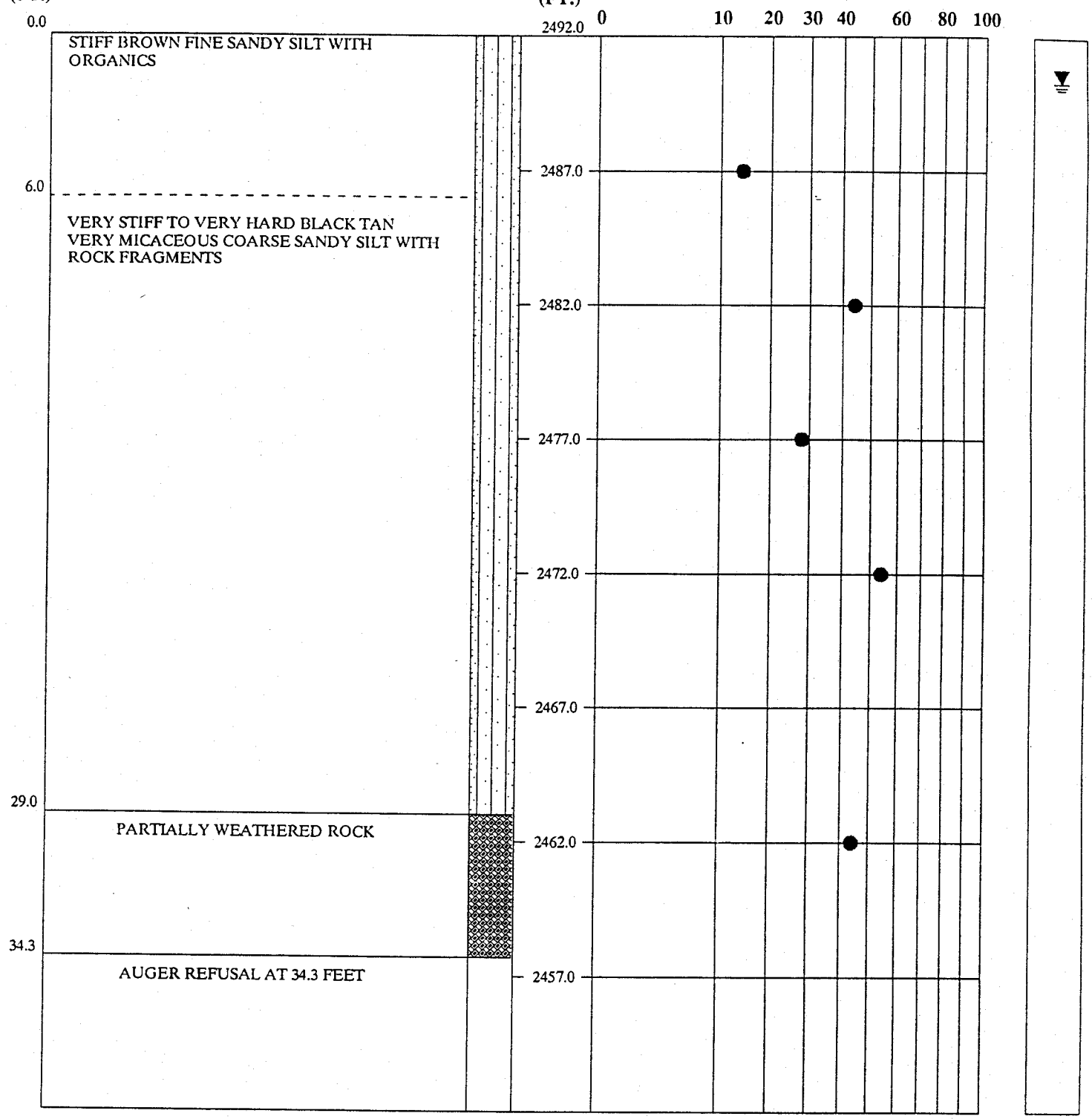
GROUND WATER MEASURED AT 5.7 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-110
DATE DRILLED	February 19, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 1.7 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

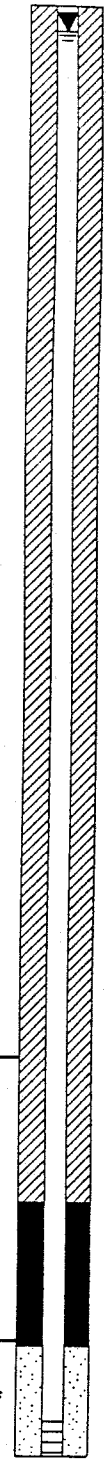
BORING NUMBER	B-111
DATE DRILLED	February 20, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 1	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
0.0	BROWN BLACK AND TAN VERY MICACEOUS FINE TO COARSE SANDY SILT	2491.3
		2486.3
10.0		2481.3
	UNDISTURBED SAMPLE	
12.0	BROWN BLACK AND TAN VERY MICACEOUS FINE TO COARSE SANDY SILT	2476.3
19.0		
	UNDISTURBED SAMPLE	2471.3
21.0	BROWN BLACK AND TAN VERY MICACEOUS FINE TO COARSE SANDY SILT	2466.3
29.0	AUGER REFUSAL AT 29.0 FEET	2461.3
	BIOTITE GNEISS - MODERATELY FRACTURED IRON STAINING, SLIGHTLY WEATHERED SOME VERTICAL JOINTING IRON STAINS EVIDENT AT 30.0 TO 32.0 FEET AND 33.5 TO 34.5 FEET VERTICAL JOINT, IRON STAINS EVIDENT	2456.3

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

NO SAMPLES TAKEN. SOIL DESCRIPTIONS BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 0.7 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-111A
DATE DRILLED	March 29, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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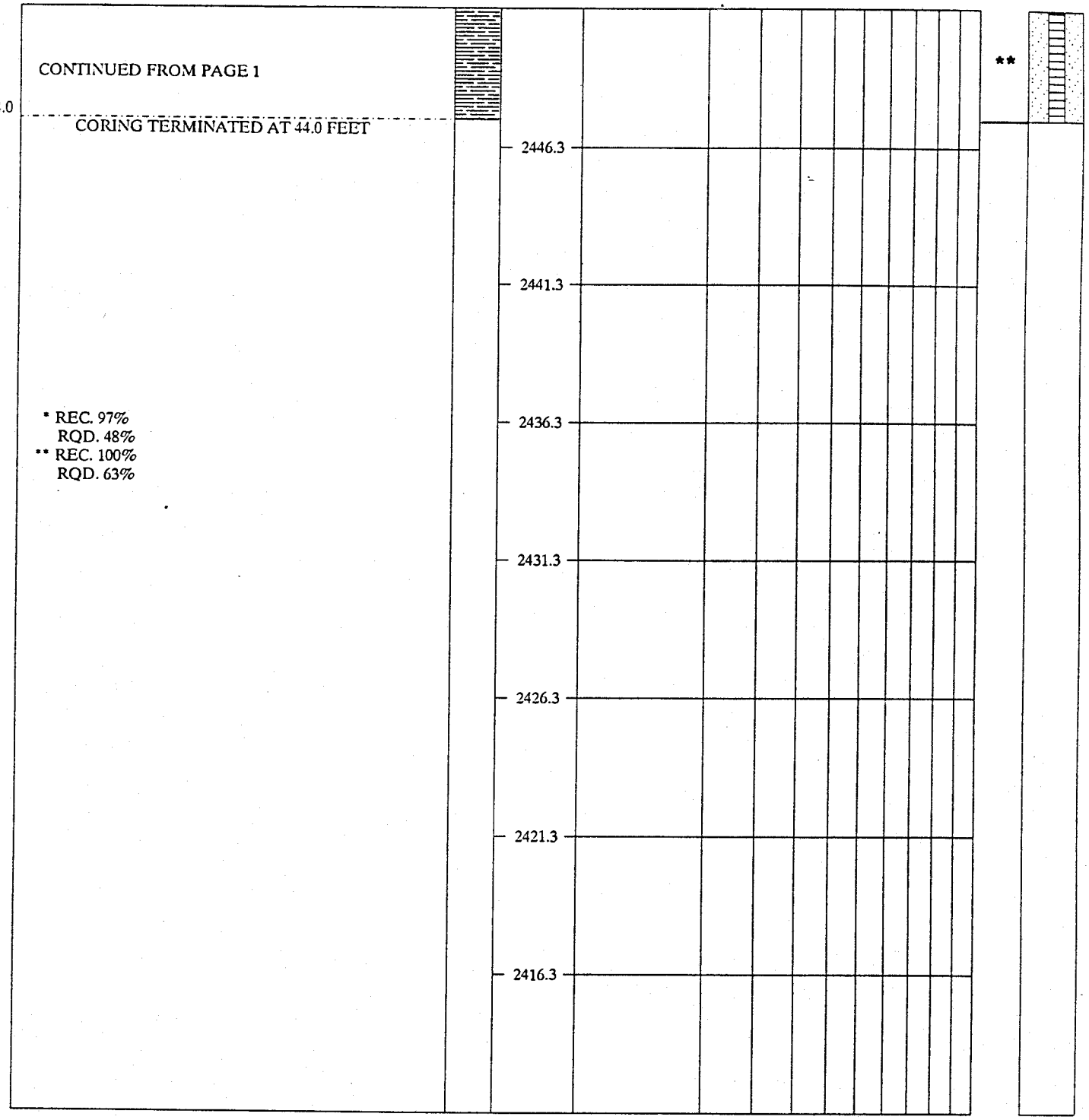
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100
	CONTINUED FROM PAGE 1		
44.0	CORING TERMINATED AT 44.0 FEET	2446.3	
		2441.3	
	* REC. 97% RQD. 48% ** REC. 100% RQD. 63%	2436.3	
		2431.3	
		2426.3	
		2421.3	
		2416.3	



REMARKS:

NO SAMPLES TAKEN. SOIL DESCRIPTIONS BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 0.7 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-111A
DATE DRILLED	March 29, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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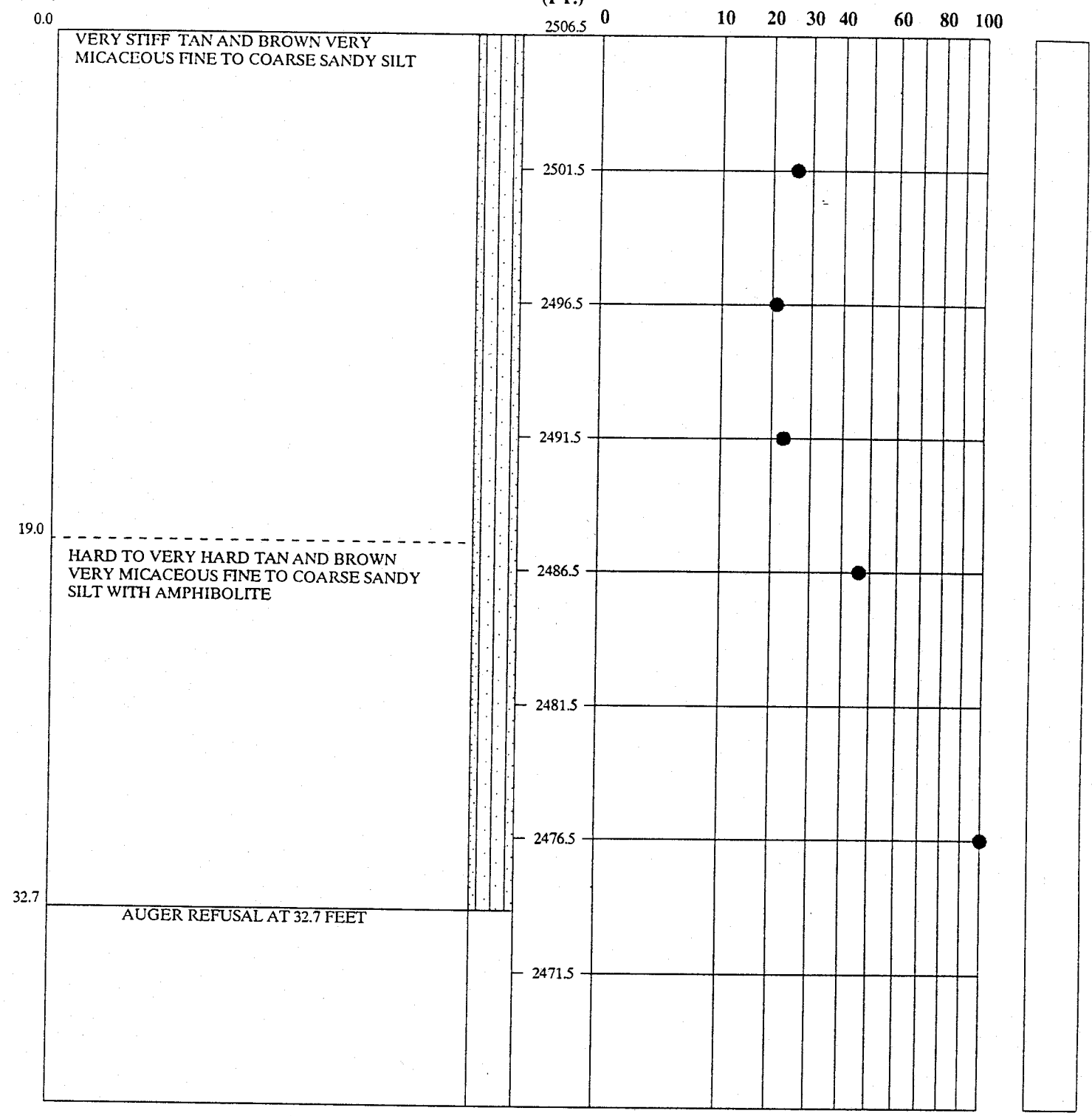
LAW ENGINEERING



REMARKS:

NO GROUND WATER ENCOUNTERED AS OF 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-112
DATE DRILLED	February 21, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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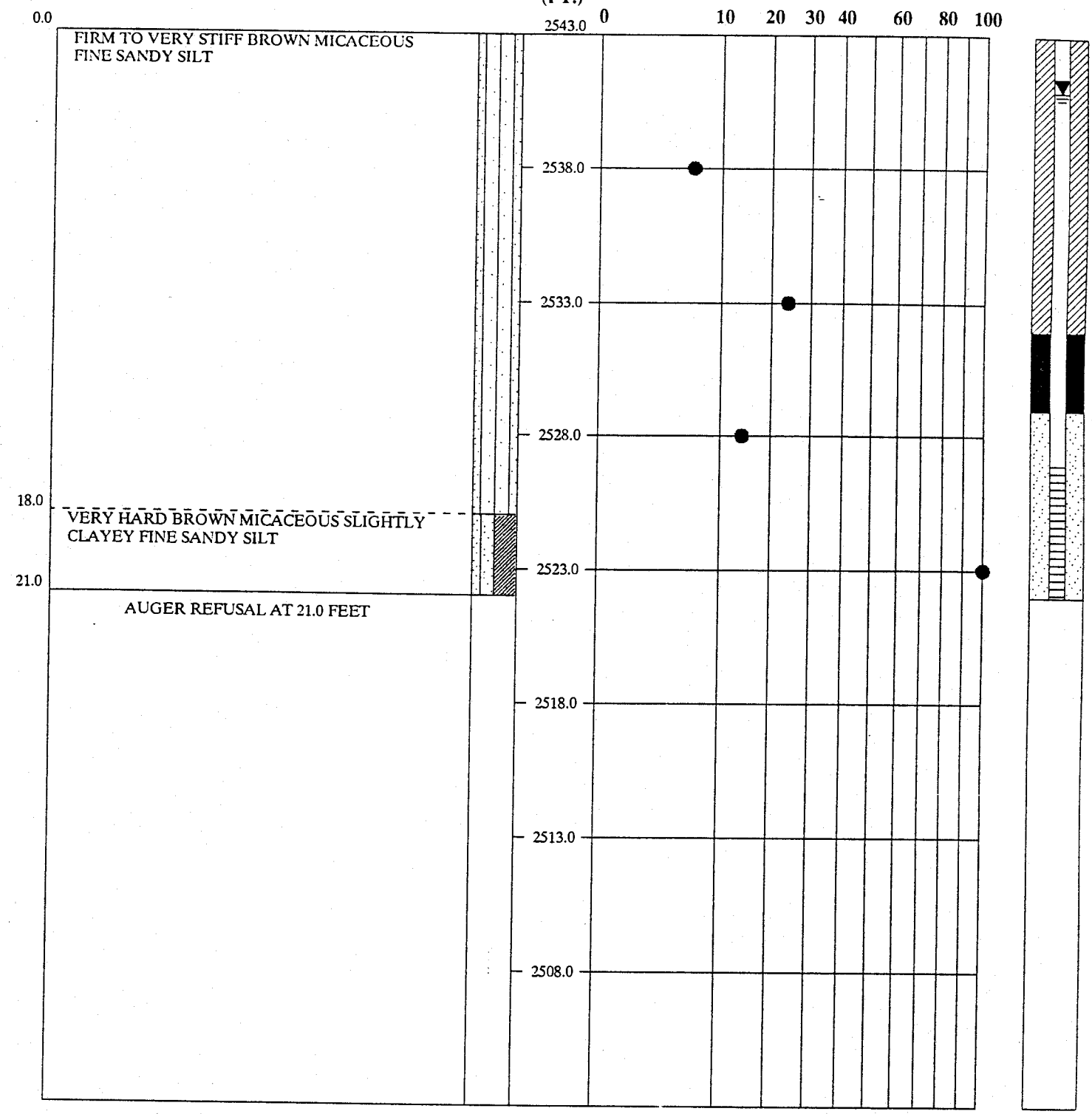
LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 2.1 FEET ON 5-21-90

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-113
DATE DRILLED	March 28, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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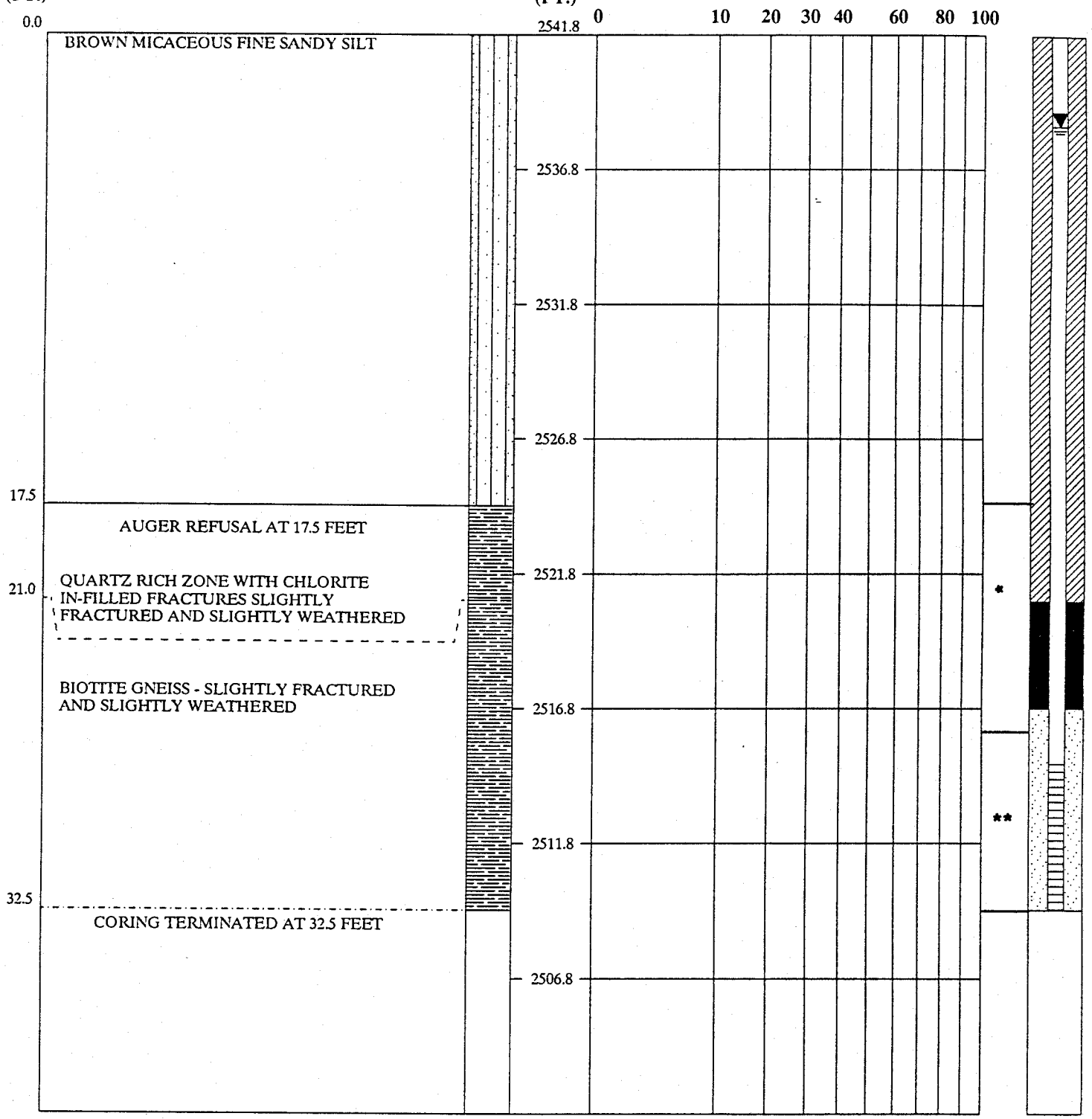
LAW ENGINEERING



REMARKS:

NO SAMPLES TAKEN SOIL. DESCRIPTION ARE BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 3.4 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-113A
DATE DRILLED	March 28, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100
	* REC. 94% RQD. 81% ** REC. 100% RQD. 100%	2496.8	
		2491.8	
		2486.8	
		2481.8	
		2476.8	
		2471.8	
		2466.8	

REMARKS:

NO SAMPLES TAKEN SOIL. DESCRIPTION ARE BASED ON VISUAL CLASSIFICATION OF THE AUGER CUTTINGS. GROUND WATER MEASURED AT 3.4 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-113A
DATE DRILLED	March 28, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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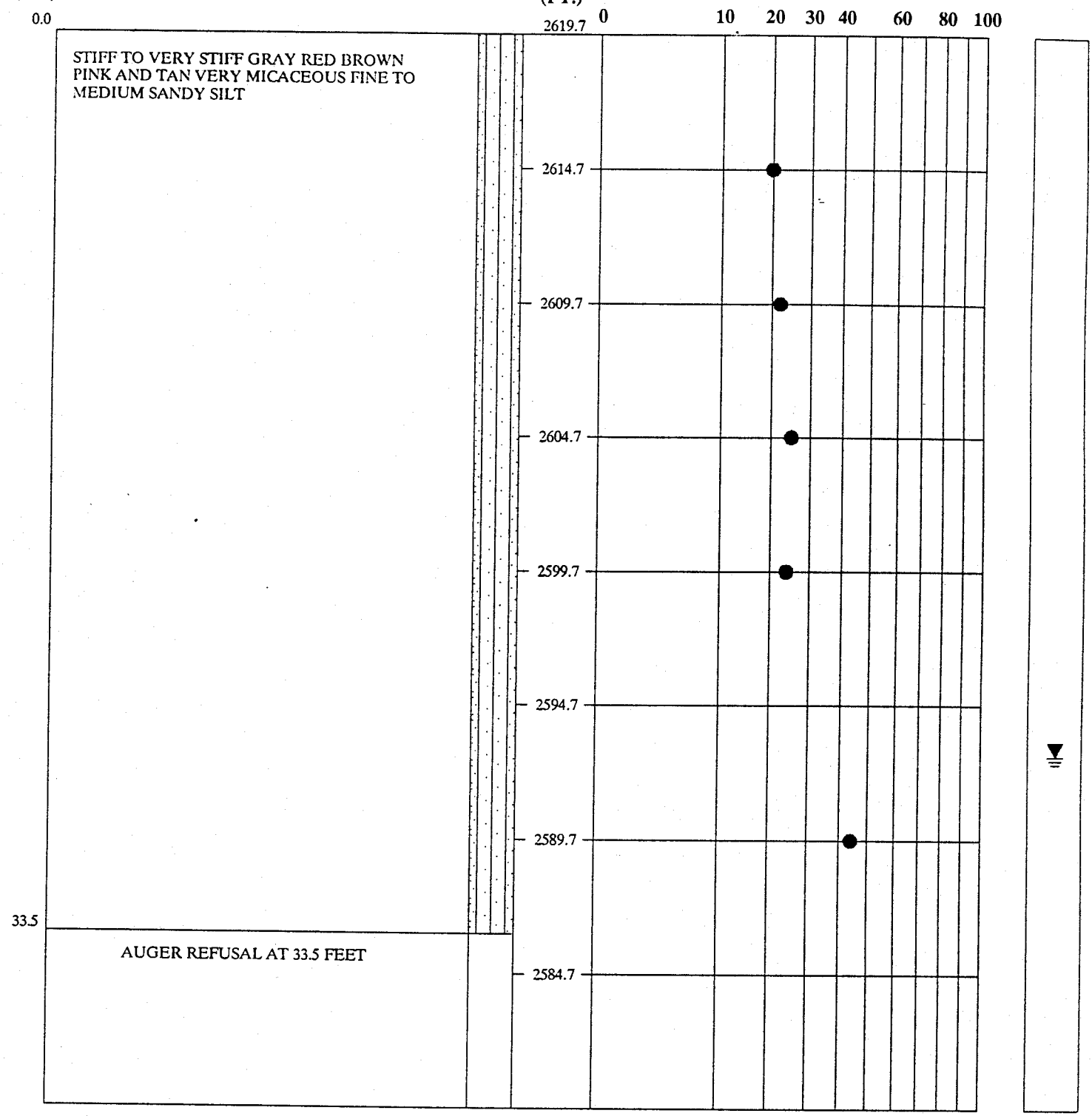
LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 26.9 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-114
DATE DRILLED	February 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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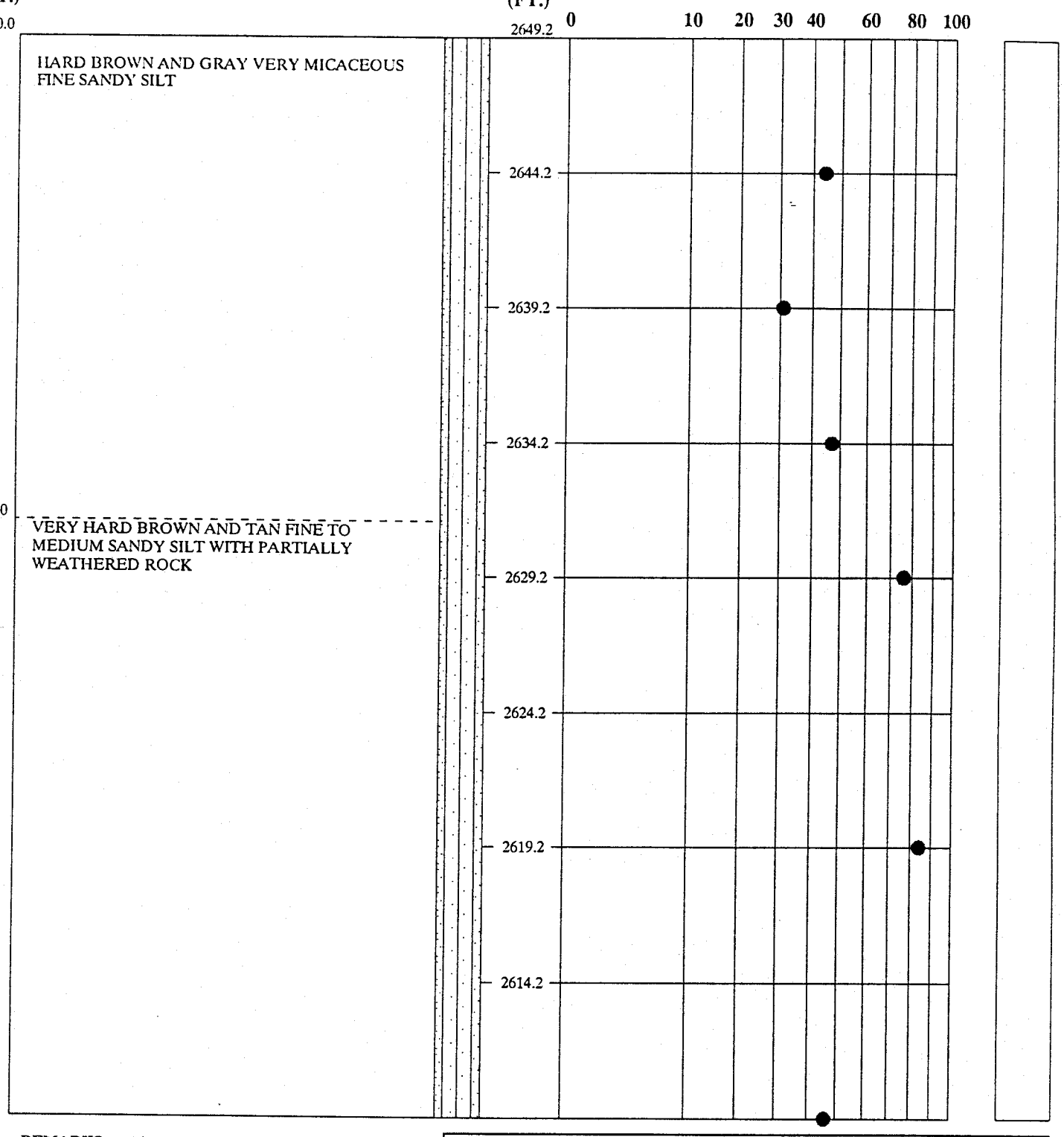
LAW ENGINEERING



REMARKS:

NO GROUND WATER ENCOUNTERED AS OF 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-115
DATE DRILLED	February 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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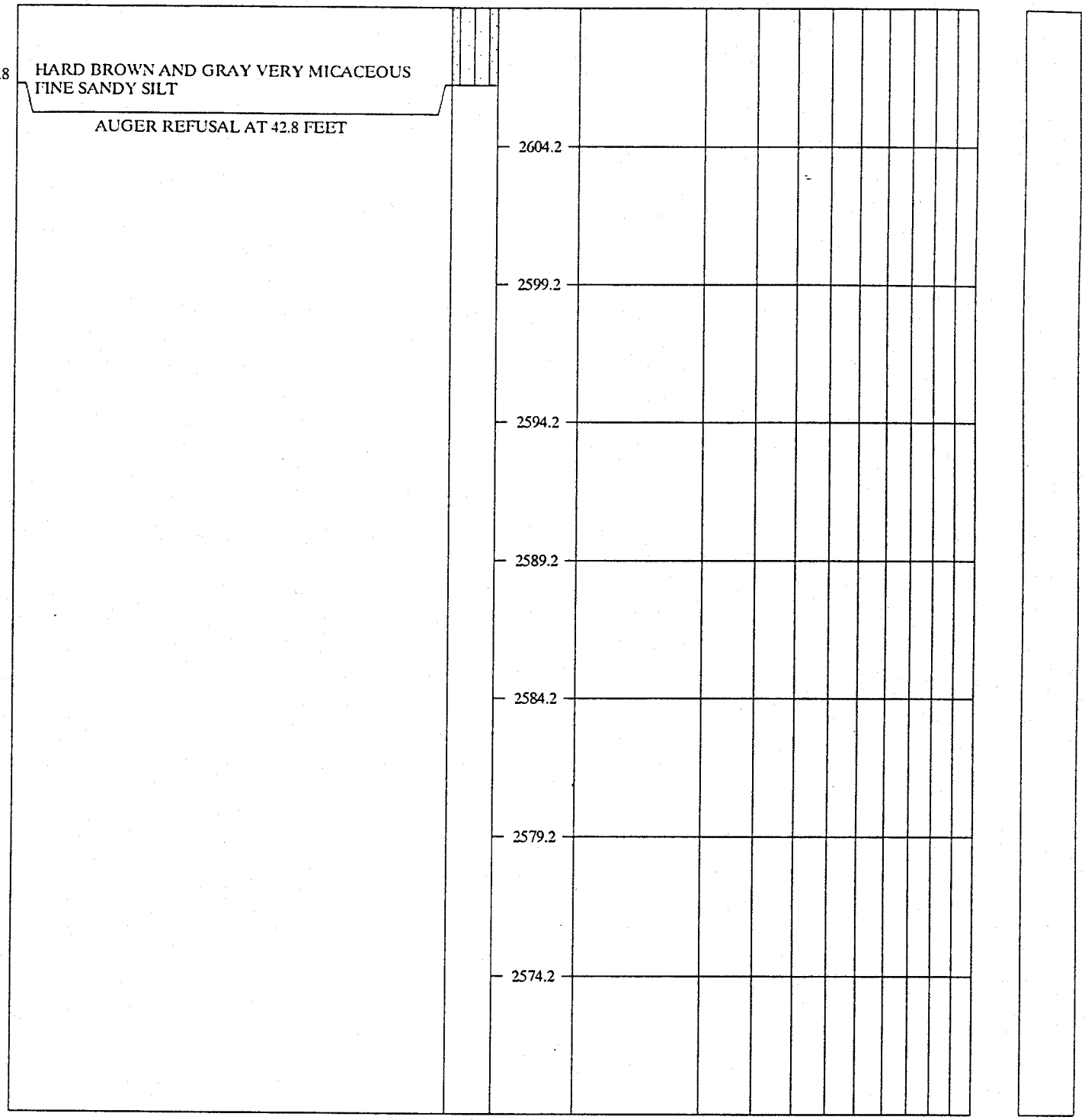
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
42.8	HARD BROWN AND GRAY VERY MICACEOUS FINE SANDY SILT AUGER REFUSAL AT 42.8 FEET	2604.2 2599.2 2594.2 2589.2 2584.2 2579.2 2574.2

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

NO GROUND WATER ENCOUNTERED AS OF 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	B-115
DATE DRILLED	February 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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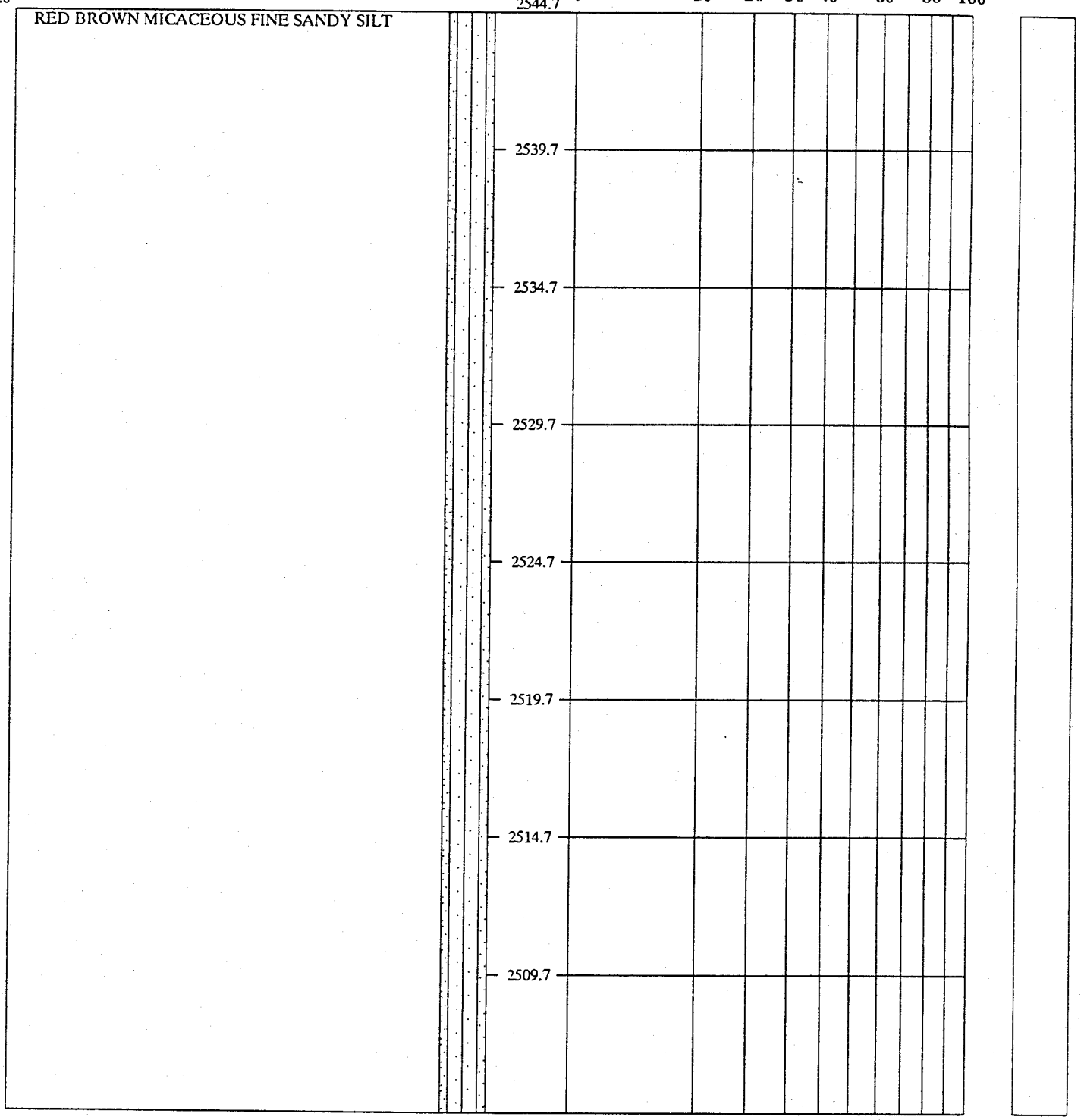
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT
0.0	RED BROWN MICACEOUS FINE SANDY SILT	2544.7	0 10 20 30 40 60 80 100
		2539.7	
		2534.7	
		2529.7	
		2524.7	
		2519.7	
		2514.7	
		2509.7	



REMARKS:

GROUND WATER MEASURED AT 41.9 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-1
DATE DRILLED	April 24, 1990
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PROJECT	HAYWOOD CO. LANDFILL
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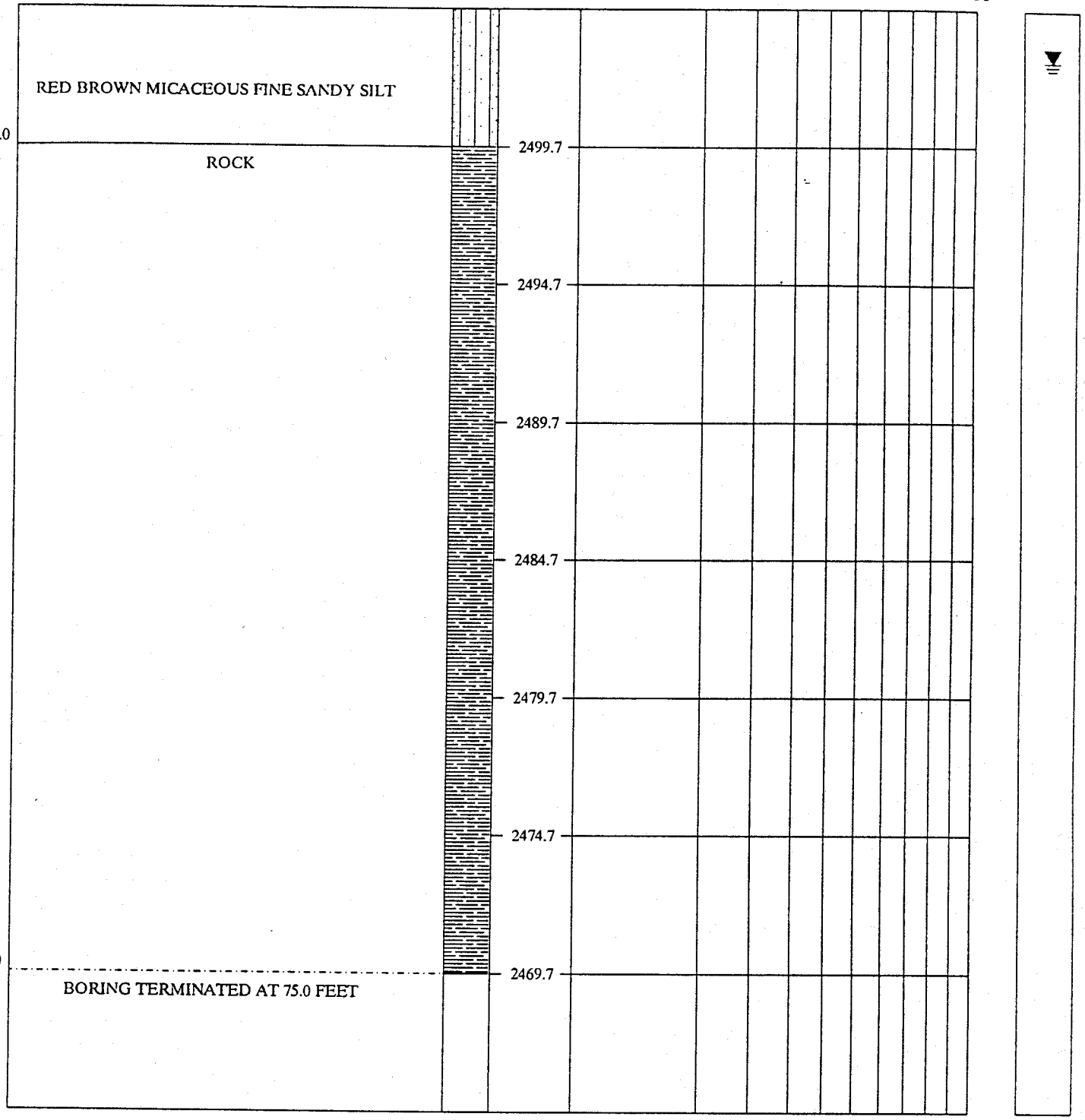
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
	RED BROWN MICACEOUS FINE SANDY SILT	
45.0	ROCK	2499.7
		2494.7
		2489.7
		2484.7
		2479.7
		2474.7
75.0	BORING TERMINATED AT 75.0 FEET	2469.7

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

GROUND WATER MEASURED AT 41.9 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-1
DATE DRILLED	April 24, 1990
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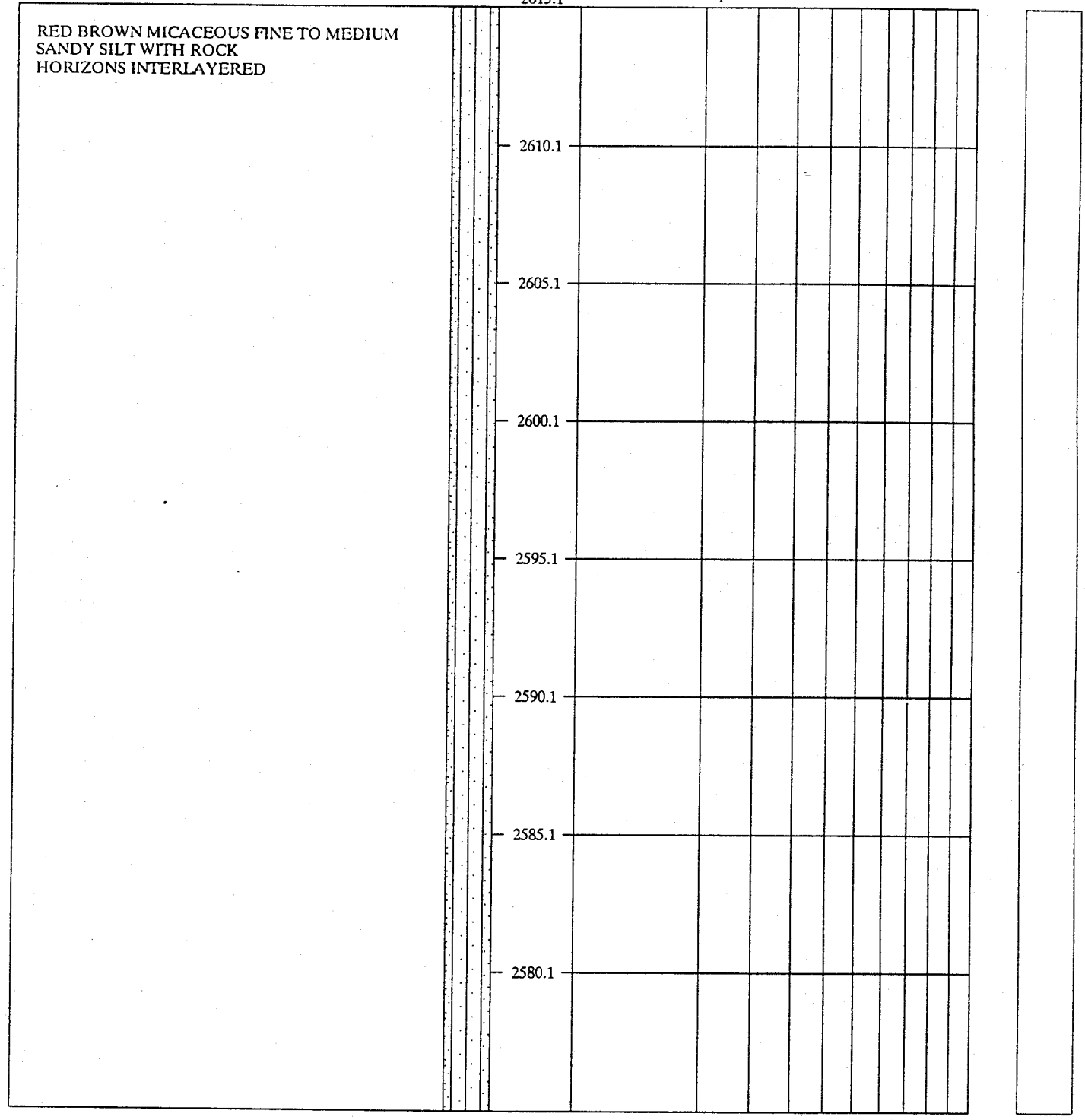
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT
0.0	RED BROWN MICACEOUS FINE TO MEDIUM SANDY SILT WITH ROCK HORIZONS INTERLAYERED	2615.1	0 10 20 30 40 60 80 100
		2610.1	
		2605.1	
		2600.1	
		2595.1	
		2590.1	
		2585.1	
		2580.1	



REMARKS:

GROUND WATER MEASURED AT 78.6 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-2
DATE DRILLED	April 23, 1990
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PROJECT	HAYWOOD CO. LANDFILL
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LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100
	RED BROWN MICACEOUS FINE TO MEDIUM SANDY SILT WITH ROCK HORIZONS INTERLAYERED	2570.1	
		2565.1	
		2560.1	
		2555.1	
		2550.1	
		2545.1	
		2540.1	

REMARKS:

GROUND WATER MEASURED AT 78.6 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-2
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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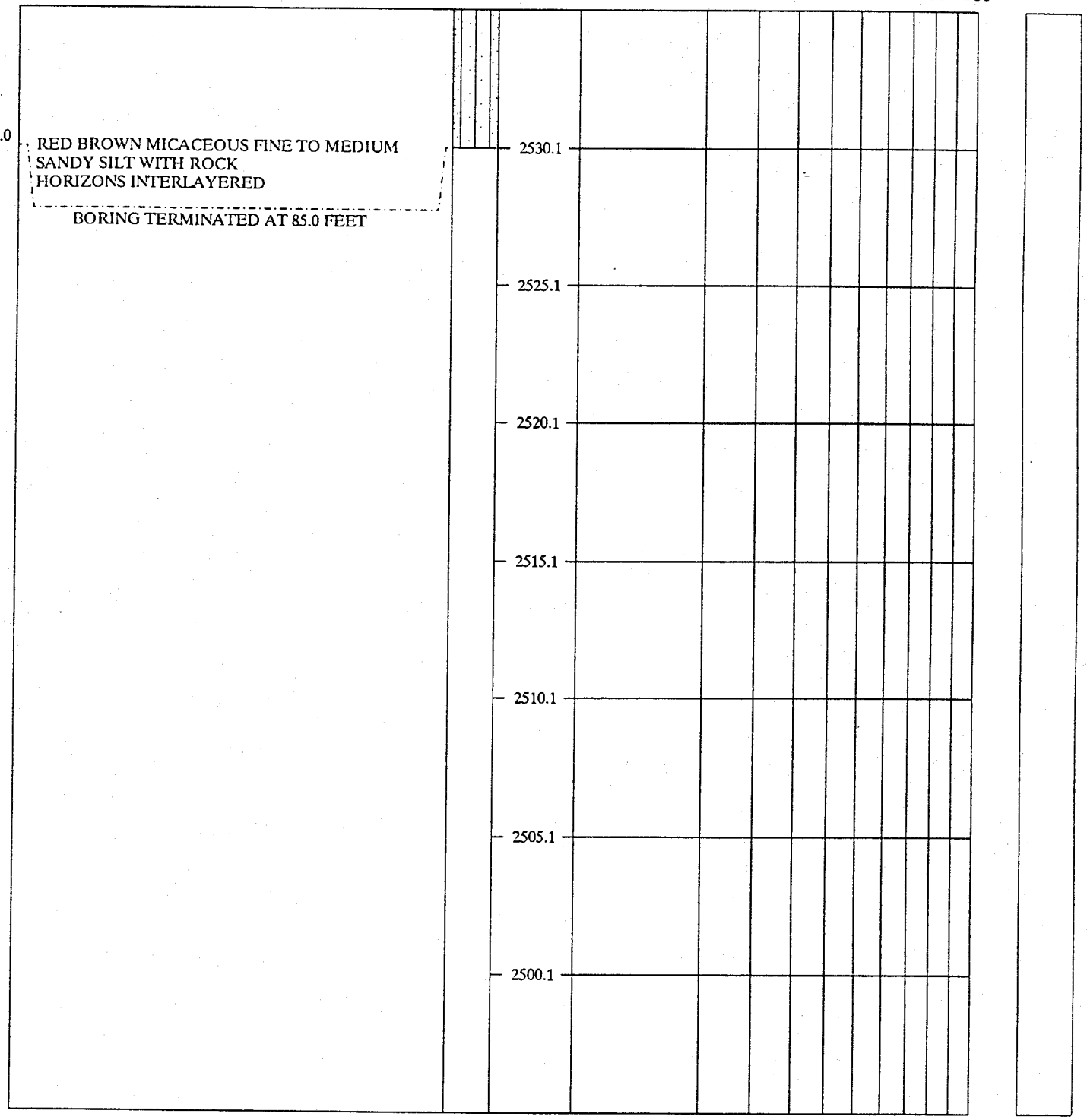
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
85.0	RED BROWN MICACEOUS FINE TO MEDIUM SANDY SILT WITH ROCK HORIZONS INTERLAYERED	2530.1
	BORING TERMINATED AT 85.0 FEET	2525.1
		2520.1
		2515.1
		2510.1
		2505.1
		2500.1

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

GROUND WATER MEASURED AT 78.6 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-2
DATE DRILLED	April 23, 1990
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LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT
0.0	RED BROWN VERY MICACEOUS FINE TO COARSE SANDY SILT	2620.2	0 10 20 30 40 60 80 100
		2615.2	
		2610.2	
		2605.2	
		2600.2	
		2595.2	
		2590.2	
		2585.2	

REMARKS:

GROUND WATER MEASURED AT 68.5 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-3
DATE DRILLED	April 23, 1990
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PROJECT	HAYWOOD CO. LANDFILL
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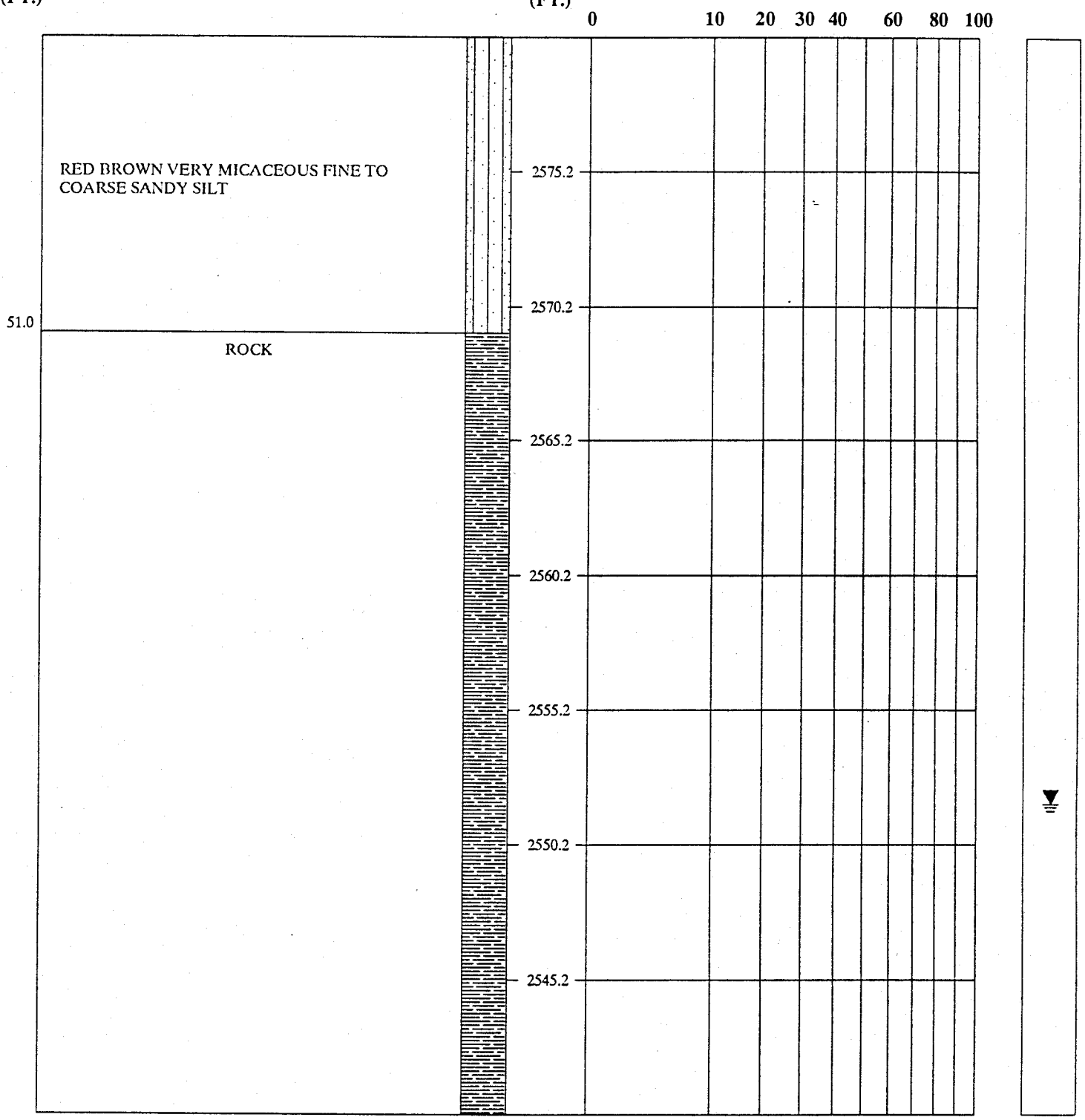
LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 68.5 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-3
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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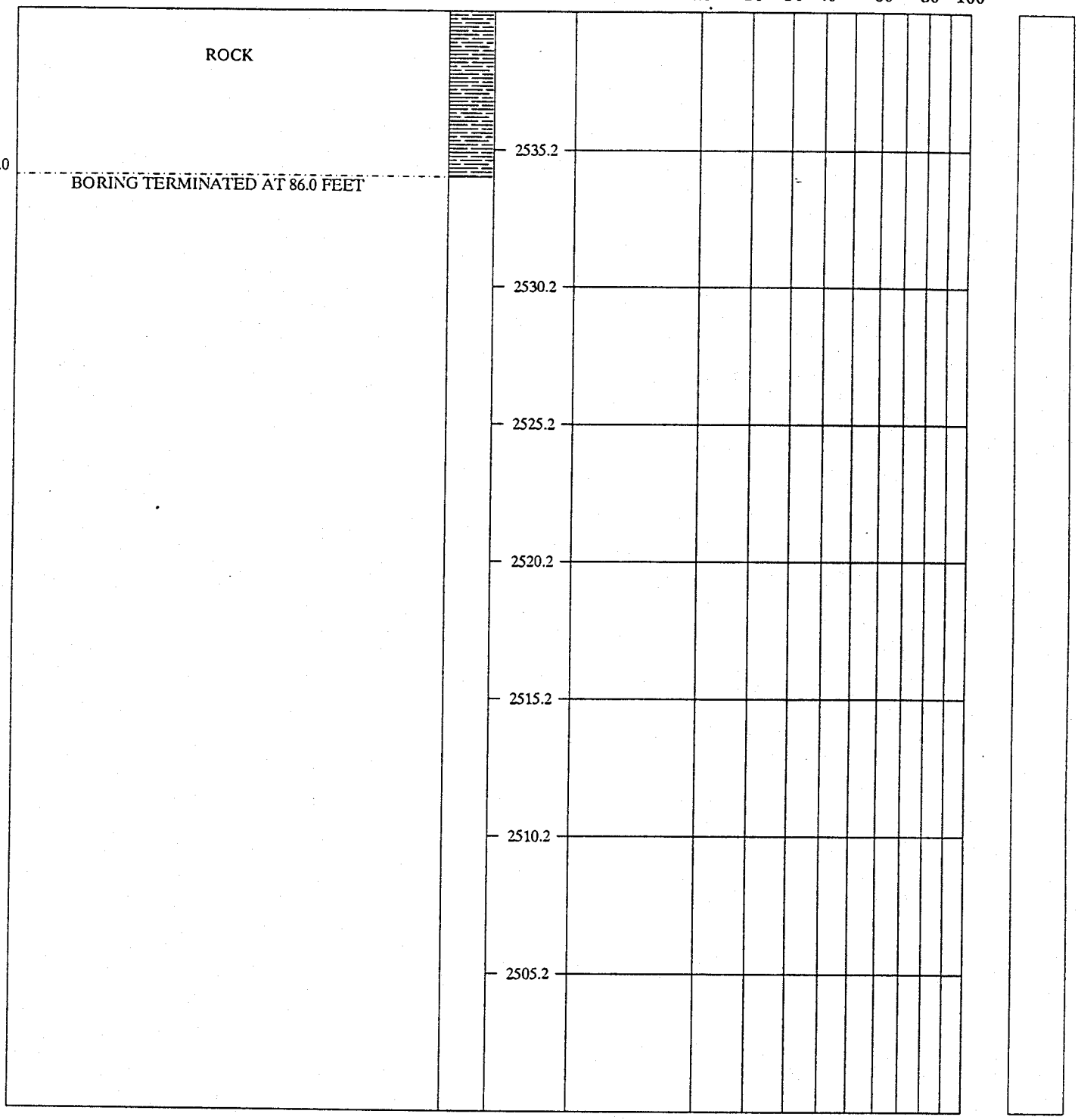
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
	ROCK	
86.0	BORING TERMINATED AT 86.0 FEET	2535.2
		2530.2
		2525.2
		2520.2
		2515.2
		2510.2
		2505.2

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100



REMARKS:

GROUND WATER MEASURED AT 68.5 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-3
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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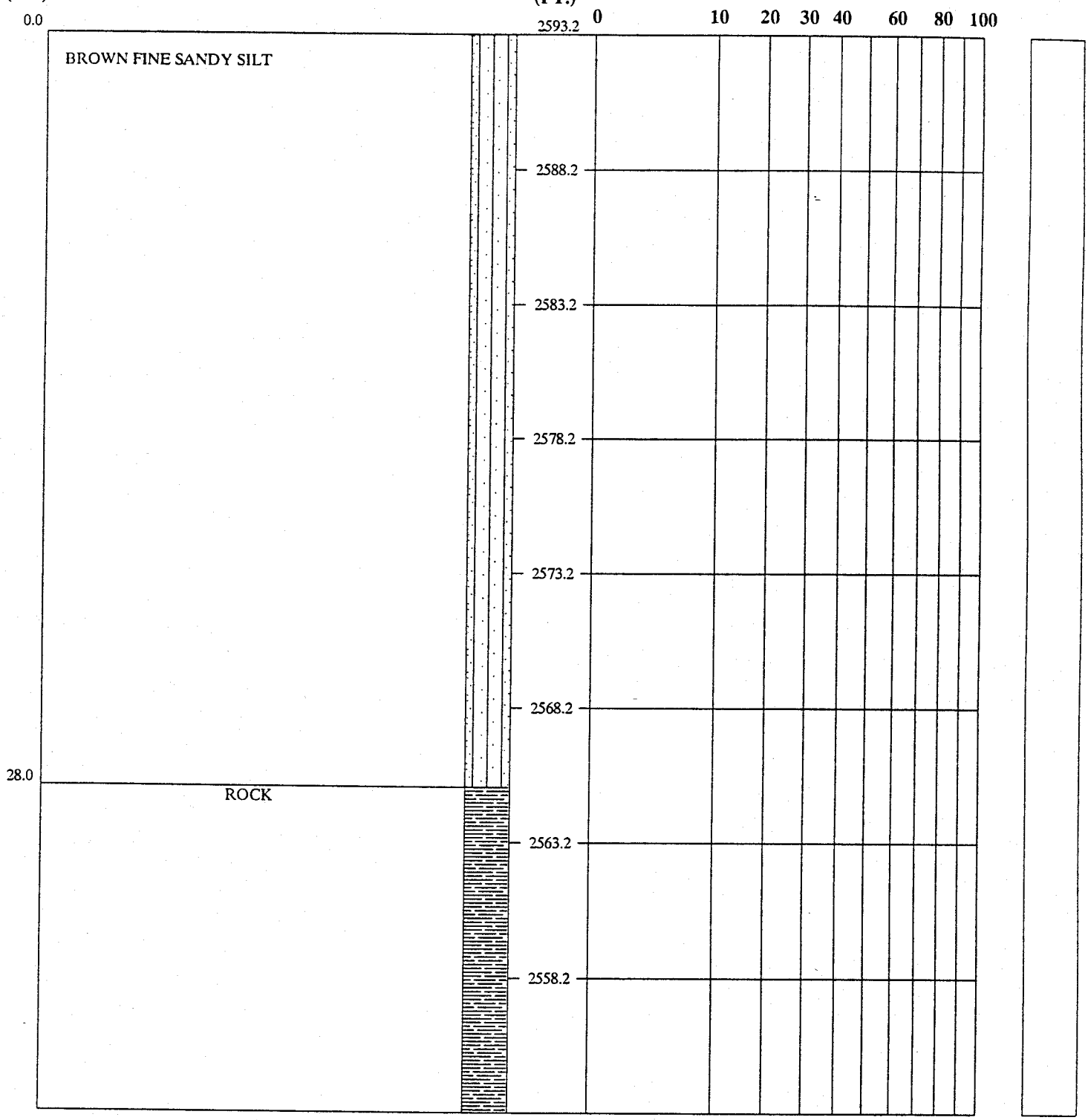
LAW ENGINEERING



REMARKS:

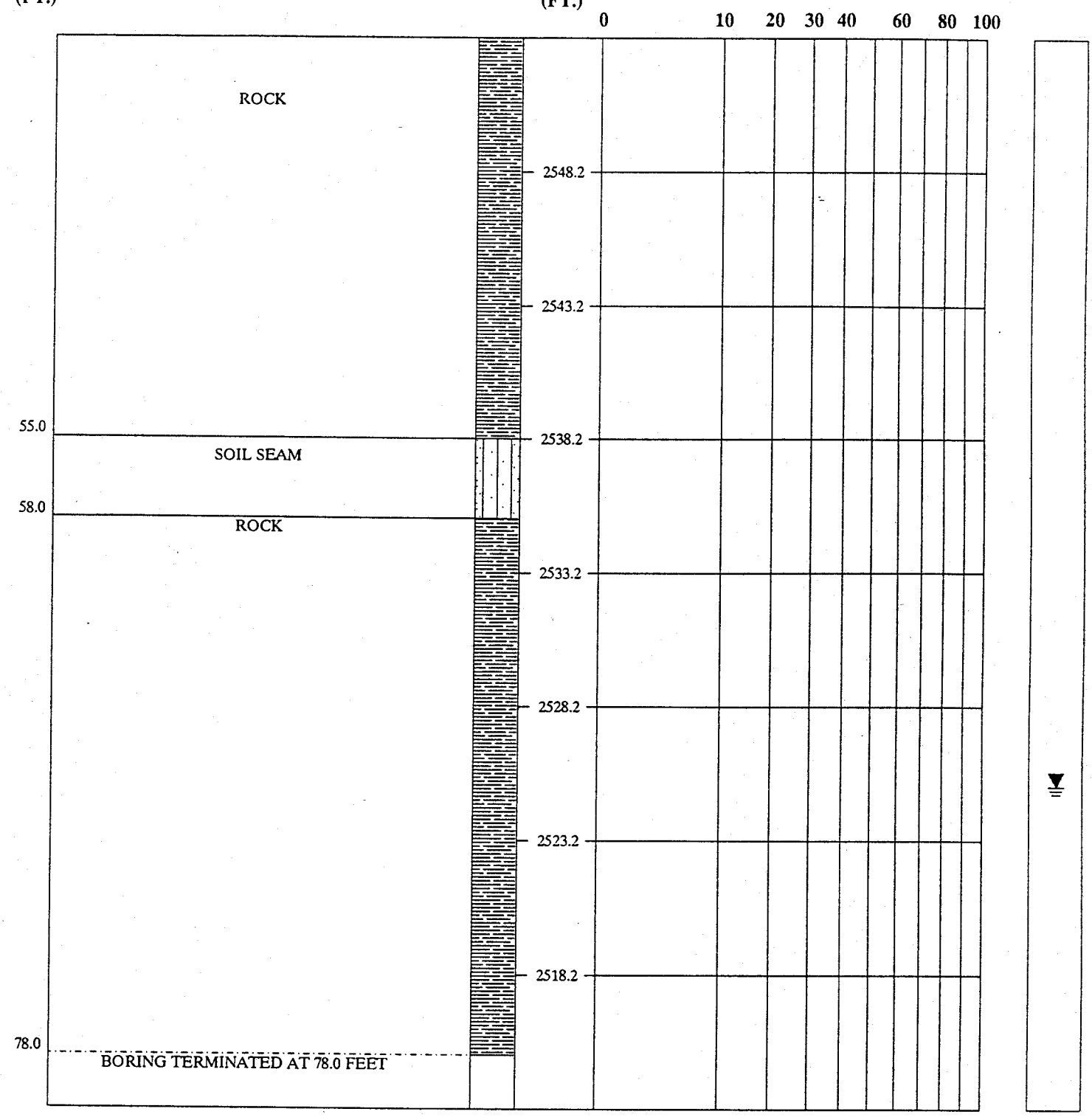
GROUND WATER MEASURED AT 68.0 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-4
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 2	

LAW ENGINEERING



REMARKS:

GROUND WATER MEASURED AT 68.0 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-4
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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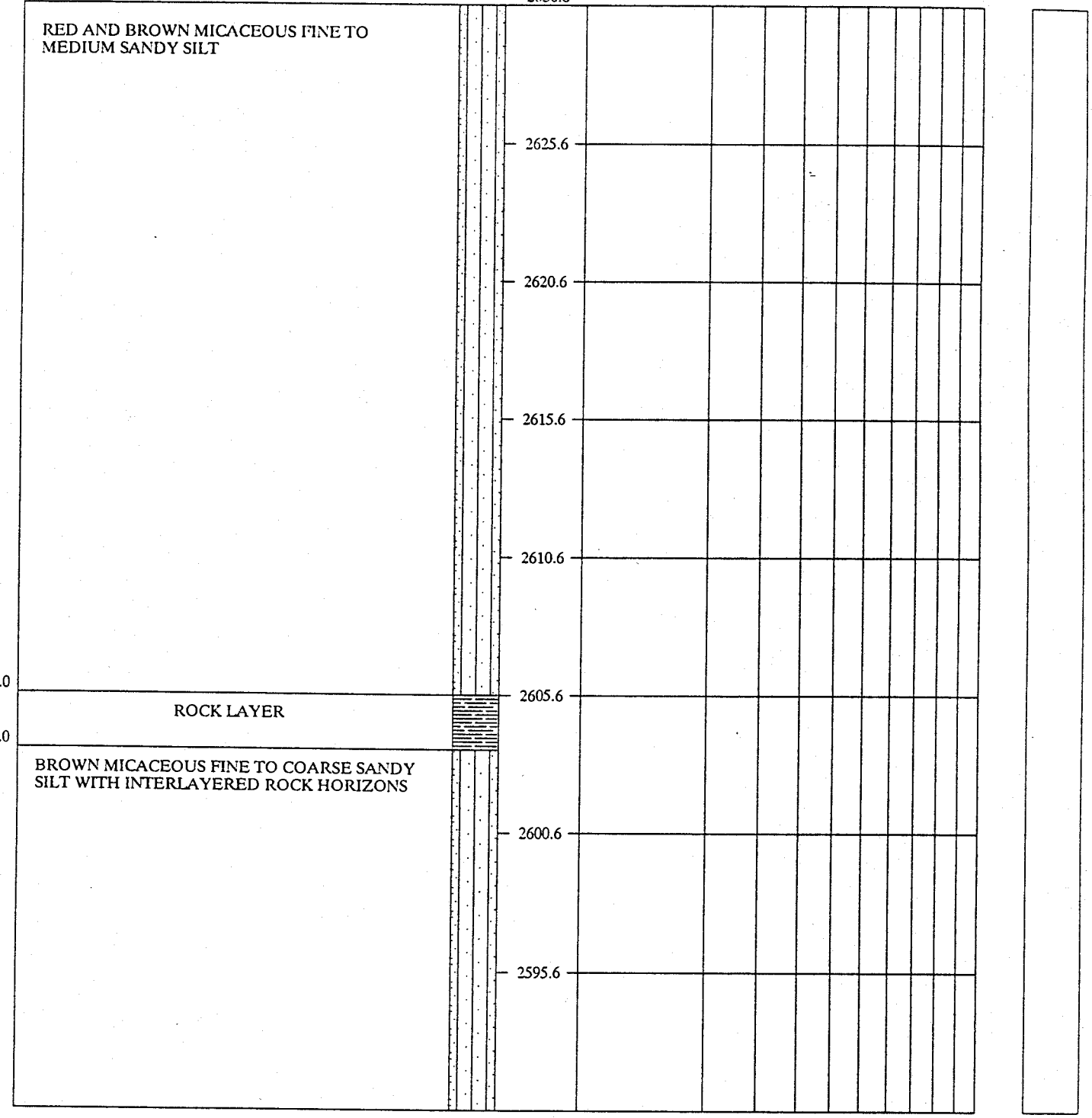
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
0.0	RED AND BROWN MICACEOUS FINE TO MEDIUM SANDY SILT	2630.6
25.0	ROCK LAYER	2605.6
27.0	BROWN MICACEOUS FINE TO COARSE SANDY SILT WITH INTERLAYERED ROCK HORIZONS	

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100

2625.6
2620.6
2615.6
2610.6
2600.6
2595.6



REMARKS:

NO GROUND WATER ENCOUNTERED AT TIME OF BORING.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-5
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT 0 10 20 30 40 60 80 100
	BROWN MICACEOUS FINE TO COARSE SANDY SILT WITH INTERLAYERED ROCK HORIZONS	2585.6	
		2580.6	
		2575.6	
60.0	BORING TERMINATED AT 60.0 FEET	2570.6	
		2565.6	
		2560.6	
		2555.6	

REMARKS:

NO GROUND WATER ENCOUNTERED AT TIME OF BORING.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-5
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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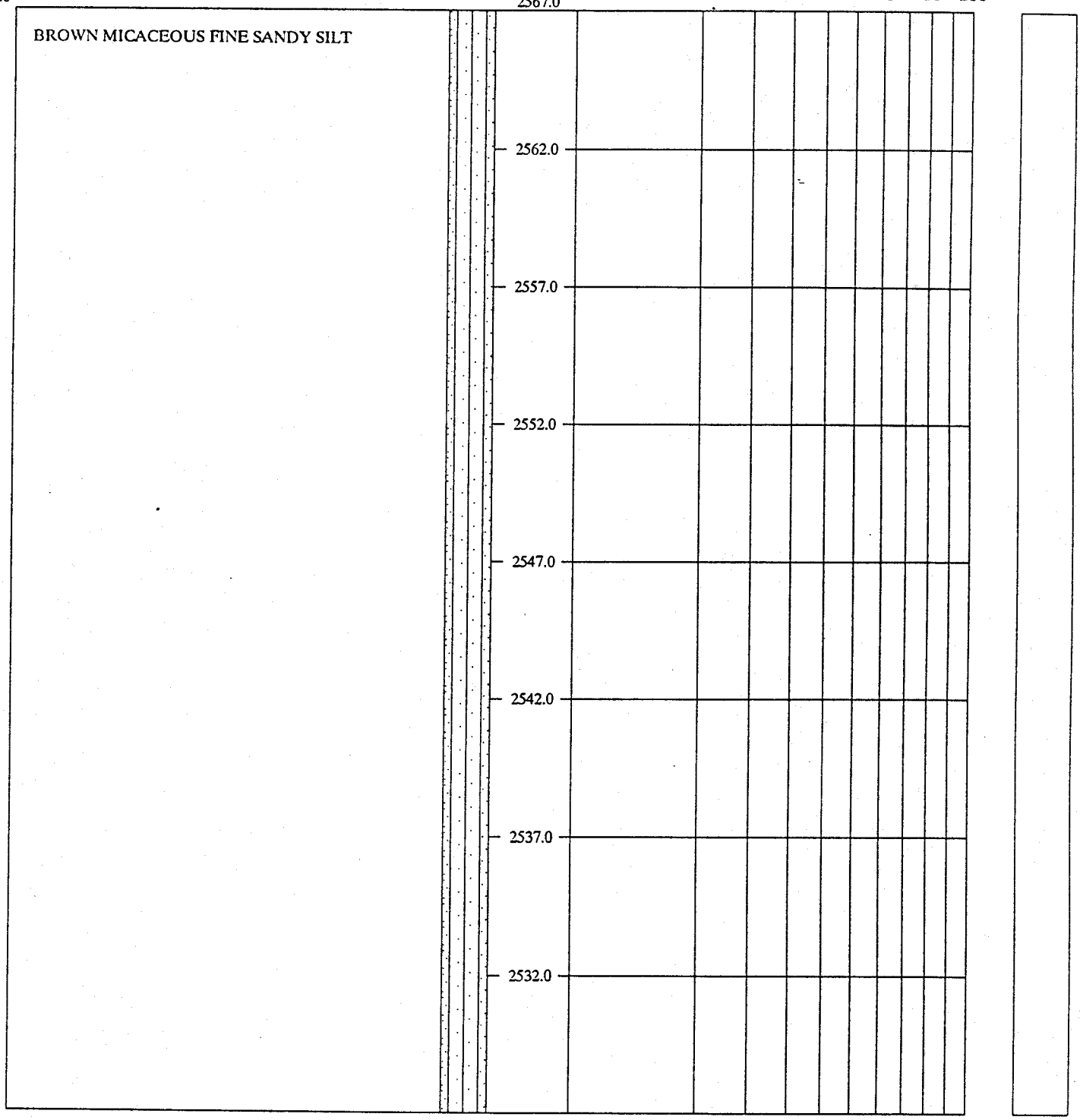
LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT
0.0	BROWN MICACEOUS FINE SANDY SILT	2567.0	0 10 20 30 40 60 80 100
		2562.0	
		2557.0	
		2552.0	
		2547.0	
		2542.0	
		2537.0	
		2532.0	



REMARKS:

GROUND WATER MEASURED AT 54.5 FEET ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-6
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
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LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
	BROWN MICACEOUS FINE SANDY SILT	2522.0
		2517.0
55.0		2512.0
	ROCK	2507.0
		2502.0
		2497.0
75.0		2492.0
	BORING TERMINATED AT 75.0 FEET	

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100

REMARKS:

GROUND WATER MEASURED AT 54.5 FEET ON 5-21-90.

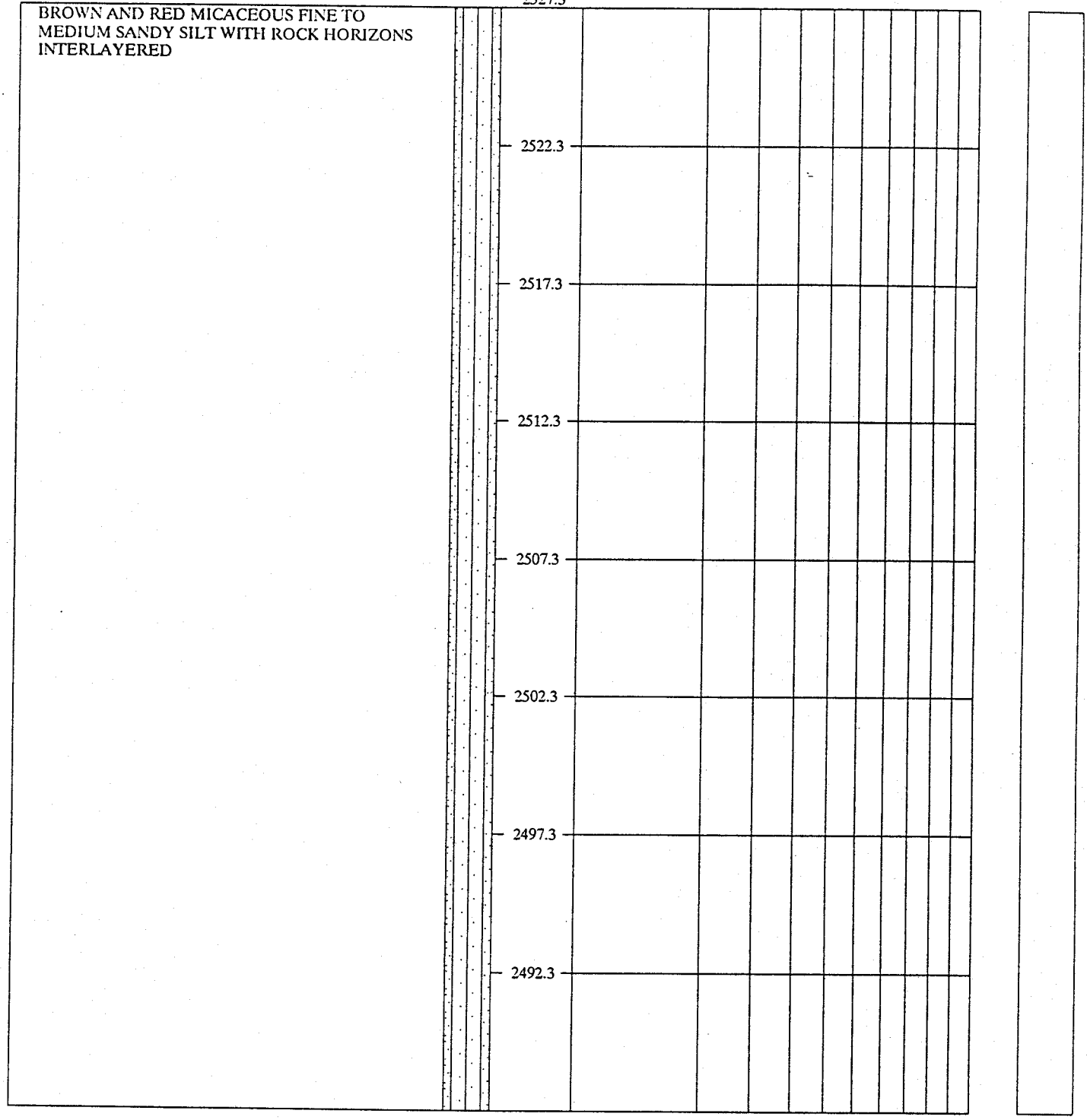
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-6
DATE DRILLED	April 23, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT
0.0	BROWN AND RED MICACEOUS FINE TO MEDIUM SANDY SILT WITH ROCK HORIZONS INTERLAYERED	2527.3	0 10 20 30 40 60 80 100
		2522.3	
		2517.3	
		2512.3	
		2507.3	
		2502.3	
		2497.3	
		2492.3	



REMARKS:

GROUND WATER MEASURED AT 43.8 FEET ON 5-21-90.

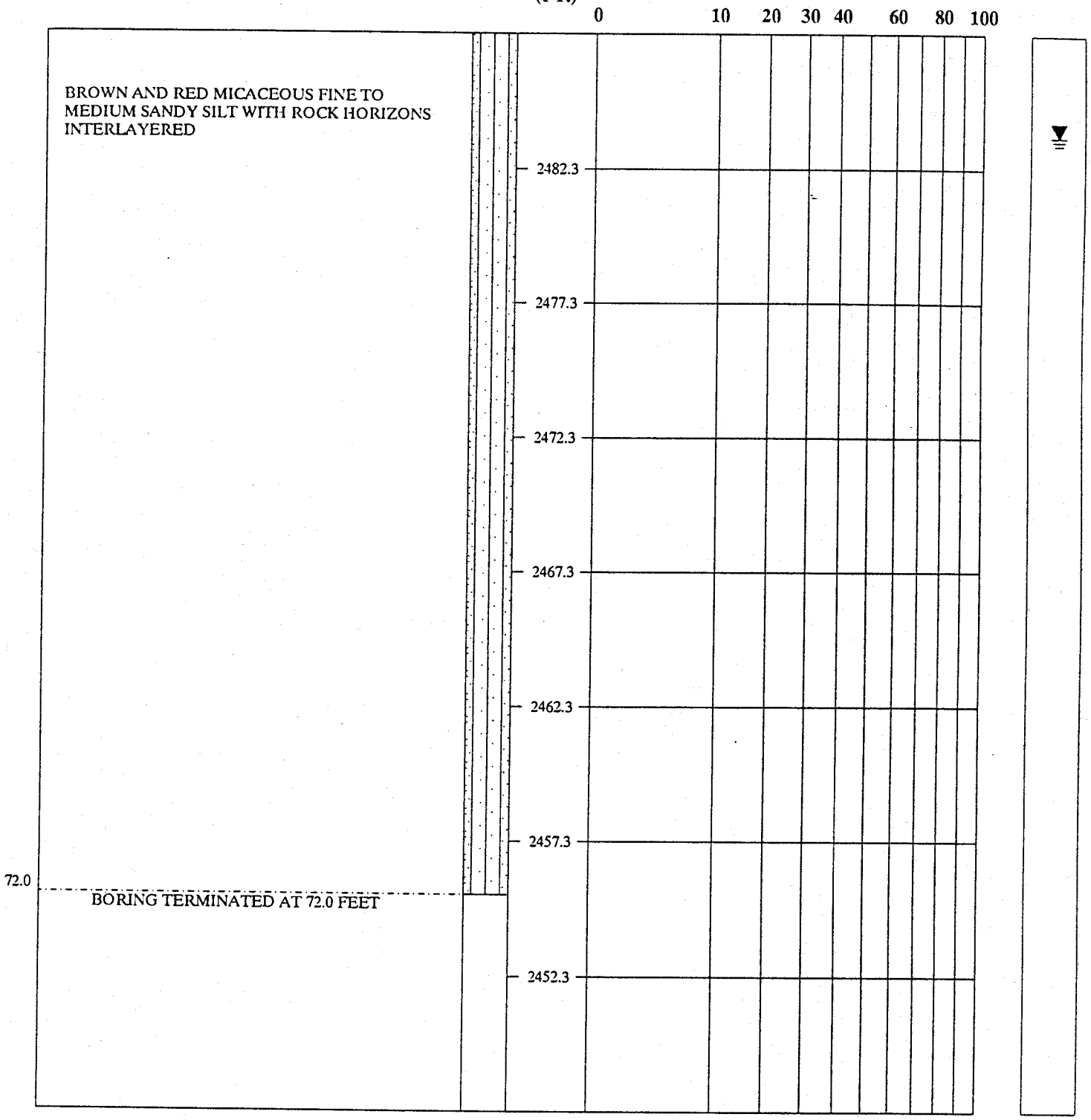
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-7
DATE DRILLED	April 24, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT



REMARKS:

GROUND WATER MEASURED AT 43.8 FEET ON 5-21-90.

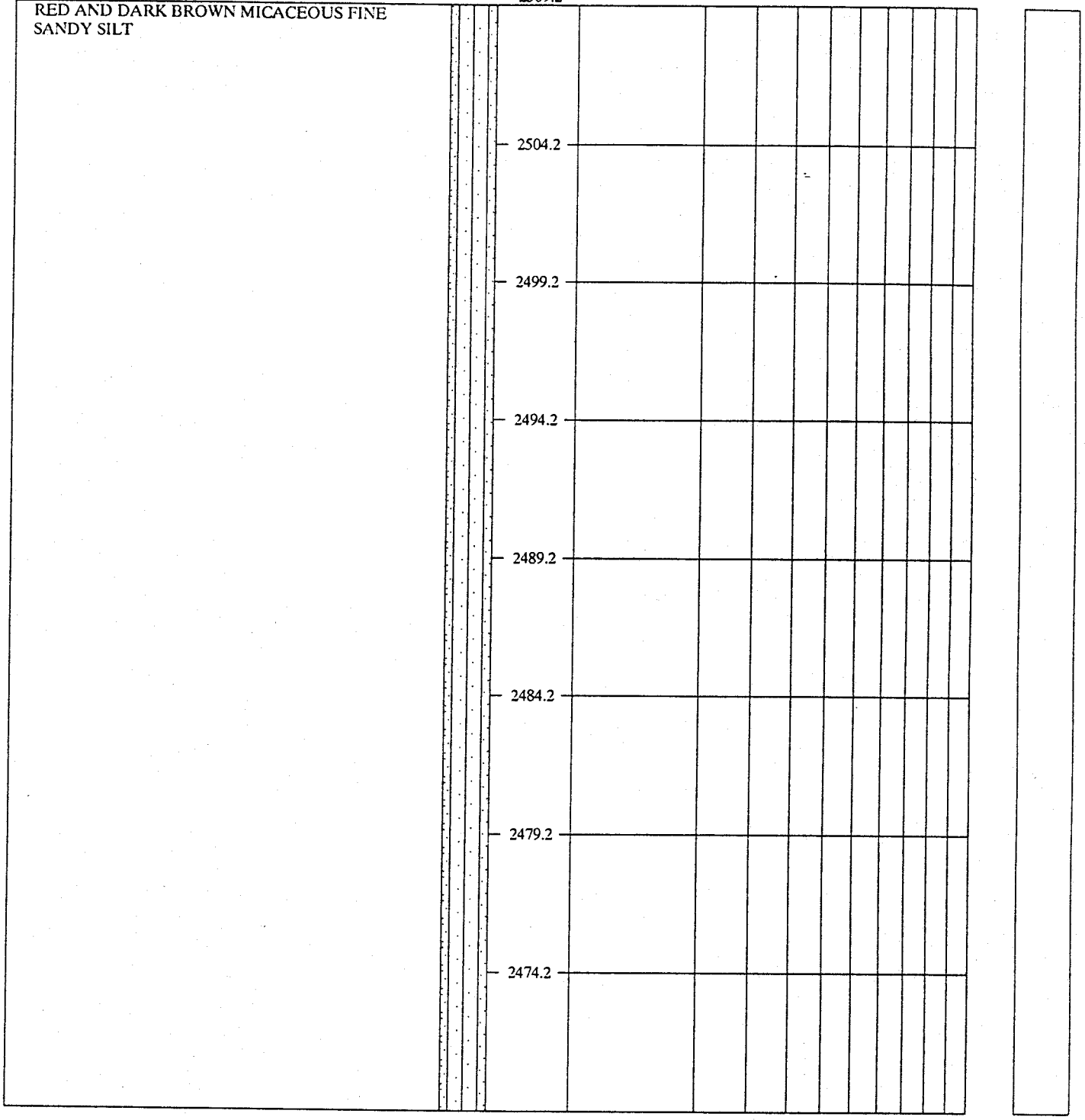
SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-7
DATE DRILLED	April 24, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)	● PENETRATION - BLOWS/FOOT
0.0	RED AND DARK BROWN MICACEOUS FINE SANDY SILT	2509.2	0 10 20 30 40 60 80 100
		2504.2	
		2499.2	
		2494.2	
		2489.2	
		2484.2	
		2479.2	
		2474.2	



REMARKS:

GROUND WATER MEASURED AT 43.1 ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-8
DATE DRILLED	April 24, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 1 OF 2	

LAW ENGINEERING

DEPTH (FT.)	DESCRIPTION	ELEVATION (FT.)
	RED AND DARK BROWN MICACEOUS FINE SANDY SILT	2464.2
50.0	BORING TERMINATED AT 50.0 FEET	2459.2
		2454.2
		2449.2
		2444.2
		2439.2
		2434.2

● PENETRATION - BLOWS/FOOT

0 10 20 30 40 60 80 100

REMARKS:

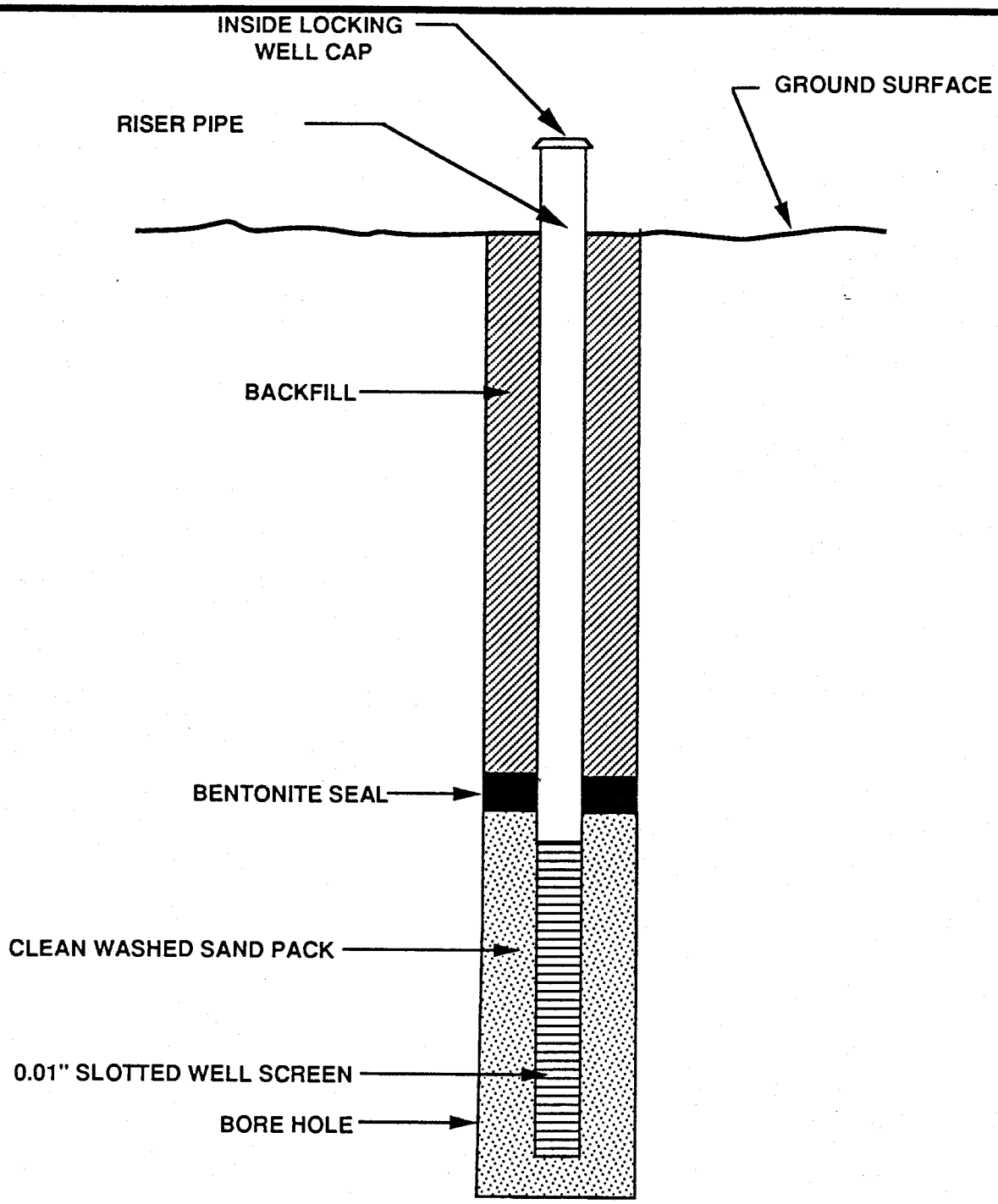
GROUND WATER MEASURED AT 43.1 ON 5-21-90.

SEE KEY SHEET FOR EXPLANATION OF SYMBOLS AND ABBREVATIONS USED ABOVE

SOIL TEST BORING RECORD

BORING NUMBER	AT-8
DATE DRILLED	April 24, 1990
PROJECT NUMBER	11-300142.01
PROJECT	HAYWOOD CO. LANDFILL
PAGE 2 OF 2	

LAW ENGINEERING



TYPICAL TYPE I MONITORING WELL CONSTRUCTION

Law Engineering Atlanta, Georgia Geotechnical, Materials & Environmental Consultants	PROPOSED WHITE OAK LANDFILL HAYWOOD COUNTY, NORTH CAROLINA	
	Job Number 11300142.01	Scale N.T.S

LAW ENVIRONMENTAL, INC.

112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

April 11, 1990

Law Engineering, Inc.
396 Plasters Avenue
Atlanta, GA 30324

Attention: Michael Talbot

LE Job Number: 1130014201

Subject: Chemical analysis of samples received on 04/03/90.

Dear Mr. Talbot:

Law Environmental National Laboratories has completed its analysis of your samples and reports the results on the following pages. These results relate only to the contents of the samples as submitted. This report shall not be reproduced except in full without the approval of Law Environmental National Laboratories.

If there are any questions, please do not hesitate to contact us.

Sincerely,

LAW ENVIRONMENTAL NATL LABS

C H McBride

Clifford H. McBride
QA/QC Coordinator

Attachment: Data Report
Invoice

LAW ENVIRONMENTAL NATIONAL LABORATORIES
TEST DATA REPORT

Date 04/11/90
Page 1

--- Project Information ---

Lab Number : 90-5657-01
Project No. :
Project Name : HAYWOOD COUNTY LANDFILL

Cust. No. :

Manager: MICHAEL TALBOT

--- Sample Information ---

Station ID : B-101 15'
Matrix : W
Type : GRAB
Collector : MT

Sampled Date/Time : / /
Received Date/Time : 04/03/90 15:50
Received From/By : MT/RKB
Chain of Custody : 8666
Number of Containers : 1

Remarks :

--- Test Data ---

Parameter	Method	Units	PQL	Results	Test Date	Analy
-- INORGANIC RESULTS --						
Cation Exchange Capacity(*meq/100g)	EPA 9080M	*	1	14	04/09/90	OR
Moisture (Oven Dried @ 105 C)	EPA 160.3M	wt %	1	19	04/05/90	GW
-- SERIES 18000						
Exchangeable Bases, Ca (*meq/100g)	EPA 6010			ND	04/10/90	KE
Exchangeable Bases, K (*meq/100g)	EPA 6010			0.42	04/09/90	KE
Exchangeable Bases, Mg (*meq/100g)	EPA 6010			0.34	04/11/90	KE
Exchangeable Bases, Na (*meq/100g)	EPA 6010			28	04/10/90	KE

Signed _____

LAW ENVIRONMENTAL NATIONAL LABORATORIES
TEST DATA REPORT

Date 04/11/90
Page 1

--- Project Information ---

Lab Number : 90-5657-02
Project No. :
Cust. No. :
Project Name : HAYWOOD COUNTY LANDFILL

Manager: MICHAEL TALBOT

--- Sample Information ---

Station ID : B-104 15'
Matrix : W
Type : GRAB
Collector : MT

Sampled Date/Time : / /
Received Date/Time : 04/03/90 15:50
Received From/By : MT/RKB
Chain of Custody : 8666
Number of Containers : 1

Remarks :

--- Test Data ---

Parameter	Method	Units	PQL	Results	Test Date	Analy
-- INORGANIC RESULTS --						
Cation Exchange Capacity(*meq/100g)	EPA 9080M	*	1	19	04/09/90	OR
Moisture (Oven Dried @ 105 C)	EPA 160.3M	wt %	1	6.7	04/05/90	GW
-- SERIES 18000						
Exchangeable Bases, Ca (*meq/100g)	EPA 6010			1.8	04/10/90	KE
Exchangeable Bases, K (*meq/100g)	EPA 6010			0.22	04/09/90	KE
Exchangeable Bases, Mg (*meq/100g)	EPA 6010			0.39	04/11/90	KE
Exchangeable Bases, Na (*meq/100g)	EPA 6010			0.76	04/10/90	KE

Signed C McBride

LAW ENVIRONMENTAL NATIONAL LABORATORIES
TEST DATA REPORT

Date 04/11/90
Page 1

--- Project Information ---

Lab Number : 90-5657-03
Project No. :
Project Name : HAYWOOD COUNTY LANDFILL

Cust. No. :

Manager: MICHAEL TALBOT

--- Sample Information ---

Station ID : B-106 15'
Matrix : W
Type : GRAB
Collector : MT

Sampled Date/Time : / /
Received Date/Time : 04/03/90 15:50
Received From/By : MT/RKB
Chain of Custody : 8666
Number of Containers : 1

Remarks :

--- Test Data ---

Parameter	Method	Units	PQL	Results	Test Date	Analy
-- INORGANIC RESULTS --						
Cation Exchange Capacity(*meq/100g)	EPA 9080M	*	1	25	04/09/90	OR
Moisture (Oven Dried @ 105 C)	EPA 160.3M	wt %	1	19	04/05/90	GW
-- SERIES 18000						
Exchangeable Bases, Ca (*meq/100g)	EPA 6010			ND	04/10/90	KE
Exchangeable Bases, K (*meq/100g)	EPA 6010			0.12	04/09/90	KE
Exchangeable Bases, Mg (*meq/100g)	EPA 6010			1.2	04/11/90	KE
Exchangeable Bases, Na (*meq/100g)	EPA 6010			ND	04/10/90	KE

Signed C McBride

LAW ENVIRONMENTAL NATIONAL LABORATORIES
TEST DATA REPORT

Date 04/11/90
Page 1

--- Project Information ---

Lab Number : 90-5657-04
Project No. :
Cust. No. :
Project Name : HAYWOOD COUNTY LANDFILL

Manager: MICHAEL TALBOT

--- Sample Information ---

Station ID : B-110 5'
Matrix : W
Type : GRAB
Collector : MT

Sampled Date/Time : / /
Received Date/Time : 04/03/90 15:50
Received From/By : MT/RKB
Chain of Custody : 8666
Number of Containers : 1

Remarks :

--- Test Data ---

Parameter	Method	Units	PQL	Results	Test Date	Analy
-- INORGANIC RESULTS --						
Cation Exchange Capacity(*meq/100g)	EPA 9080M	*	1	26	04/09/90	OR
Moisture (Oven Dried @ 105 C)	EPA 160.3M	wt %	1	25	04/05/90	GW
--- SERIES 18000						
Exchangeable Bases, Ca (*meq/100g)	EPA 6010			0.47	04/10/90	KE
Exchangeable Bases, K (*meq/100g)	EPA 6010			0.10	04/09/90	KE
Exchangeable Bases, Mg (*meq/100g)	EPA 6010			0.45	04/11/90	KE
Exchangeable Bases, Na (*meq/100g)	EPA 6010			0.89	04/10/90	KE

Signed C McBride

LAW ENVIRONMENTAL NATIONAL LABORATORIES
TEST DATA REPORT

Date 04/11/90
Page 1

--- Project Information ---.

Lab Number : 90-5657-05
Project No. :
Project Name : HAYWOOD COUNTY LANDFILL

Cust. No. :

Manager: MICHAEL TALBOT

--- Sample Information ---

Station ID : B-112 15'
Matrix : W
Type : GRAB
Collector : MT

Sampled Date/Time : / /
Received Date/Time : 04/03/90 15:50
Received From/By : MT/RKB
Chain of Custody : 8666
Number of Containers : 1

Remarks :

--- Test Data ---

Parameter	Method	Units	PQL	Results	Test Date	Analy
-- INORGANIC RESULTS --						
Cation Exchange Capacity(*meq/100g)	EPA 9080M	*	1	19	04/09/90	OR
Moisture (Oven Dried @ 105 C)	EPA 160.3M	wt %	1	15	04/05/90	GW
-- SERIES 18000						
Exchangeable Bases, Ca (*meq/100g)	EPA 6010			0.15	04/10/90	KE
Exchangeable Bases, K (*meq/100g)	EPA 6010			0.20	04/09/90	KE
Exchangeable Bases, Mg (*meq/100g)	EPA 6010			0.52	04/11/90	KE
Exchangeable Bases, Na (*meq/100g)	EPA 6010			0.35	04/10/90	KE

Signed C m Brid

LAW ENVIRONMENTAL NATIONAL LABORATORIES
TEST DATA REPORT

Date 04/11/90
Page 1

--- Project Information ---

Lab Number : 90-5657-06
Project No. :
Project Name : HAYWOOD COUNTY LANDFILL

Cust. No. :

Manager: MICHAEL TALBOT

--- Sample Information ---

Station ID : B-115 10'
Matrix : W
Type : GRAB
Collector : MT

Sampled Date/Time : / /
Received Date/Time : 04/03/90 15:50
Received From/By : MT/RKB
Chain of Custody : 8666
Number of Containers : 1

Remarks :

--- Test Data ---

Parameter	Method	Units	PQL	Results	Test Date	Analy
-- INORGANIC RESULTS --						
Cation Exchange Capacity(*meq/100g)	EPA 9080M	*	1	21	04/09/90	OR
Moisture (Oven Dried @ 105 C)	EPA 160.3M	wt %	1	17	04/05/90	GW
-- SERIES 18000						
Exchangeable Bases, Ca (*meq/100g)	EPA 6010			0.15	04/10/90	KE
Exchangeable Bases, K (*meq/100g)	EPA 6010			ND	04/09/90	KE
Exchangeable Bases, Mg (*meq/100g)	EPA 6010			0.76	04/11/90	KE
Exchangeable Bases, Na (*meq/100g)	EPA 6010			0.14	04/10/90	KE

Signed C McBride

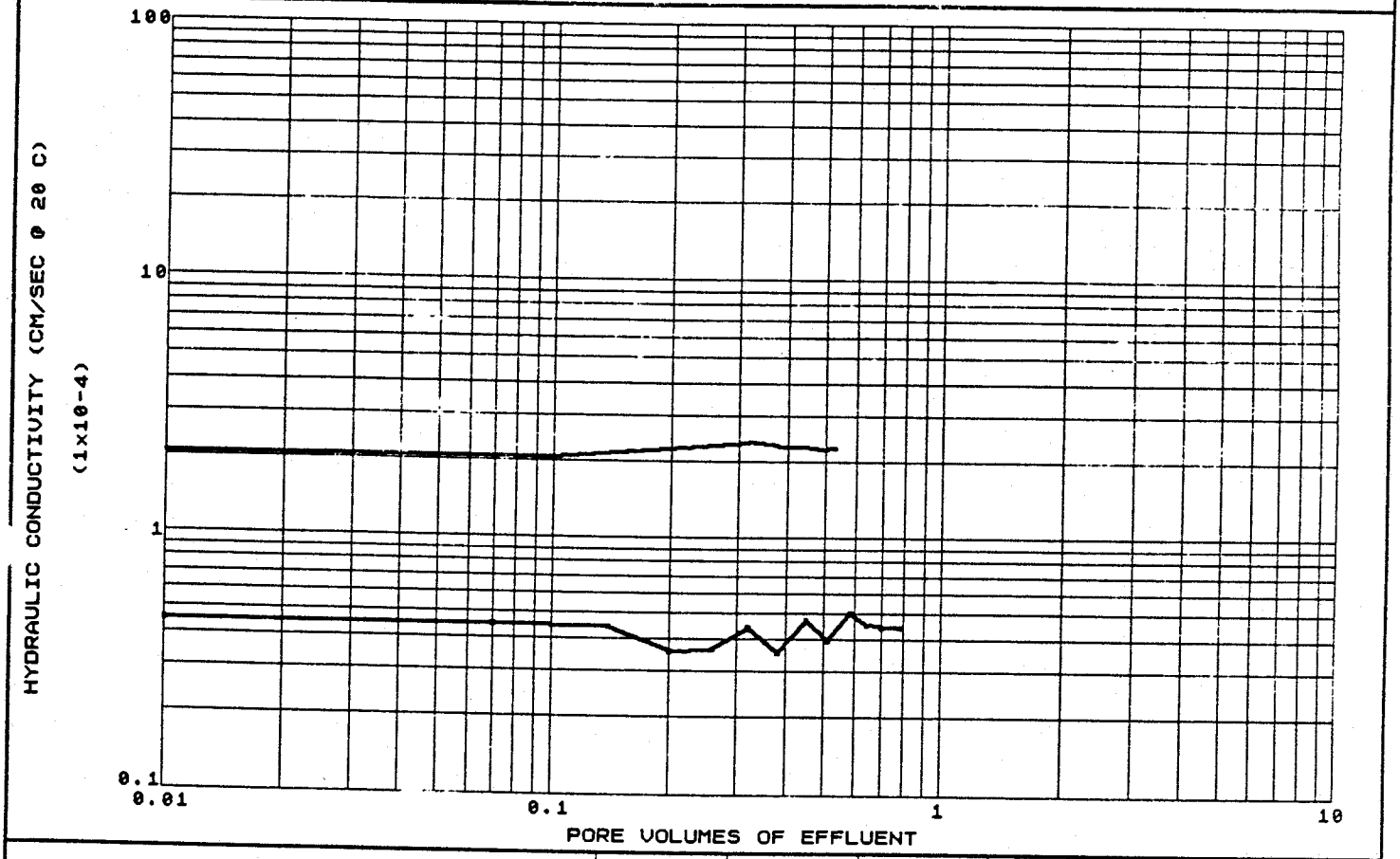
LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

HYDRAULIC CONDUCTIVITY

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
TESTED BY JTM, MAO PAGE 1

PROJECT Haywood Co.Law Engr.#1130014201 TEST METHOD US Army Corps of Engrs. EM1110-2-1906.



LAB NO.	9836	9839				
SAMPLE IDENTIFICATION	B-103 15.0'- 17.0'	B-113 5.0'- 7.0'				
RECEIPT DATE	4/3/90	4/3/90				
TEST COMPLETION DATE	4/9/90	4/9/90				
SAMPLE TYPE	Undist	Undist				
INITIAL WATER CONTENT (% BY DRY WEIGHT)	14.5	20.9				
DRY UNIT WEIGHT (PCF)	96.7	106.5				
PERCENT COMPACTION IF REMOLDED	N/A	N/A				
ONE PORE VOLUME (CC)	131	94				
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	2.3E-04	4.4E-05				

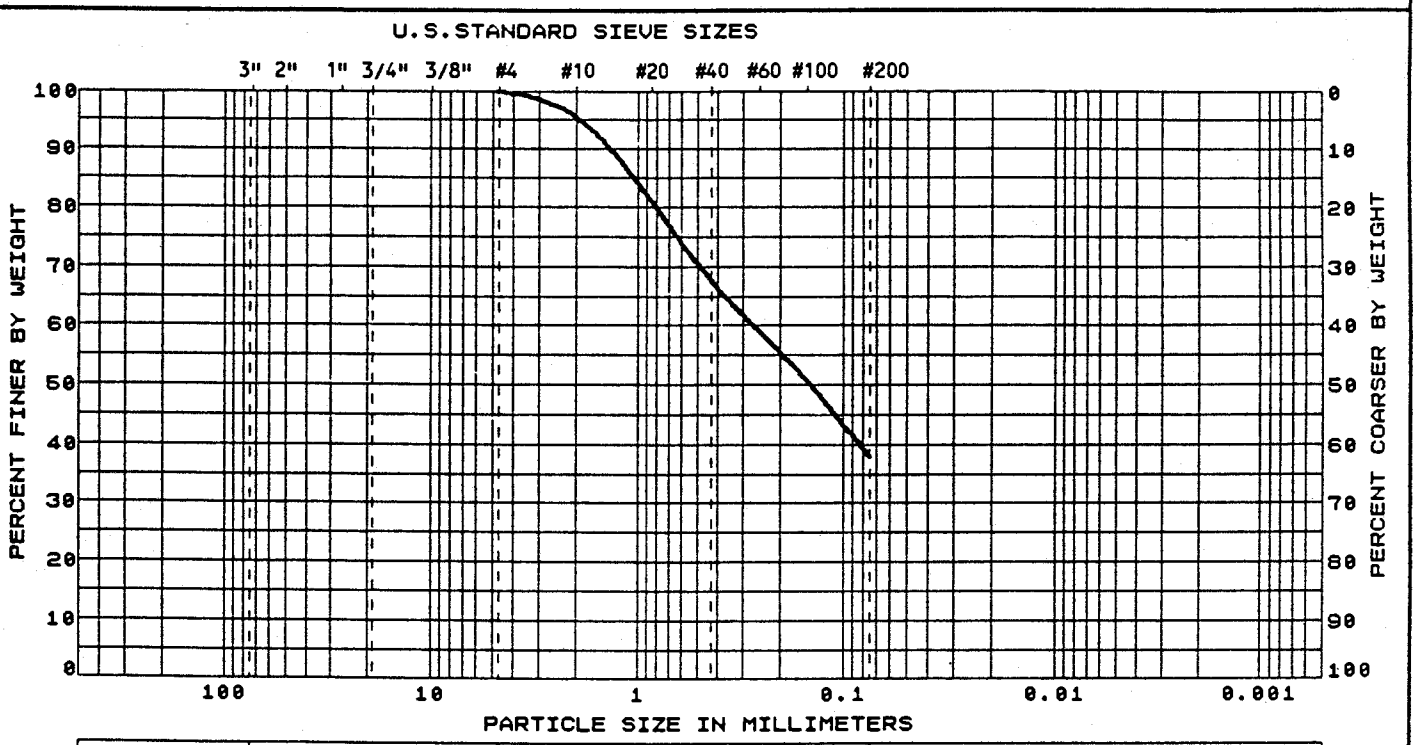
LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9840 PAGE 1
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-103 20.0'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
#4	4.75	100.0		
#10	2.00	95.6		
#20	0.850	81.0		
#40	0.425	67.4		
#60	0.250	58.9		
#100	0.150	50.9		
#200	0.075	37.9		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION ( )

WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

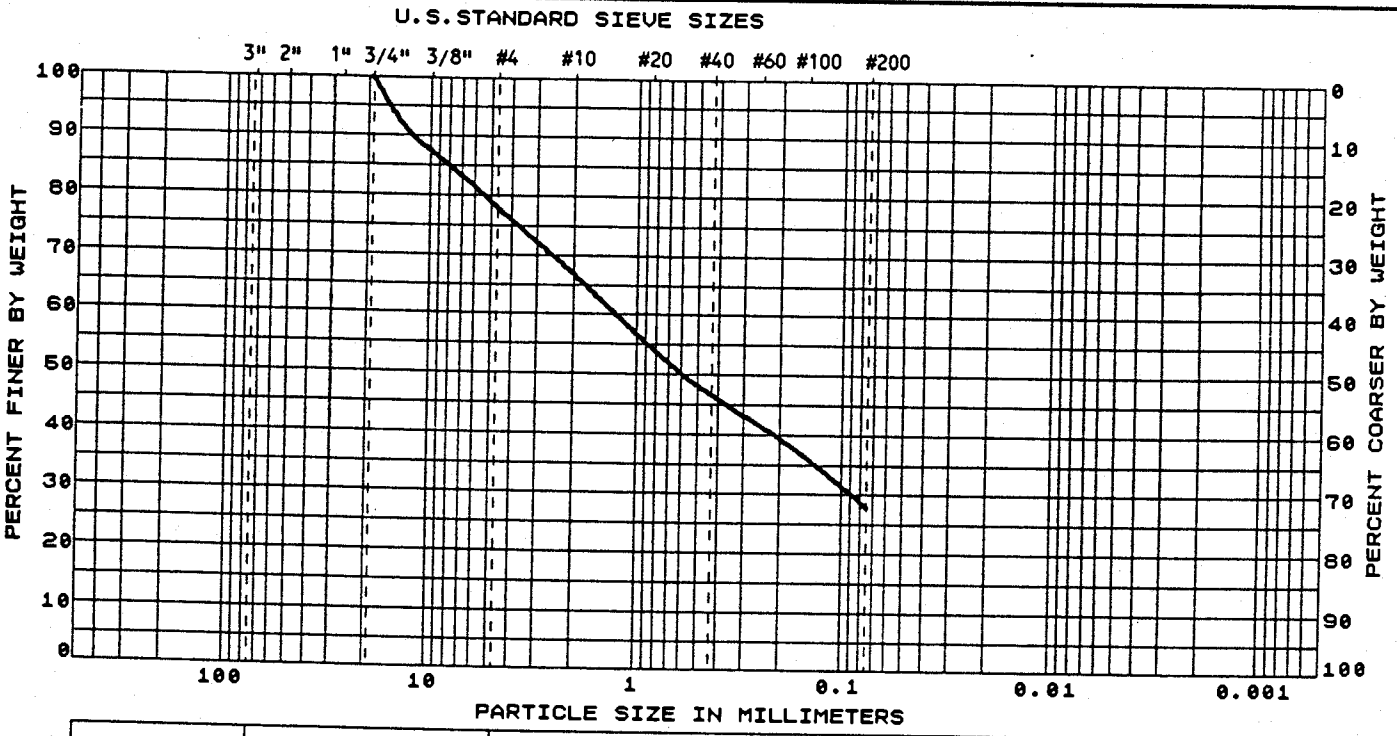
LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9841 PAGE 2
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-104 10.0'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19	100.0		0.001
1/2"	12.5	90.5		
3/8"	9.5	87.1		
#4	4.75	78.2		
#10	2.00	66.8		
#20	0.850	54.6		
#40	0.425	46.4		
#60	0.250	41.5		
#100	0.150	36.4		
#200	0.075	27.9		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION ( )
WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

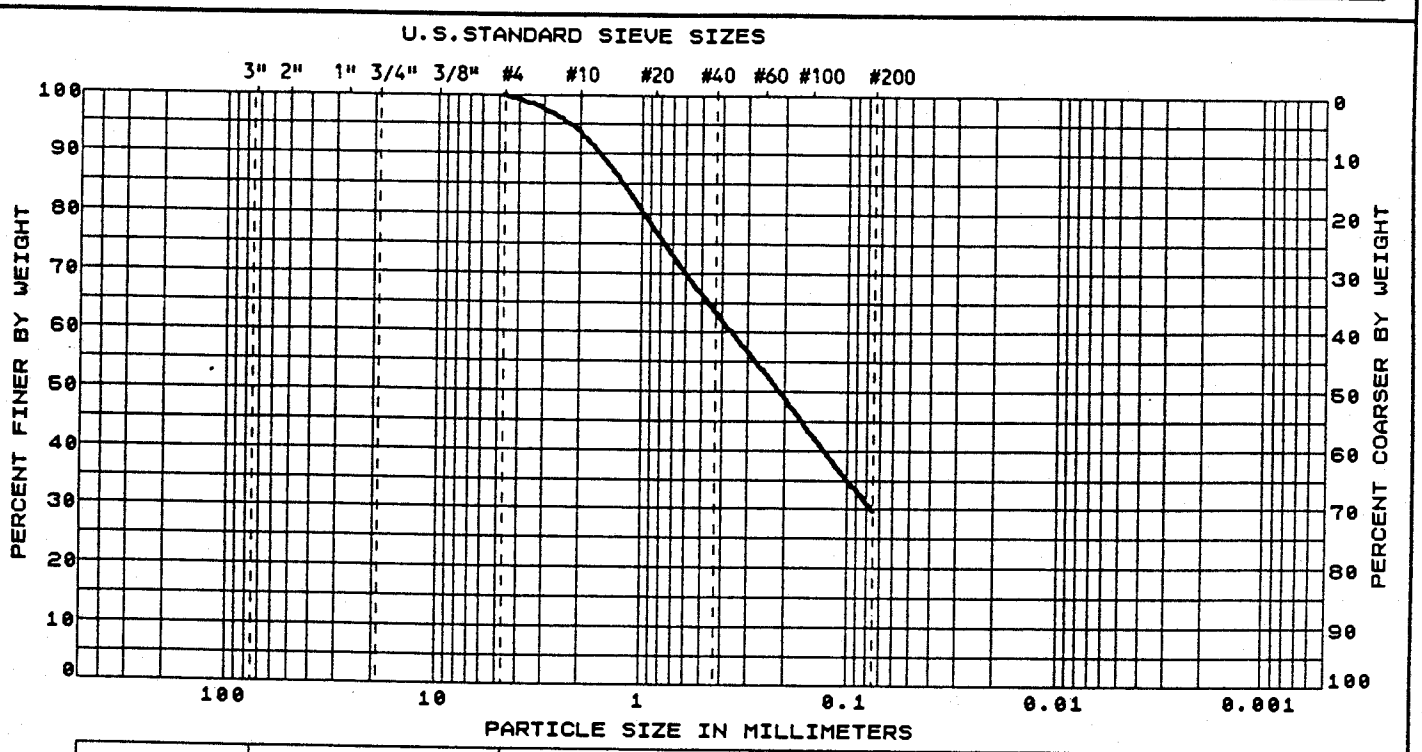
LAW ENVIRONMENTAL, INC.
M. A. O'Kelley

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9842 PAGE 3
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-112 4.0'-5.5'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
#4	4.75	100.0		
#10	2.00	93.7		
#20	0.850	77.2		
#40	0.425	63.1		
#60	0.250	53.2		
#100	0.150	43.1		
#200	0.075	29.6		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION ( )
WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

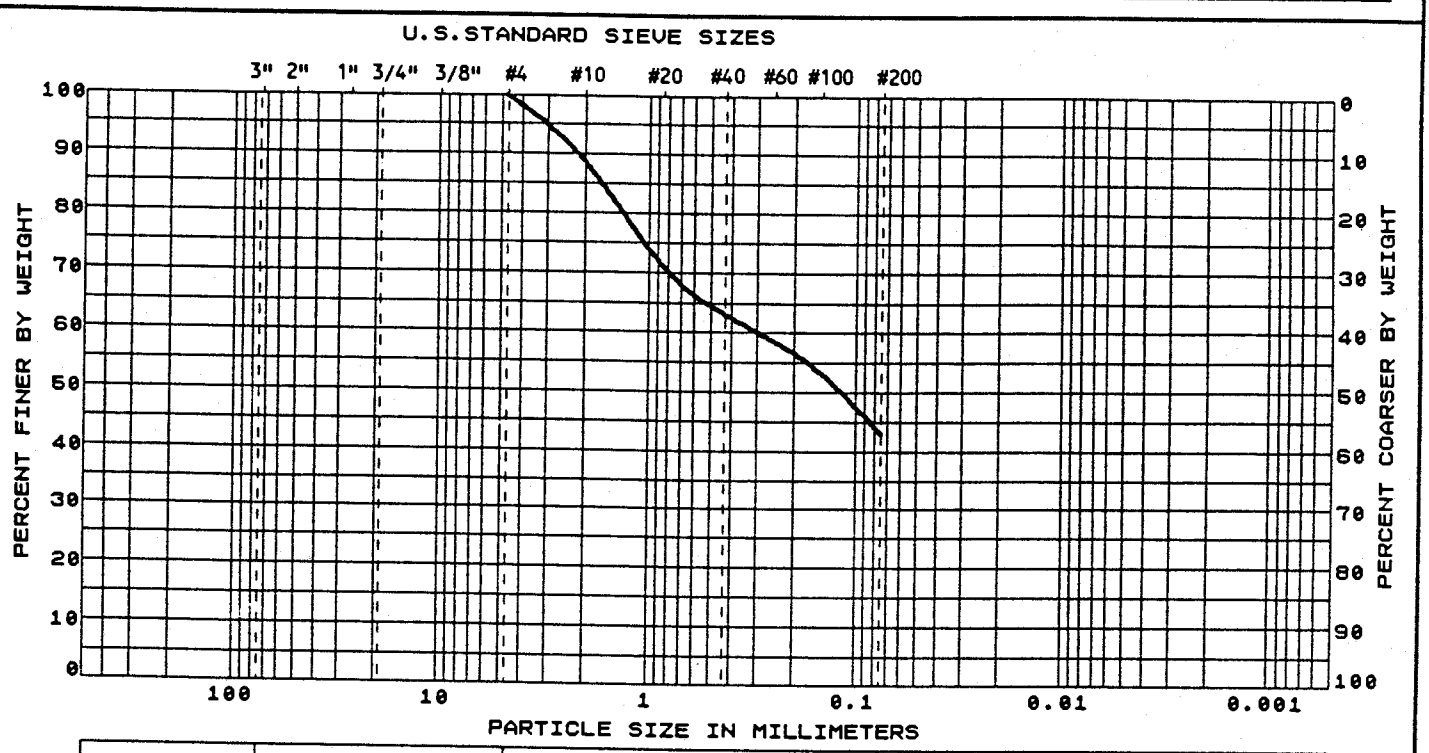
LAW ENVIRONMENTAL, INC.
M.A. O'Kelly

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9843 PAGE 4
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-113 5.0'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

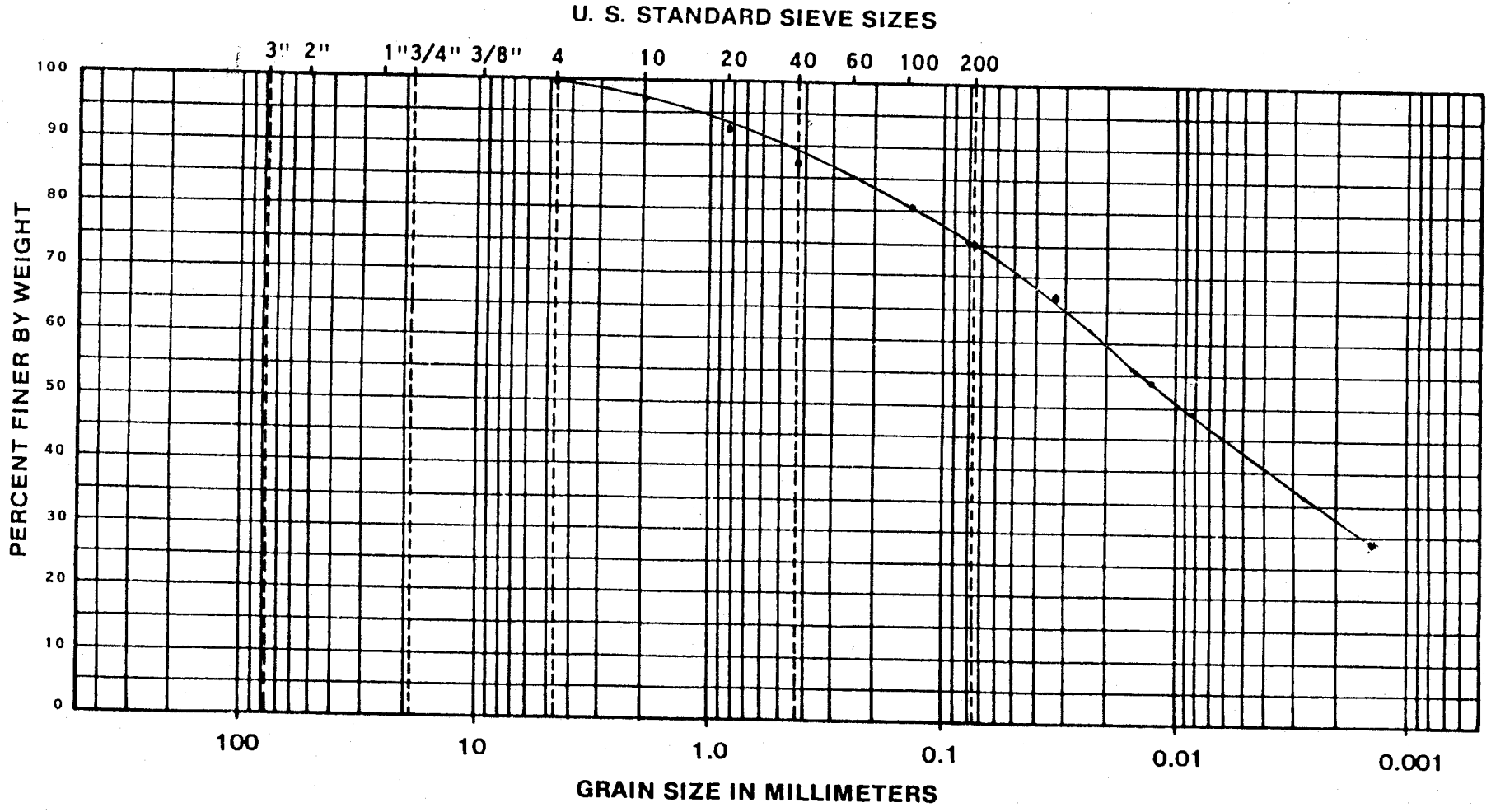
U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
#4	4.75	100.0		
#10	2.00	88.7		
#20	0.850	71.0		
#40	0.425	63.0		
#60	0.250	58.6		
#100	0.150	53.5		
#200	0.075	42.9		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION ( )

WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.
M.A O'Kelley

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



Law Engineering

Grain Size Distribution

BORING NO.	DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-105	4 TO 5.5	29.2	55	32	23	BROWN MEDIUM TO FINE SANDY CLAYEY SILT (MH)
JOB NO. 11-300 142.01						

LAW ENVIRONMENTAL, INC.
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

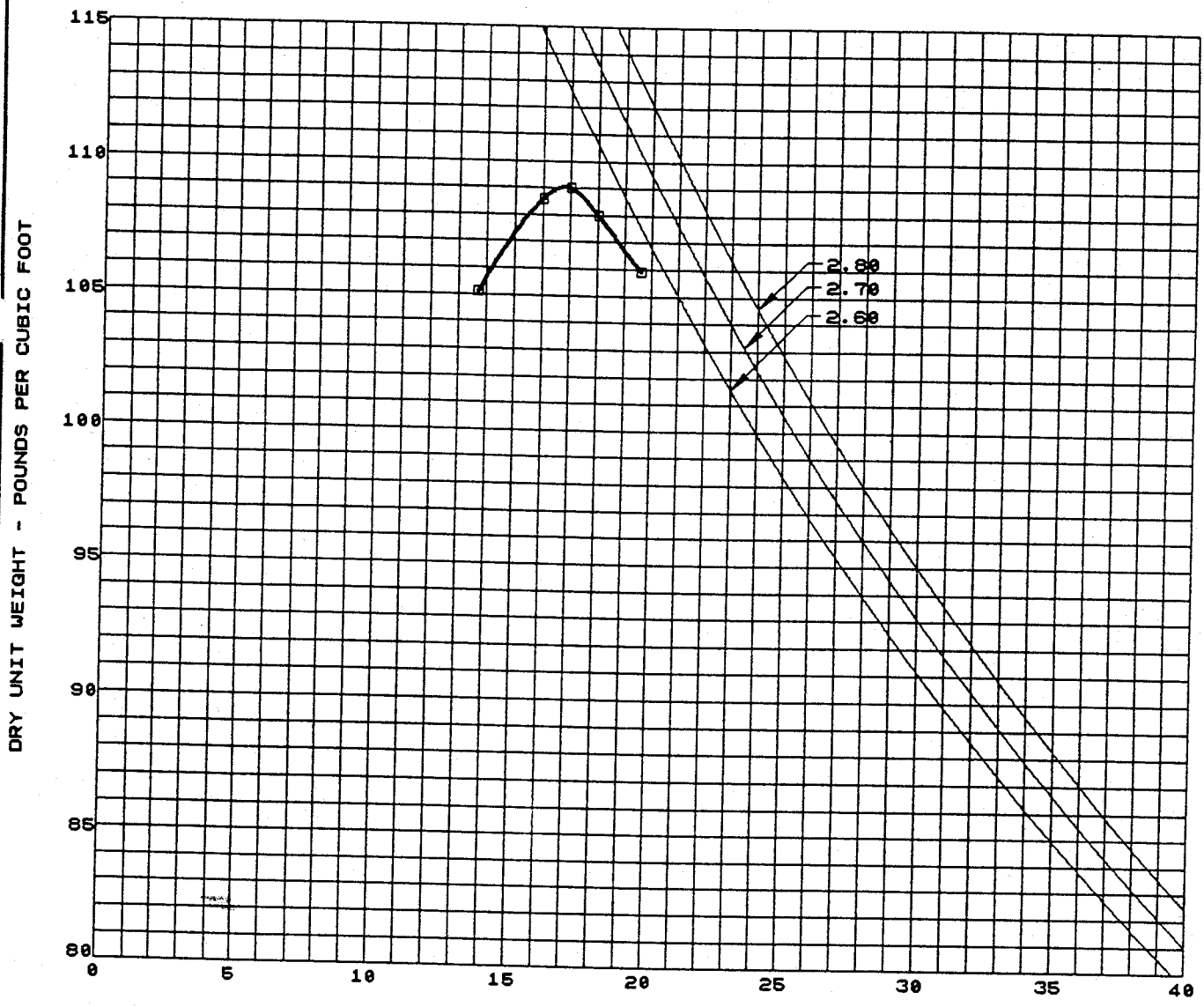
COMPACTION TEST

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9845 PAGE 1
BORING NO. B-112
SAMPLE NO.

PROJECT Haywood Co.Law Engr.#1130014201 DEPTH 0.0'- 15.0'
LOCATION
SOIL DESCRIPTION Brown SlCl Si Sa
METHOD OF TEST ASTM D698
TESTED BY JTM, MAO

MAXIMUM DENSITY (PCF) 109.0
OPTIMUM MOISTURE CONTENT (%) 17.0



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COMPACTION TEST

CLIENT Law Engineering, Inc.
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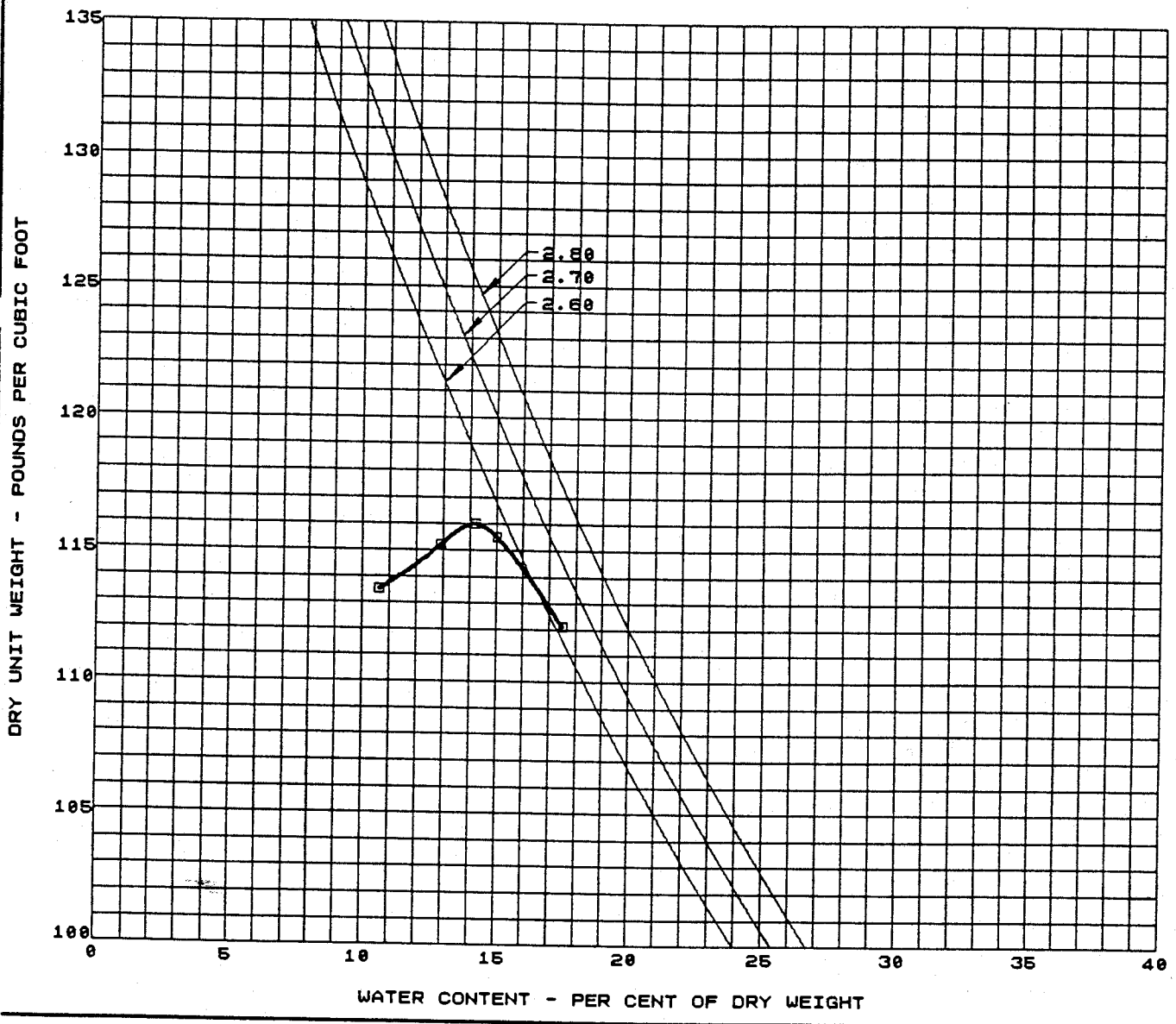
JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9844 PAGE 1
BORING NO. B-111
SAMPLE NO.

PROJECT Haywood Co.Law Engr.#1130014201 DEPTH 0.0'- 10.0'
LOCATION
SOIL DESCRIPTION Brown SlCl Si Sa
METHOD OF TEST ASTM D698-A TESTED BY JTM, MAO

MAXIMUM DENSITY (PCF) 116.0 OPTIMUM MOISTURE CONTENT (%) 14.2



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404-421-3400

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

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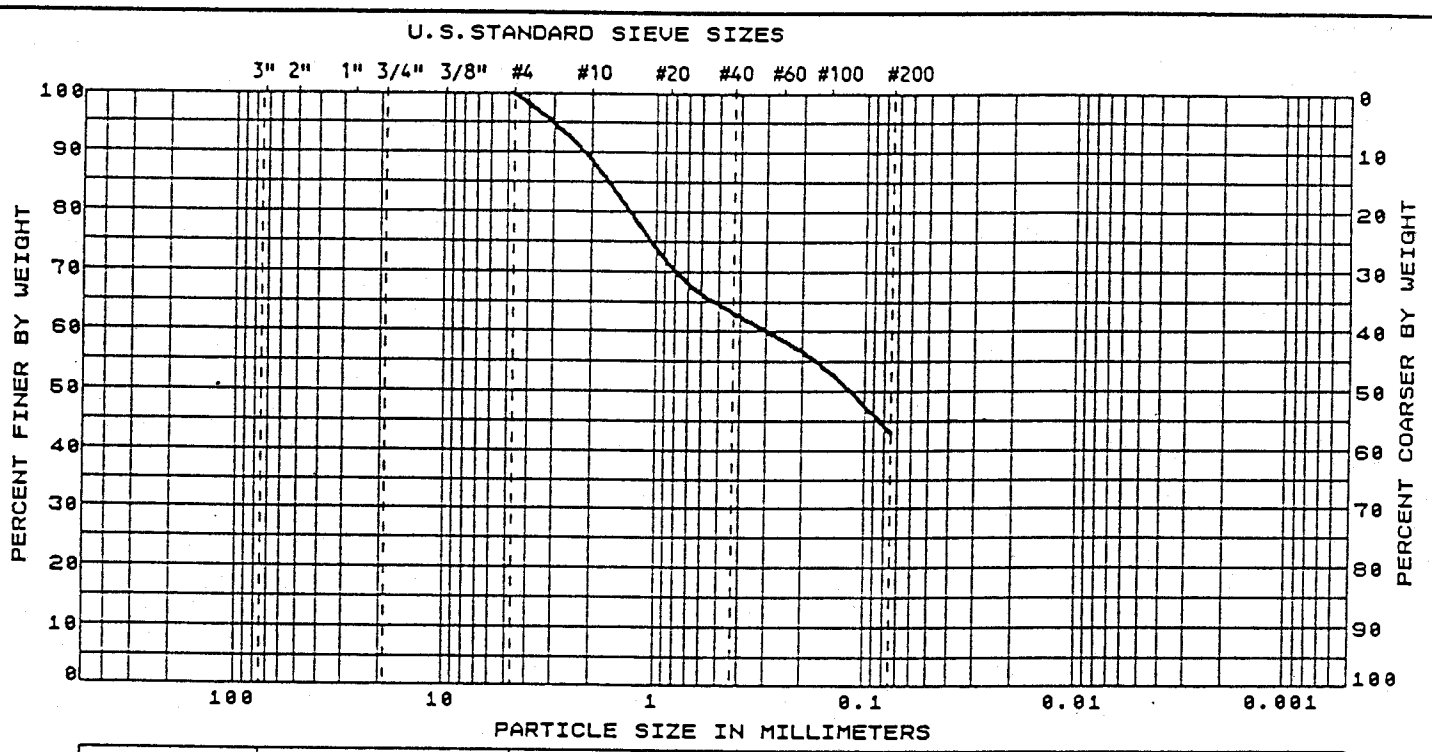
JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9843 PAGE 4
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-113 5.0'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
#4	4.75	100.0		
#10	2.00	88.7		
#20	0.850	71.0		
#40	0.425	63.0		
#60	0.250	58.6		
#100	0.150	53.5		
#200	0.075	42.9		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION SM ( )
WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

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KENNESAW, GEORGIA 30144-5599
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PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
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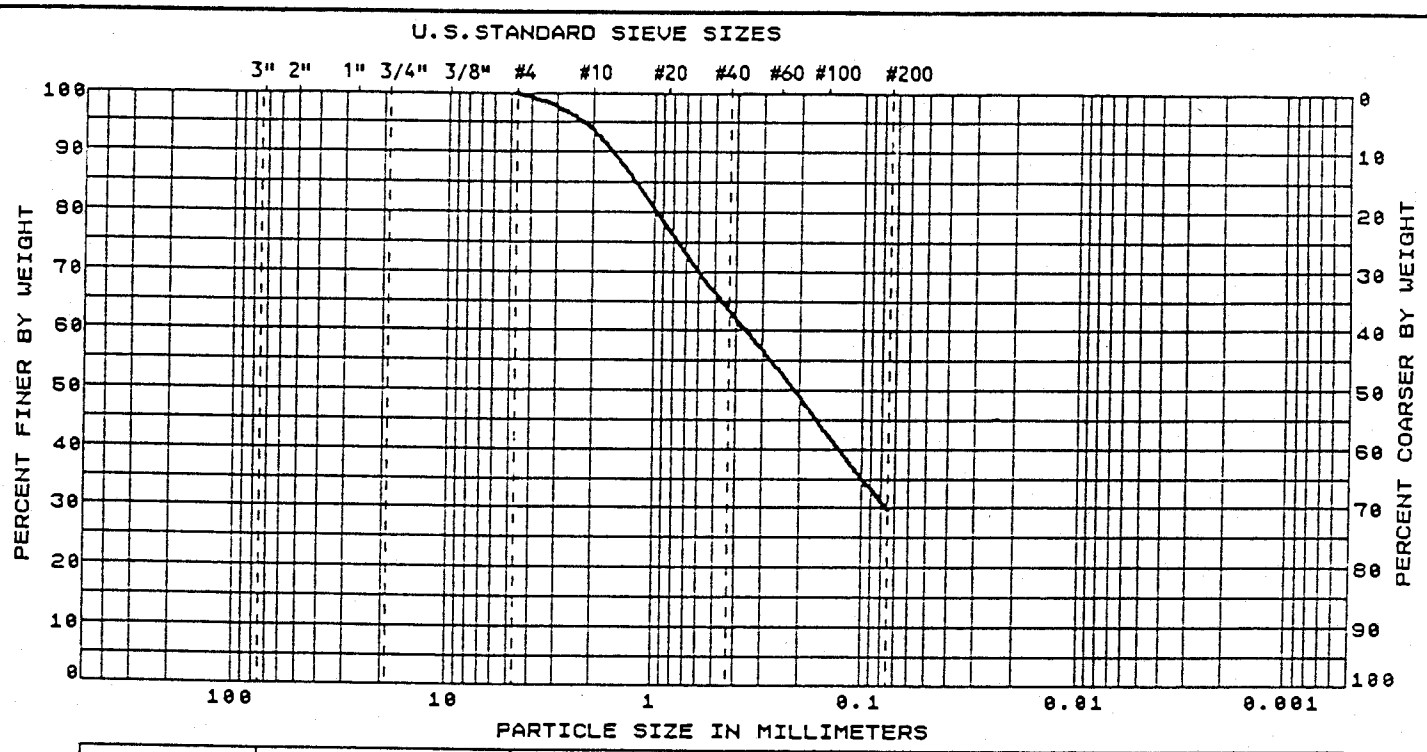
JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9842 PAGE 3
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-112 4.0'-6.5'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
#4	4.75	100.0		
#10	2.00	93.7		
#20	0.850	77.2		
#40	0.425	63.1		
#60	0.250	53.2		
#100	0.150	43.1		
#200	0.075	29.6		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION SM ( )

WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

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M.A. O'Kelley

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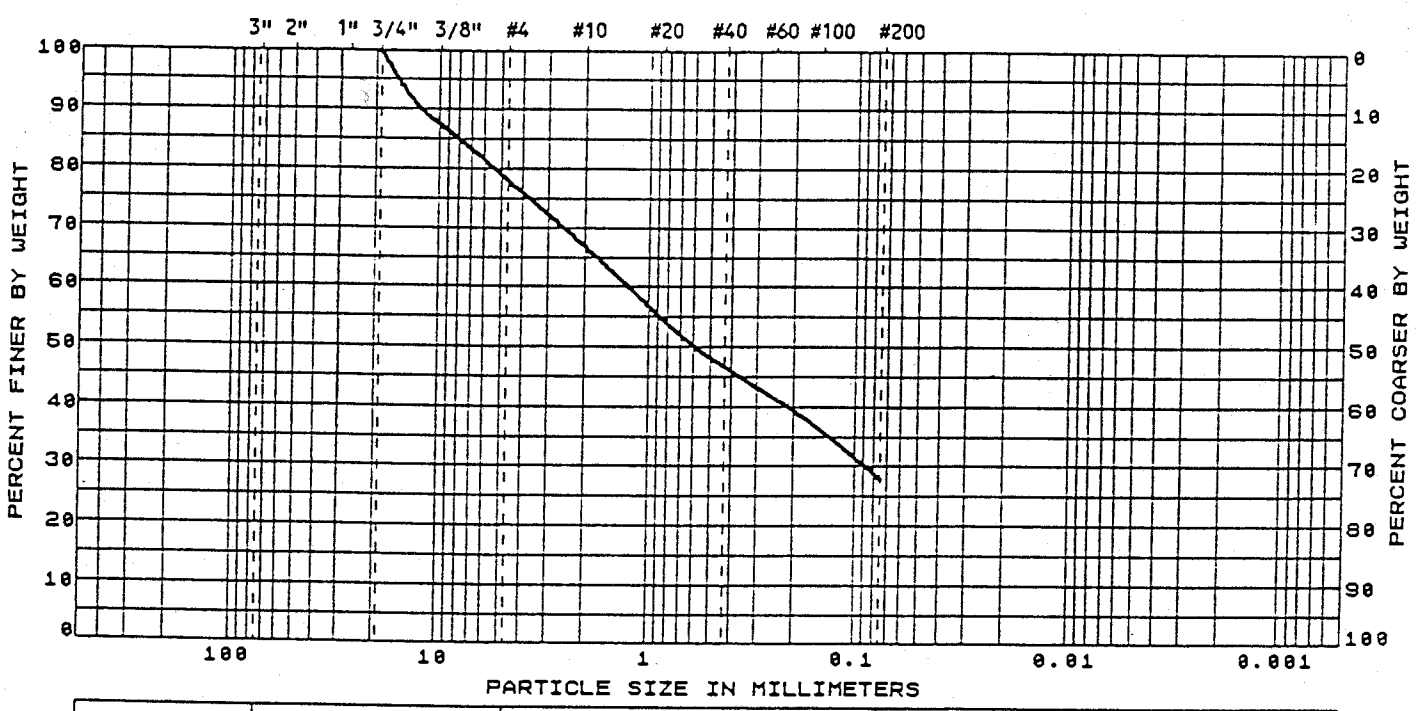
112 TOWNPARK DRIVE
KENNESAW, GEORGIA 30144-5599
404-421-3400

PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9841 PAGE 2
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-104 10.0'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19	100.0		0.001
1/2"	12.5	90.5		
3/8"	9.5	87.1		
#4	4.75	78.2		
#10	2.00	66.8		
#20	0.850	54.6		
#40	0.425	46.4		
#60	0.250	41.5		
#100	0.150	36.4		
#200	0.075	27.9		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION SM ( )
WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

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PARTICLE SIZE DISTRIBUTION & PHYSICAL PROPERTIES

CLIENT Law Engineering, Inc.
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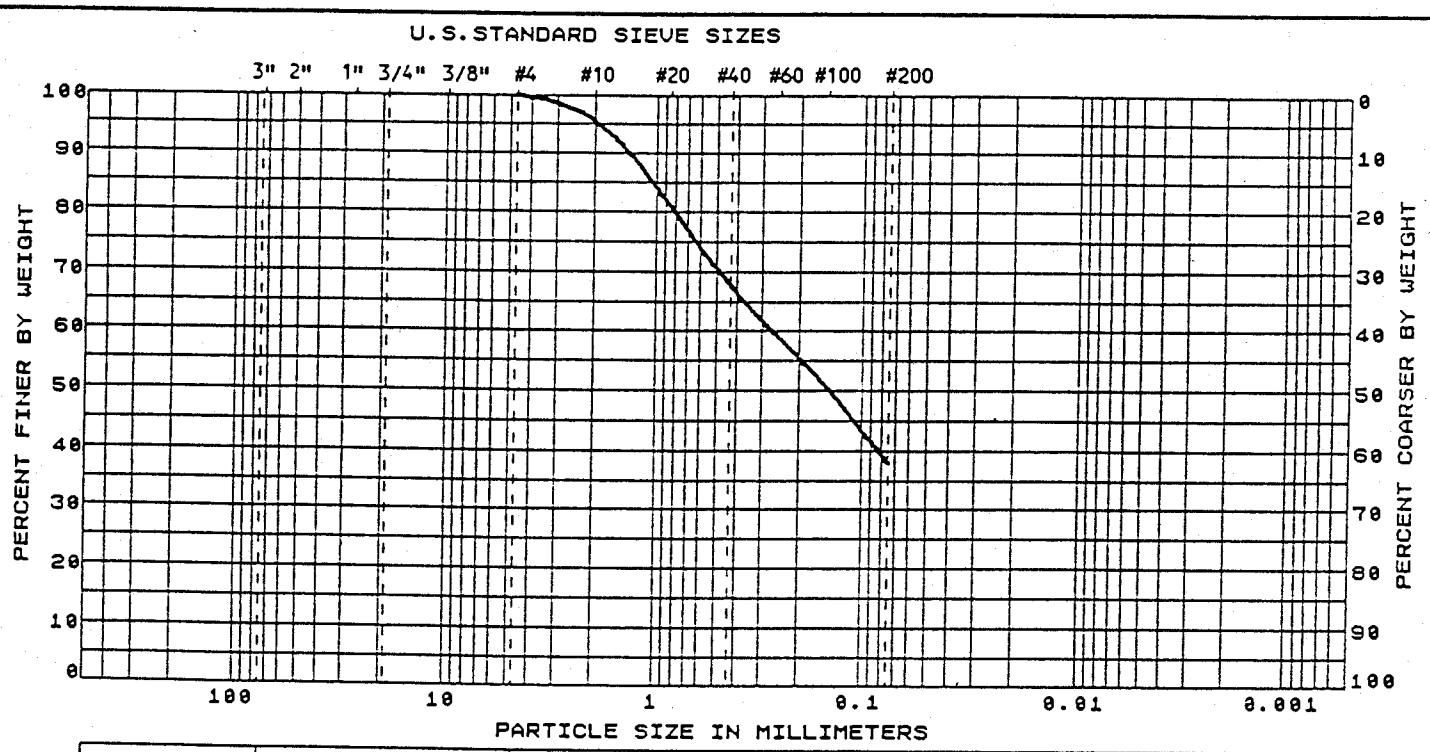
JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9840 PAGE 1
PROJECT Haywood Co.Law Engr.#1130014201
SAMPLE ID B-103 20.0'



COBBLES	GRAVEL		SAND			SILT & CLAY
	COARSE	MEDIUM	CO.	MEDIUM	FINE	

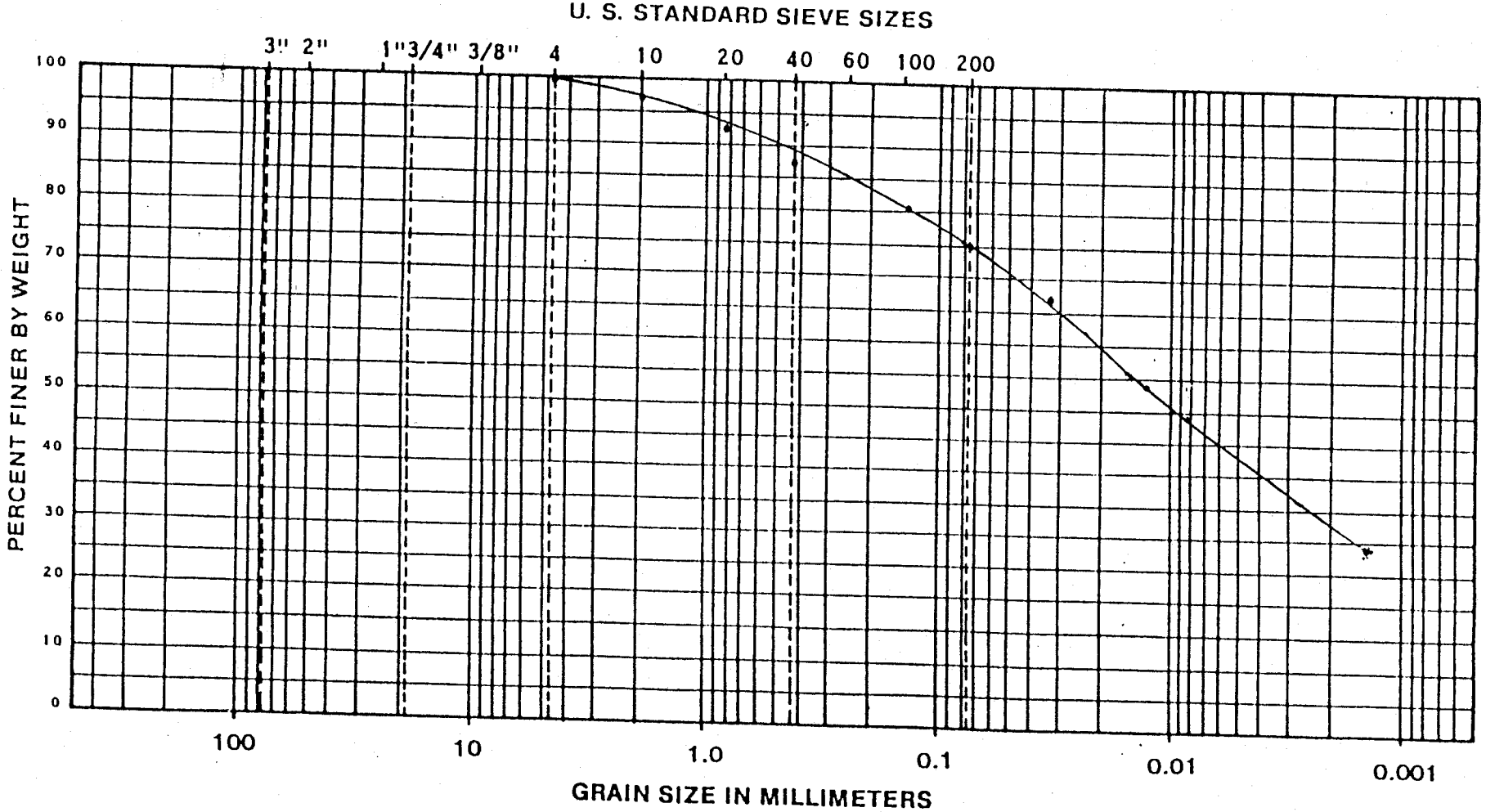
U.S.STANDARD SIEVE SIZE		PERCENT PASSING		HYDROMETER
SIEVE NO.	SIEVE SIZE (MILLIMETERS)			PARTICLE DIAMETER (MILLIMETERS)
3"	75			0.050
2"	50			0.020
1-1/2"	37.5			0.005
1"	25			0.002
3/4"	19			0.001
1/2"	12.5			
3/8"	9.5			
#4	4.75	100.0		
#10	2.00	95.6		
#20	0.850	81.0		
#40	0.425	67.4		
#60	0.250	58.9		
#100	0.150	50.9		
#200	0.075	37.9		

POROSITY (%) _____
EFFECTIVE SIZE (mm) _____
COEFFICIENT OF UNIFORMITY _____
COEFFICIENT OF CURVATURE _____
LIQUID LIMIT _____
PLASTIC LIMIT _____
PLASTICITY INDEX _____
CLASSIFICATION SM ( )

WATER CONTENT (%) _____
DRY DENSITY (PCF) _____
SPECIFIC GRAVITY _____
HYDRAULIC CONDUCTIVITY (cm/sec - 20C) _____
TEST PROCEDURES: ASTM D422.

LAW ENVIRONMENTAL, INC.
M.A.O'Kelley

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



Law Engineering

Grain Size Distribution

BORING NO.	DEPTH	NAT WC	LL	PL	PI	DESCRIPTION OR CLASSIFICATION
B-105	4 TO 5.5	29.2	55	32	23	BROWN MEDIUM TO FINE SANDY CLAYEY SILT (MH)
JOB NO. 11-300 142.01						

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COMPACTION TEST

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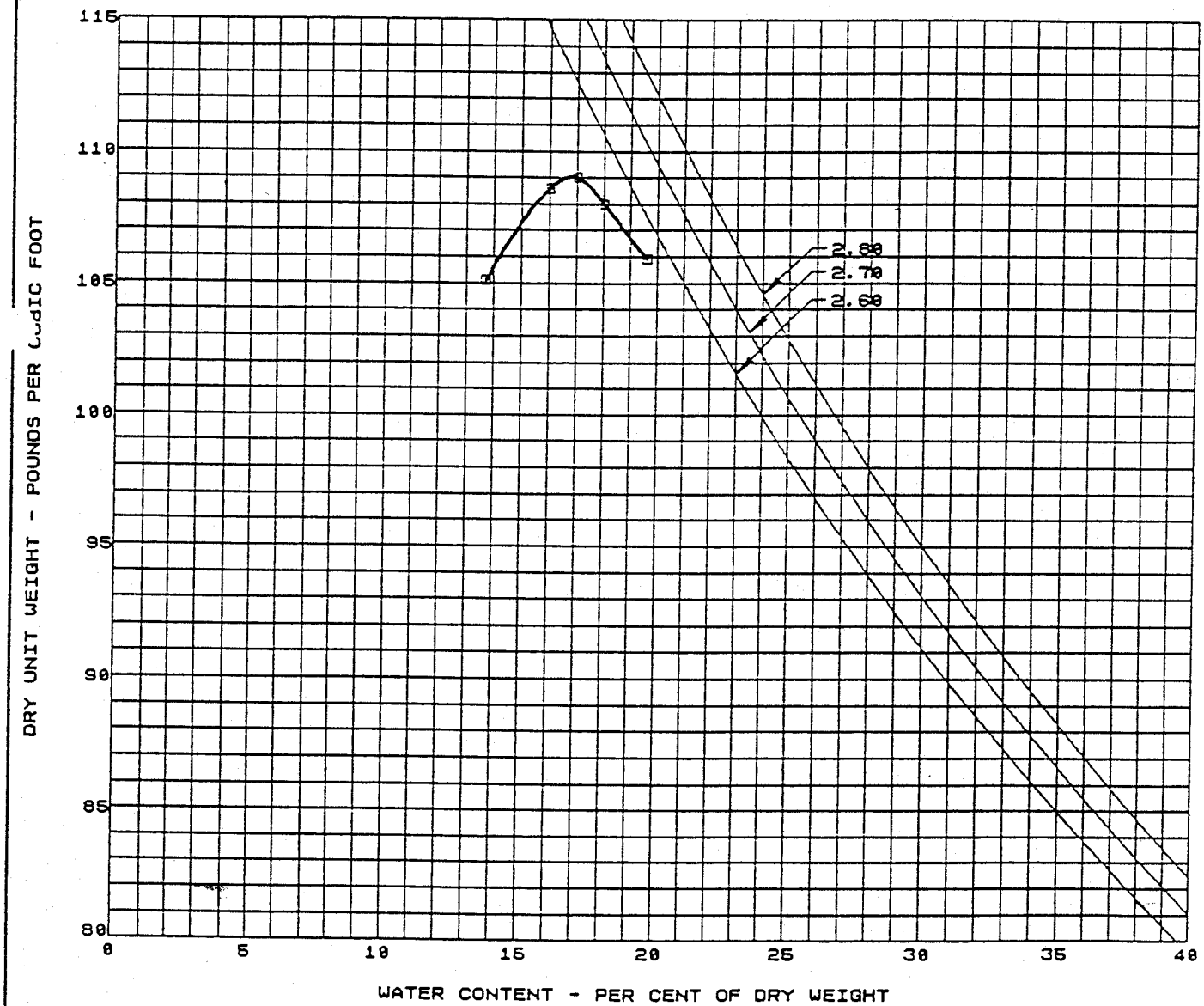
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9845 PAGE 1
BORING NO. B-112
SAMPLE NO.

PROJECT Haywood Co.Law Engr.#1130014201 DEPTH 0.0'- 15.0'
LOCATION
SOIL DESCRIPTION Brown SlCl Si Sa
METHOD OF TEST ASTM D698
TESTED BY JTM, MAO

MAXIMUM DENSITY (PCF) 109.0
OPTIMUM MOISTURE CONTENT (%) 17.0



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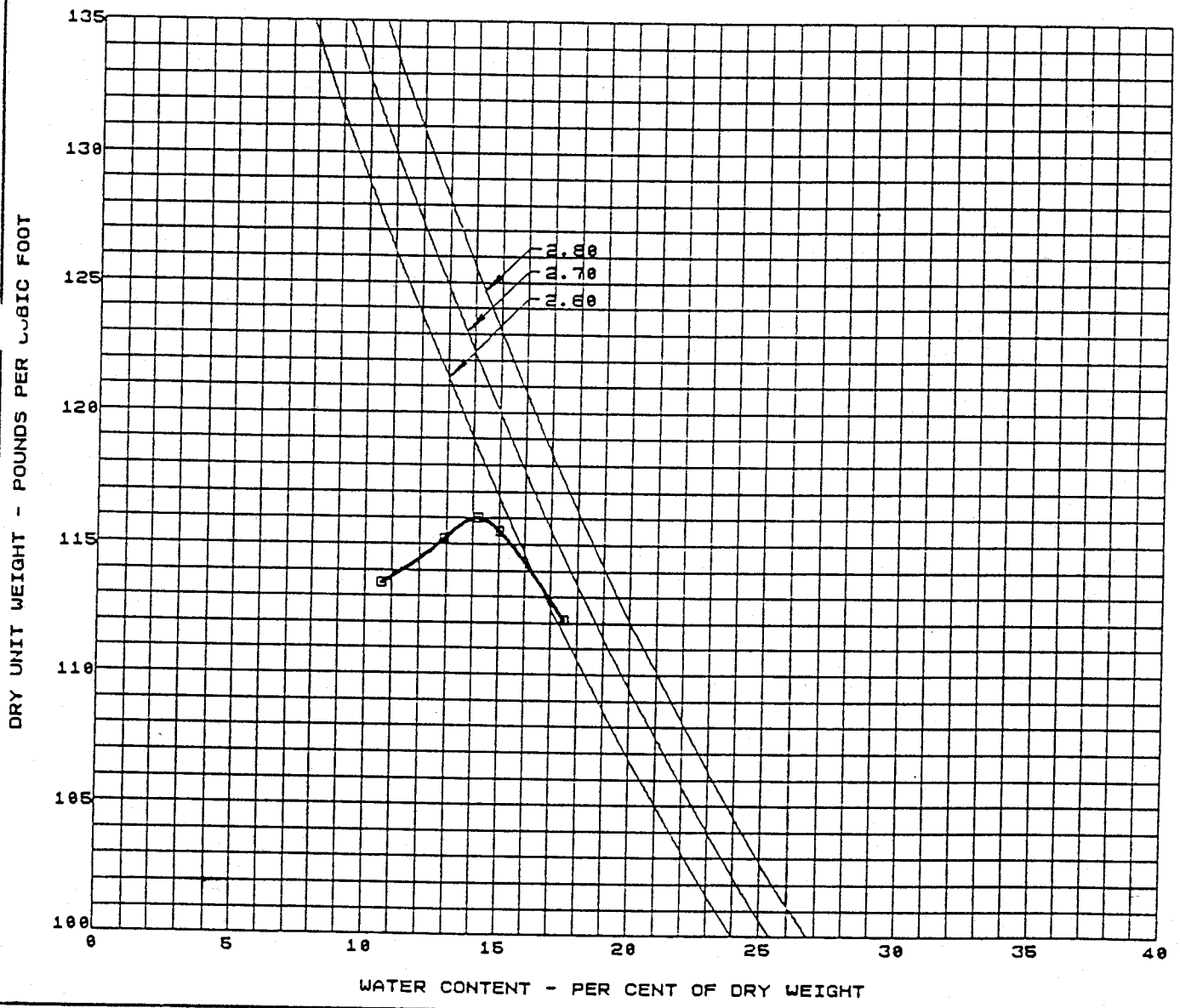
COMPACTION TEST

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
LAB NO. 9844 PAGE 1
BORING NO. B-111
SAMPLE NO.

PROJECT Haywood Co.Law Engr.#1130014201 DEPTH 0.0'- 10.0'
LOCATION SOIL DESCRIPTION Brown SlCl Si Sa
METHOD OF TEST ASTM D698-A TESTED BY JTM, MAO

MAXIMUM DENSITY (PCF) 116.0 OPTIMUM MOISTURE CONTENT (%) 14.2



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M. A. O'Kelley

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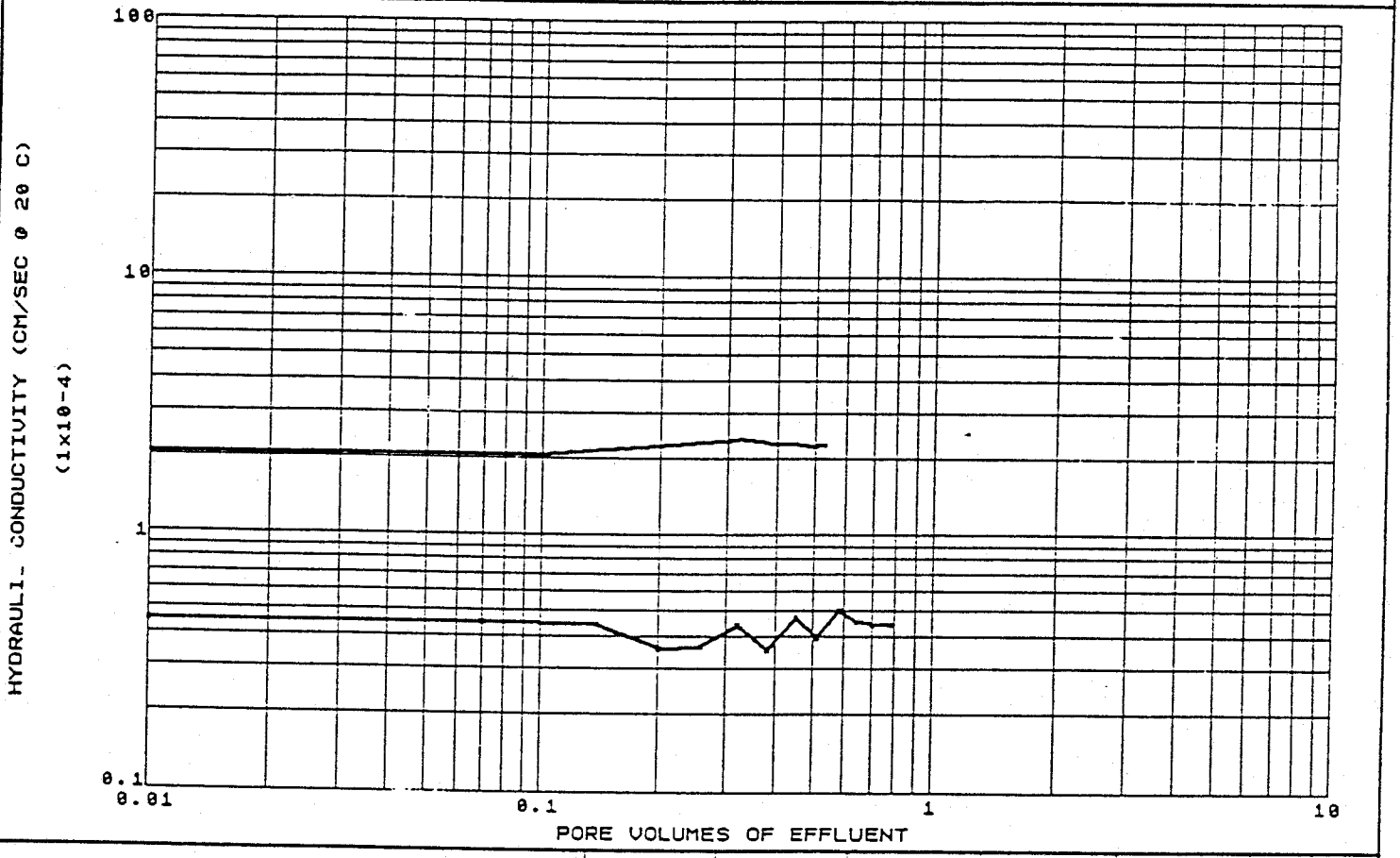
404-421-3400

HYDRAULIC CONDUCTIVITY

CLIENT Law Engineering, Inc.
396 Plasters Avenue
Atlanta, Georgia 30324

JOB NO. 41-8902.05 DATE April 10, 1990
TESTED BY JTM, MAO PAGE 1

PROJECT Haywood Co.Law Engr.#1130014201 TEST METHOD US Army Corps of Engrs. EM1110-2-1906.



LAB NO.	9836	9839				
SAMPLE IDENTIFICATION	B-103 15.0'- 17.0'	B-113 5.0'- 7.0'				
RECEIPT DATE	4/3/90	4/3/90				
TEST COMPLETION DATE	4/9/90	4/9/90				
SAMPLE TYPE	Undist	Undist				
INITIAL WATER CONTENT (% BY DRY WEIGHT)	14.5	20.9				
DRY UNIT WEIGHT (PCF)	96.7	106.5				
PERCENT COMPACTION IF REMOLDED	N/A	N/A				
ONE PORE VOLUME (CC)	131	94				
HYDRAULIC CONDUCTIVITY (CM/SEC @ 20 C)	2.3E-04	4.4E-05				

LAW ENVIRONMENTAL, INC.
M.A. O'Kelley

F&R File No. P-70-613
Report No. 1

LABORATORY TEST RESULTS

CLASSIFICATION TESTING

Sample No.	Depth ft.	Nat. W%	Limits LL	Limits PI	Sieve #4	Sieve #10	(% finer) #40	(% finer) #200	Classification
B-5	9-14	17.6	34	NP	99.0	95.6	74.4	55.1	ML
B-6	1.5-10	14.3	34	NP	99.7	94.7	76.9	46.5	SM
B-7A	0-10	13.5	29	NP	98.0	94.3	74.4	48.7	SM
B-7B	15-25	20.0	49	NP	100.0	98.5	94.9	83.0	ML

PERMEABILITY RESULTS

SAMPLE NO. Boring B-5, 9-14' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH (cm): 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1900.5

Moist.: 20.6% DRY DENSITY (pcf): 104.3 COMP.: 98.2

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	10,440	5.5	3.0	$3.6 * 10^{-7}$
2	21	4,500	4.1	5.0	$3.7 * 10^{-7}$
3	21	3,720	3.5	5.0	$3.8 * 10^{-7}$
				k (ave)=	$3.7 * 10^{-7}$

F&R File No. P-70-613
Report No. 1

PERMEABILITY RESULTS (Cont.)

SAMPLE NO. Boring B-6, 9-14' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1896.0

Moist.: 19.9% DRY DENSITY (pcf): 104.6 COMP.: 94.9%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	28,140	13.2	3.0	$3.2 * 10^{-7}$
2	20	5,700	2.2	3.0	$2.6 * 10^{-7}$
3	20	52,920	21.6	5.0	$2.8 * 10^{-7}$
				k (ave)=	$2.9 * 10^{-7}$

SAMPLE NO. Boring B-7A, 0-10' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1918.7

Moist.: 20.7% DRY DENSITY (pcf): 105.4 COMP.: 100.5%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	10,380	7.7	3.0	$5.0 * 10^{-7}$
2	21	1,481	1.8	5.0	$5.0 * 10^{-7}$
3	21	3,240	4.2	5.0	$5.3 * 10^{-7}$
				k (ave)=	$5.1 * 10^{-7}$

F&R File No. P-70-613
Report No. 1

PERMEABILITY RESULTS (Cont.)

SAMPLE NO. Boring B-7B, 15-25' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.62

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1859.7

Moist.: 23.8% DRY DENSITY (pcf): 99.4 COMP.: 97.9%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	22,260	15.6	3.0	$3.8 * 10^{-7}$
2	20	5,820	3.3	3.0	$3.9 * 10^{-7}$
3	20	53,040	27.4	3.0	$3.5 * 10^{-7}$
				k (ave)=	$3.7 * 10^{-7}$

GROUND-WATER VELOCITY CALCULATIONS
PROPOSED HAYWOOD COUNTY LANDFILL SITE
Law Engineering Project Number 57400142.01

Darcy's
Formula: $V = k\,i\,/\,n_e$

Where V = flow velocity in centimeters per second
k = permeability in centimeters per second
i = hydraulic gradient (ft/ft)
n_e = effective porosity

Calculations

Location	Head Drop	Distance	Permeability	Effective Porosity	Velocity cm/sec	Velocity ft/year
Central Area	120 ft	550 ft	2.0×10^{-4}	.25	0.0002	180
Eastern Saddle	60 ft	390 ft	2.0×10^{-4}	.25	0.0001	130

SPRING FLOW CALCULATIONS
PROPOSED HAYWOOD COUNTY LANDFILL
Law Engineering Project Number 57400142.01

Measurement Device: 90° V-notch Weir

Formula: $Q = 2.50\ H^{2.50}$

Where Q = quantity of flow in cubic feet per second
H = height of rise in feet

Test Location	Height of Rise	Q (cfs)	Q (gal/min)
WP-1	0.1875 ft	0.0381	17.1
WP-2	0.1583 ft	0.0249	11.2
WP-3	0.1250 ft	0.0138	6.2
WP-4	0.1250 ft	0.0138	6.2
WP-5	0.1458 ft	0.0203	9.1
WP-6	0.2083 ft	0.0495	22.2

Johanna Wood and
Mary Henigbaum

SURVEY OF WHITE OAK RESIDENTS

October 9, 1989

1. White house with gate on Steven's Creek (last house in 2 mile radius). Did not leave info. Neighbors said no one living there.

2. Brown house with plastic steer in yard. Left info.

3. Trailer at church. Left info.

4. Tommie Conard, Rt. 4, Box 214, Waynesville 28786
Rowe (sp?) Ledford owned property. Bill Davis bought it.
Community will have another meeting about the landfill.
Leatherwood property at entrance.
White Oak Road a problem in winter.
Water - spring
No cattle.

5. Betty McMahan, Rt. 4, Box 204E
Water - well
No cattle

6. ~~Brick house south of McMahan's~~
~~Left info.~~

6 ~~5~~. Charles Teague, Rt. 4, Box 204C
Wonders if site is best one for landfill.
Raised here and know property.
Crabtree site already approved.
Will have to haul dirt, there are rocks at site.
Would not mind if it's the best spot.
Water - well
No cattle

7 ~~6~~. William Lee Teague, Rt. 4, Box 204B
Brick house.
Brother of Charles.
Left info.
Water - well
Has horse that drinks from stream.

8 ~~7~~. Georgia E. Teague, Rt. 4, Box 204A
Mother of Charles & William
Left info with Charles
Water - spring
No cattle

Oct. 9 (cont.)

9 ~~10~~. George Michal, Rt. 4, Box 203A
Water - spring
No cattle

10 ~~11~~. Joyce Jaynes, Rt. 4, Box 203
Hikes all over, and knows Bill Davis property.
Says beautiful country, lots of deer and wild flowers.
Asked if found unusual wild flowers and she mentioned yellow lady slippers.
Wanted to know if will leave trees around landfill.
Will it be visible from I-40?
Mentioned ugly clearcutting on Dick's Trail.
Water - spring
No cattle

11 ~~12~~. House down by creek with the elaborate turnaround.
Rt. 4, Box 201
Left info

12 ~~13~~. House by pond, up drive without mail boxes.
Left info

13 ~~14~~. Second house on same drive as above
Did not leave info

14 ~~15~~. Richard Woody, Rt. 4, Box 200A
Water - well
Has chickens, no cattle

15 ~~16~~. Odie Fish, Rt. 4, Box 200
Rowe (sp?) Ledford owned property.
Thinks cannot have entrance road at site as planned.
The government owns to the guardrail.
Thinks the government will not give access.
Suggestion: condemn enough property in each township to have a landfill for each.
Mr. Fish used to work for ASCS.
He says the government holds 2000 foot access to the Park Road.
He says there is a lot of rock at site.
Water - spring
No cattle

Oct. 9 (cont.)

16 ~~17~~. Brian E. Bennett, Rt. 4, Box 200AA
Left info

17 ~~18~~. Henry A. Davis, Rt. 4,
Mobile home #1918
Left info

18 ~~19~~. Raphael Strivelli, Rt. 4, Box 196 (?)
Rainbow Builders 627-8460
Did not leave info
House occupied?

19 ~~20~~. H. E. Sler, Rt. 4, Box 197
WHITE OAK STUDIO
Left info

~~20 21~~. Wayne Bramlett, Rt. 4, Box 196 (?)
Mr. Bramlett is 85.
Small house without electricity or water.
He carries water from spring 1/4 mile down road which is present entrance to Bill Davis property.
He also uses rain water.
We found him working on his wood pile.
He did not voice any concerns about the landfill, but did comment on the Champion-Tennessee problem and the hurricane.
His neighbor, Mrs. Thomas, said people bring him wood and food.

21 ~~22~~. Mrs. I. E. Thomas, Rt. 4, Box 193
Mrs. Thomas (and Mrs. Mitchell Phillips) are organizing the community to protest the landfill site.
She said the county has no permission to build the entrance road as planned.
Concerned about noise, odor, rats and mosquitoes.
Concerned about where the money will come from to carry out all the measures that must be taken.
Bramletts own a lot of property in area.
For the Park Road, the government tore down Bramlett's house.
The county should not take property.
The county should use what people offer - like Redmond's.

Oct. 9 (cont)

Mrs. Thomas (cont.)

Messer permit? (Property in Crabtree approved)
Leatherwood property is solid rock, according to Larry Jones in the White Oak Development.
Why add seepage to the Pigeon?
People will be able to see the landfill from the interstate.
It will be bad for visitors from Tennessee.
She has stood at the top of the Davis property and can see the interstate.
Trucks that cannot get into the landfill will dump on the White Oak road.
If the gate is closed and there is no guard, they will just dump.
She is concerned about Wayne Bramlett's spring being contaminated.
Water - well
No cattle

October 10, 1989

22. Tim Gann, Rt. 4, Box 191
Concerns - rats in winter, White Oak Road not adequate.
Would prefer that the county require recycling or have a high temperature incinerator.
Water - spring
Has pony that drinks from pond.
Has pond and eat fish from pond.

23. First log house after Gann
Left info.

24. Small house on spit of land
Left info

25. Jack R. Martin
Telephone wire down
Left info.

26. Catherine Gardner, Rt. 4, Box 190A
Solid rock at entrance site.
Concerned about cost of transfer and covering trash.
Two creeks through property.
Not enough soil, area soil is shallow to rock.
Most people in subdivision are on wells.
Davis bought land on purpose to sell as landfill.
Water - well.
No cattle.

27. Sue Justice, Rt. 4, Box 193
Water - spring
Chickens drink spring water

28. Andy Presnell, Rt. 4, Box 194
Last house on road by river.
Old home place on rock outcrop.
Husband in accident.
Water - well
Cattle are watered from well

OCTOBER 11, 1989

29. Hugh Williams, Rt. 4, Box 186A
Aware of community meetings.
Sees no problem with landfill.
Water - well
No cattle

30. Kelly Williams, Rt. 4, Box 186B
Left info
Water - spring
Cattle drink from spring

Oct. 11 (cont.)

31. Mrs. W. T. Williams, Rt. 4, Box 186
Left info
Water - spring
No cattle

32. Doris Audrey Ringer, Rt. 4, Box 186C
Left info with mother, Gladys Daly
Water - well
No cattle

33. Gladys Daly, Rt. 4, Box 186D
Double wide mobile home on Ringer property
Share well with daughter above.

34. R. W. Miner, Rt. 4, Box 187A
Left info

35. Tetrault, Rt. 4, Box 187
Remodeled large house with gate.
Left info
Lance said owners from NY.
Old Rob Davis house.

Oct. 11 (cont.)

36. Johnnie Lee, Jr. and
Nellie Lance, Rt. 4, Box 189
Lots of rock on site.
Solid rock going in.
Site will be seen from I-40.
Panther Creek better place.
Lance looked after cattle on Ledford's and Bramlett's property.
Site has yellow lady slippers, showy orchis and red and white trillium.
PLEASE LET PEOPLE COME IN AND GET WILD FLOWERS TO TRANSPLANT BEFORE SITE IS DISTURBED.
Site has red and gray foxes, coon and deer which come across river from Wilkins Creek.
There are three branches on the site.
Steep pasture.
Hope to keep trees around the site.
The government did not allow Bramlett to cross the right of way for the Park Road.
SUGGESTION: (Mary's) SHARE BIO SURVEY WITH COMMUNITY.
Aware of meeting on Oct. 13 with county officials.
Concerned that it is a long way to haul trash.
Mentioned a property owner with 119 acres and a house in the center the community calls "Rambo".

Johanna Wood

SURVEY OF WHITE OAK RESIDENTS

October 12, 1989

1. Lee. J. Ferguson, Rt. 3 Clyde, NC
   Water - spring
   Bernard Ferguson has cattle on this property that are watered by a stream.

2. Log house. Left info. in door.

3. Log house on hill above the last house. Left info in door.

4. Edward T. Rathbone, Rt. 3 Box 230-B, Clyde.
   Water - well.

5. Rock house with beige siding. Appeared to be empty, but I left info in door.

6. Mrs. David Nolan, Rt. 3 box 215, Clyde.
   Action should have been taken sooner.
   Water - well.
   Cattle (they operate a dairy) - well.

7. White two-story house across from the dairy. Left info. in door.

8. Mr. Billy McElroy, Rt. 3 Box 212, Clyde.
   David Nolan has cattle in pasture on hill behind the McElroy home.
   Water - well.

9. White house with black shudders. Left info. in door. Two mailboxes with Forbes and Bobby G. Rathbone

10. Mr. Weaver E. Ledford, Rt. 3 Box 206, Clyde
    Water - spring.

11. Ernest Russell, Rt. 3 Box 204, Clyde
    Water - well.

12. White house with Russell on the house. Left info. in door. Had talked with their daughter-in-law at the last house. The two families use the same well as their water source.

13. Louise Hubbard, Rt. 3 Box 205, Clyde.
    Water - spring.

14. Dennis Rathbone, Rt. 3 Box 194, Clyde.
    Water - well.

15. Green and white trailer on the hill. Left info in door.

16. Brown trailer. Left info. in door.

17. Brown double wide trailer. Left info in door.

18. Jim & Bobby Greene, Rt. 3 Box 192, Clyde.
    Water - well.

* For 15 - 18. There were four mailboxes at the road leading into the area where I found the last four homes. The names on the mailboxes

were: R. D. Summey Box 193-B; Tom, Sandy, Brian Beasley Box 193-C;James Greene; the fourth mailbox did not have a name on it.

19. Earl Henson, 15 Valley St. Canton
This gentleman was camping along Fines Creek Road.
He gets his water from Jack Ferguson.
He felt the White Oak site was a better site for the landfill than the Panther Creek site.

October 13, 1989

1. Log house with rock entrance. The first road to the left after going into Shelton Laurel. Left info in the gate.

2. Log house. Left info.

3. John Snipes, Rt. 3 Box 224, Clyde.
Will waste going into the landfill be just from Haywood County or will waste be brought in from other counties and other states?
Water - well.
His well is tested every yar and is always good. He doesn't want anyone bothering his well. He said he came home one day and found a man pulling insulation off his well and starting to drop some kind of pills down into his well. When I asked him about whether or not he had cattle he said he would not answer any more durn questions until he had looked at the information I gave him.

4. White trailer - green sticker #3510. Sign at the driveway entrance that said Jim Henry's. Left info in door.

5. White trailer with old truck. 1989 Mobile Home Sticker #220. Left infor in the door.

6. White house at the mission. Left info in the door.

7. Blue house at the mission. Left info in door.

8. Grey house behind the mission to the left of the cemetery. Left info in the door.

* Names on mailboxes at the mission: James P. Henry; James F. Doyle; J. L. Frese & S. G. Wilburn

9. Glen Inman, Rt. 3 Box 227-A, Clyde.
Water - well.
Has horses that are watered by stream in the pasture.

10. Wilbur Teague, Rt. 3 Clyde.
How many years can the landfill operate at the White Oak location?
Water - well.
Cattle - watered by a branch.

11. Hugh Rogers' house. Left info in the door.

12. Mike Mehaffey, Rt. 3 Box 222, Clyde
Water - well.
Cattle - watered by a branch.

13. Bertha Moody, Rt. 3 Box 221, Clyde
Water - well.

14. Log house with Gratton's on the house. Left info in the door.

15. Jack Redmond, Rt. 3 Box 218, Clyde
Is property for landfill being condemned?
Water - well & spring.
Sheep - water from branch.

16. Jerry Trivette, Rt. 3 Box 219-B, Clyde
Water - spring.

17. Beige trailer to the left of Trivette. Box 192. Left info in the door.

18. Albert Beasley, Rt. 3 Box 220, Clyde
Water - spring.

19. Fannie Ledford, Rt. 3 Box 219, Clyde
Water - well. She shares with Wilburn Sutton. I gave Mrs. Ledford my last information, so I asked her to share it with other family members living close to her. She gave me information about the water source for family members I did not talk with. Milas Ledford has a well. Lizzie Sutton has a well.

October 16, 1989

1. Irene Norton, Rt. 3 Box 234, Clyde
Will the Panther Creek Road be used for hauling waste to the landfill?
Water - spring.

2. Francis E. Morton, Rt. 3 Box 235-A, Clyde
Blue and white moble home. I left info in the door. I got his name and mailing address from his sister-in-law who lived at the next house I visited.

3. Mr. & Mrs. Water Morton, Rt. 3 Box 235-A, Clyde (Panther Creek Rd.)
Will the landfill be visible from the house? Mrs. Morton took me to the upper deck of the house to try to see if the landfill would be visible from their upper deck. I could not tell much at that time. The bridge crossing the Pigeon going into White Oak is visible from the upper deck. I suggested Mrs. Morton take the map to the proposed sight for the landfill, pick out a landmark and go back to their deck to try to determine if the landfill would be visible from their house.
Other questions: She wanted to know about smell from the landfill. She is also concerned about traffic to the landfill, she is concerned about school buses and the large hauling trucks being on the road together, particularly in bad weather.
Water - well. No cattle.

4. James A. Morton, Rt. 3 Box 235-A, Clyde.
This is the son of Mrs. Morton whose remarks are listed in #3. James Morton was not at home, so I left the information for him with his mother.
Water - well. No cattle.

5. Green house on main road to the left of the road to the Morton's. Left info in the door.

6. House to the right of road to the Morton's. Mailbox had John Rathbone. Left info in door.

7. Brown house sitting back off the main road. Left info in the door.

8. Mobile home with mailbox that had the Greene's on it. Did not leave information.

9. House up behind mobile home. Mailbox with John Russell Box 236. Left info in the door.

10. Geraldine Parking Rt. 3 Box 239, Clyde
Water - spring.
Cattle - (The Parkins' have a dairy.) watered by a spring and some from a branch.

11. Cathy Parkins, Rt. 3 June Rd., Clyde
Will the landfill affect the water? Mrs. Parkins had heard that the landfill could cause the spread of diseases through the water. She was concerned about this.
Water - well.

12. Brown house above the Parkins dairy. The sign said "Walnut Grove Farm". I left info in the door.

13. Brick house with James W. Parkins on the mailbox. I left info in the door.

14. Rev. Bill Turner, Rt. 3 Box 240-A, Clyde.
Water - well.

15. Mobile home located next door to the home of James Parkins. Moble home 1989 license #2762. Left info in the door.

16. House with Box 245. Did not leave material. Met dog in the yard acting very aggressive and dragging the chain he had been chained with.

17. House with Parkins Box 244 on the mailbox. House appeared vacant so I did not leave info. Another neighbor told me this house was vacant.

18. Earl Bradley, Rt. 3 Box 243, Clyde
Water - well. No cattle.

19. Brickhouse up above Earl Bradley. Did not leave info.

*There were several houses located on down the dirt road past the home of Earl Bradley, I was not sure about whether or not I should go to these houses, so I did not go at that time. If these houses should be surveyed, please let me know.

SUMMARY OF GEOLOGIC OBSERVATIONS AT THE PROPOSED WHITE OAK LANDFILL SITE HAYWOOD COUNTY, NORTH CAROLINA

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Prepared December 10-11, 1989

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Introduction

The proposed White Oak landfill site is located some 2000 ft southwest of the Pines Creek exit on the south side of Interstate Highway 40 in Haywood County, North Carolina. The site and nearby exposures were visited by Dr. Hatcher and Dr. John R. Tabor, Post-Doctoral Research Associate in structural geology (working with Professor Hatcher), on December 6, 1989, at the request of local resident Mrs. Nancy Hoffman. Approximately 5 hours were spent in the proposed site area, with the majority of the time (3.5 to 4 hours) spent walking over the proposed site, making observations and recording measurements of geologic structures and the character of the bedrock exposed in the proposed site. The goal of spending this time here was to make observations of bedrock and surficial geology that might bear on the quality of the proposed site as a long-term (20 to 30 year) site for disposal of municipal (mostly household) solid waste.

It is assumed that the landfill, if constructed, will be built and maintained at least cost and will meet the minimum standards defined by county, state, and EPA regulations. It is also assumed that regardless of whatever care will be exercised in construction and day-to-day operation and maintenance of the landfill, total isolation of the waste materials placed in the landfill will not be accomplished, and that there will be some leakage into the impounded Pigeon River (Walters Reservoir). It is therefore assumed that the landfill will contribute leachate to Walters Lake and the ground water system in the area.

Nontechnical Summary

The bedrock unit underlying the proposed landfill consists of coarse- to very coarse-grained foliated granitic gneiss (metamorphosed granite) cut by veins of pegmatite and quartz. Some fault rock (mylonitic gneiss formed by ductile faulting – clearly premetamorphic) was observed at one locality. These observations of bedrock type in the proposed site reconfirm the high quality of geologic mapping of Hadley and Goldsmith (1963) in this area.

Rocks exposed within the proposed site generally contain relatively few joints (average spacing one to five feet or more), except locally. Rocks along the principal flowing stream in the proposed site are more intensely fractured (spacing of one to two inches) and the drainage of this stream, like most in the crystalline southern Appalachians, appears to be controlled by the bedrock fracture system. The NW-SE orientation of the valleys in the proposed site area is parallel to one of the major regional fracture sets in the southern Appalachian region. Fresh bedrock exposures are most likely to be present because the rock mass contains fewer fracutures and weathers more slowly. Consequently, a trenching and drilling program would be needed to properly assess the spacing and intensity of fractures present in the proposed site.

The ground water system in this region (entire crystalline southern Appalachians – the Blue Ridge and Piedmont – along with the Valley and Ridge of Alabama, Georgia, Tennessee, and Virginia) is located in fractures in bedrock, except locally where it may occur in surficial deposits (floodplain alluvium, soils, and colluvium). Despite opinions to the contrary, there are no "underground streams" in the crystalline rocks, except very locally where limestone or dolomite (or metamorphic equivalent marbles) may occur. Limestone and dolomite are rare in the Blue Ridge and Piedmont. Ground water in the Blue Ridge and Piedmont does not travel for great distances (generally less than one mile) once it enters the ground water reservoir. Open fractures (commonly joints but also brittle faults) that permit surface water to carry contaminants into the ground water system will create problems within a relatively short distance of the point of entry of the contaminant into the ground water.

Geologic Observations

The area that will be directly affected by the proposed landfill ranges in elevation from ~ 2300 ft on Walters Reservoir to >2680 ft along the crests of the divides in the proposed site (Fig. 1; TVA/USGS, 1967). Slopes here range from gentle to steep, and the proposed site is drained by several small intermittent to permanent streams that originate within the proposed site.

Slopes are mostly covered by residual soils, and small amounts of alluvium occur in the valleys. Soil thickness ranges from 0 to an estimated 50 to 70 feet, based on observed depth of westhering in nearby road and stream cuts. Exposures of fresh bedrock are sparse, but sufficient, along with several exposures of saprolite, to confirm the nature of bedrock in the proposed landfill.

The bedrock unit underlying the proposed landfill consists of coarse- to very coarse-grained strongly foliated and lineated to moderately foliated granitic orthogneiss composed of feldspar-quartz-biotite gneiss cut by veins of pegmatite and quartz. Some amphibole-bearing gneiss was observed at one locality (#7 along Walters Lake, Fig. 1), and mylonitic orthogneiss (clearly premetamorphic mylonite) was observed at one locality (#6, Fig. 1). These observations of bedrock type in the proposed site reconfirm the high quality of geologic mapping of Hadley and Goldsmith (1963) in this area.

Rocks within the proposed site generally contain relatively few joints (average spacing one to five feet or more), except locally. Rocks along the principal flowing stream in the proposed site are more intensely fractured (spacing of one to two inches) and the drainage of this stream, like most in the crystalline southern Appalachians, appears to be controlled by the bedrock fracture system. The NW-SE orientation of the valleys in the proposed site area is parallel to one of the major regional fracture sets in the southern Appalachian region. Fresh bedrock exposures are most likely to be present because the rock mass contains fewer fracutures and weathers more slowly. Consequently, a trenching and drilling program would be needed to properly assess the spacing and intensity of fractures present in the proposed site.

The dominant foliation here is defined by the parallel orientation of platy minerals, principally biotite, with quartz and feldspars flattened into the foliation. It has a somewhat variable orientation, and numerous folds were observed in some exposures within the proposed site in which axial surfaces are parallel to the dominant foliation. As the bedrock weathers, the foliation may open and become a fracture surface along which ground water may flow.

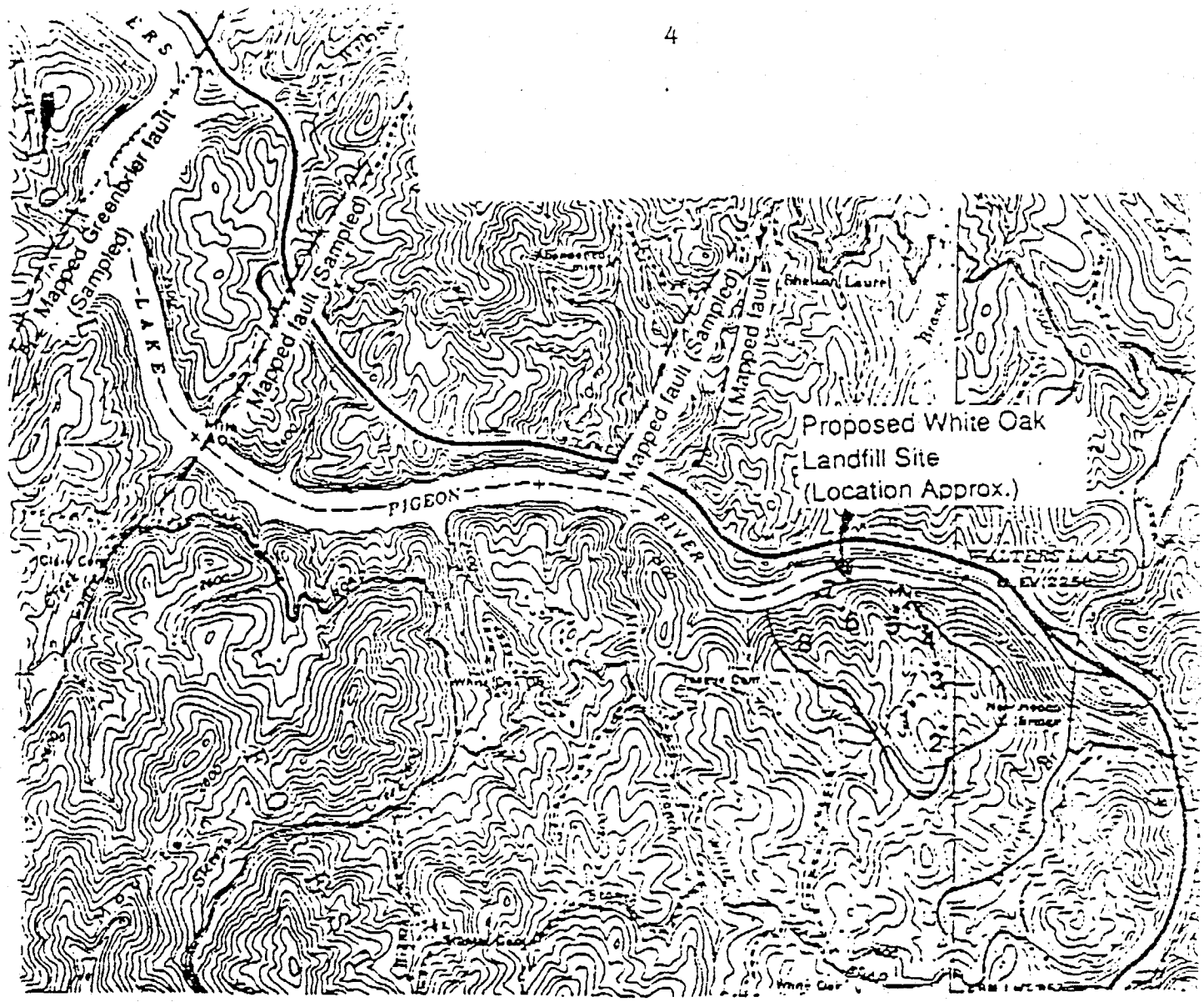

Figure 1. Topographic map of the proposed White Oak landfill site (from TVA/USGS, 1967) showing the locations of measurements and observations of bedrock exposures, along with measurements of geologic structures at numbered points. 1 – Strongly foliated feldspar-quartz-biotite gneiss. Rocks are strongly isoclinally folded with fold axial surfaces parallel to the dominant foliation. Foliation N11E/36SE. Unfilled joints N68W/69SW, N67E/75NW. Fracture density is low (2-3 ft spacing) 2 – Massive, coarse grained feldspar-quartz-biotite orthogneiss. Foliation N59E/32SE. Unfilled joint N61E/32NW. 3 – Massive, exfoliated coarse-grained feldspar-quartz-biotite orthogneiss. Garnet and orthopyroxene metacrysts up to 0.5 cm in some parts of exposure, oriented parallel to compositional banding. Almost no fractures. Joint spacing 20-30 ft. Unfilled joints N32E/79NW, N56W/77SW. 4 – Strongly foliated and lineated feldspar-quartz-biotite orthogneiss. Foliation N9E/32SE. Unfilled joints (spacing 0.5-1 ft) N45E/76NW, N70E/80SE. 5 – Strongly fractured feldspar-quartz-biotite orthogneiss. Foliation N67E/32SE. Dominant closely spaced (1 in to 3 in) fracture set (N38W/77NW) approximately parallel to valley orientation. 6 – Medium-grained annealed mylonite derived from feldspar-quartz-biotite orthogneiss. No measurements taken because is a large block, probably locally derived (within <100 ft of present location), but appears out of place. 7 – Strongly foliated feldspar-quartz-amphibole gneiss along Walters Lake. Foliation N66E/22SE. Unfilled joint N40W/69W. 8 – Large cliff exposure of coarse-grained feldspar-quartz-biotite orthogneiss. Rock mass is moderately fractured, with a zone of intense fracturing (spacing <1-2 in) in part of the exposure. Foliation N33E/24SE. Unfilled joints N53W/86NE, N41W/81NE, N47W/68SW, N23E/vertical, N43E/vertical.

Medium-grained mylonitic orthogneiss occurs in a block that is probably a few feet out of place at one locality (#6, Fig. 1). This mylonite is clearly premetamorphic, but indicates the presence of a ductile shear zone or premetamorphic fault of unknown dimensions, geometry, or extent in the proposed site. This fault rock was not sampled and sectioned for microscopic study, but consists of massive, strongly foliated, annealed mylonite, easily determined from field observations. There is no indication of any reactivation along this fault from the limited exposure available.

Samples were collected from other mapped fault zones located along I-40 3000, 8000, and 11,000 feet respectively northwest of the western edge of the proposed site. All of these faults would cross Walters Lake on the Pigeon River, and microscopic examination of samples from all three of these faults reveals that all are postmetamorphic faults, but all contain mylonite: no brittle fault rocks (gouge, breccia, other cataclasites) were observed.. Ironically, the fault crossing I-40 some 11,000 feet NW of the proposed site is the Greenbrier fault, almost universally recognized by all who have studied it and related faults nearby like the Hayesville (Hadley and Goldsmith, 1963; King, 1964; Hatcher, 1978, 1987) as the type premetamorphic fault in the southern Appalahcians. At this locality, the trace of the Greenbrier fault was mapped by Hadley and Goldsmith (1963) and correctly located during our brief time in the field. The fault here was locally reactivated forming a retrograde assemblage of muscovite, chlorite, and other minerals, and sulfides (principally pyrrhotite) were deposited in the fault zone. This fault zone is very easy to locate because of the occurrence of iron-oxide stain on the road cut. The other fault zones to the southeast are easy to recognize because of the strong contrast between the character of bedrock and mylonite in the fault zones. The mylonite contains abundant shear-sense indicators (rotated porphyroclasts, S-C fabrics, mica fish) and new retrograde minerals (muscovite, chlorite) that, together with microtextures, are indicative of a postmetamorphic movement history.

fracture porosity/permeability, except for that occurring in surficial materials (soils, alluvium, colluvium). Fractures generally are closed below depths of approximately 200 ft, except for a few isolated throughgoing fractures that may propagate ground water to much greater depth. Generally speaking, most ground water in wells is derived from within 200 ft of the surface and involves surface (meteoric) recharge of the fracture system over periods of a few weeks to months to several years, depending on the interconnected nature of the fracture system and how well it is connected to the surface. Faults can play a major or minor role in ground water distribution because they are isolated fracture planes that may either impede flow or serve as conduits. They may also create additional fracture porosity near the fault plane. Because of the limited time available, no attempt was made to ascertain if the faults observed (except for the Greenbrier) are aquicludes or conduits for ground water flow. The Greenbrier fault is obviously locally a conduit for flow where exposed in I-40.

In conclusion, while I was not informed of the criteria for siting this landfill, I would not have chosen this site because leakage and leachate will accumulate in a nearby standing body of water, thereby increasing the chances of contamination of the local ground water.

References Cited

Hadley, J. B., and Goldsmith, R., 1963, Geology of the eastern Great Smoky Mountains, and North Carolina and Tennessesee: U. S. Geological Survey Professional Paper 349-B, 118 p.

Hatcher, R. D., Jr., 1978, Tectonics of the western Piedmont and Blue Ridge, southern Appalachians: Review and speculation: American Journal of Science, v. 278, p. 276-304.

Hatcher, R. D., Jr., 1987, Tectonics of the southern and central Appalachian internides: Annual Review of Earth and Planetary Sciences, v. 15, p. 337-362.

King, P. B., 1964, Geology of the central Great Smoky Mountains, Tennessee: U. S. Geological Survey Professional Paper 349-C, 148 p.

Tennessee Valley Authority/U. S. Geological Survey. 1967. Cove Creek 7 1/2 minute quadrangle, scale 1/24,000.

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December 8, 1980

Haywood County Board of Commissioners
c/o Jensen Engineering
Post Office Box 1818
Asheville, North Carolina 28814

Attention: Mr. George Jensen, P.E.

Re: Preliminary Subsurface Exploration
Proposed Haywood County Landfill
White Oak Township
Haywood County, North Carolina
F&R File No. P-70-613
Report No. 1

Gentlemen:

Froehling and Robertson, Inc has performed the preliminary subsurface exploration for the referenced project as authorized verbally by Mr. Ralph Owens of Jensen Engineering and we are submitting our findings herein. The exploration was performed to evaluate subsurface conditions as they pertain to site evaluation and the design and construction of the proposed landfill facilities. This report presents a brief description of our understanding of the project, the information obtained in the subsurface exploration and our conclusions and recommendations.

PROJECT DESCRIPTION

We have discussed the project with the Mr. George Jensen of Jensen Engineering and have been furnished site boundary plan showing the survey locations prepared by Gibson Land Surveying. We understand that the project is in the conceptual stages and specific details regarding site design have not been completed.

SUBSURFACE EXPLORATION

The subsurface exploration included the performance of eight soil test borings and eleven auger probe borings at locations selected by representatives of Jensen Engineering. The boring locations were established in the field by a representative of Jensen Engineering and the approximate boring locations are presented on a plan in the Appendix. The Appendix also contains Test Boring Records presenting the information obtained in the subsurface exploration, a key to the terms used in the Test Boring Records, and a brief description of the boring procedures used. The borings were drilled with a CME 55 truck mounted drill rig and were advanced using a 6-inch hollow stem auger. Soil specimens were obtained by standard split spoon and by bulk methods.

LABORATORY TESTS

Laboratory test included the performance of classification test (ASTM D-4318, D-421, D-2487), Standard Proctor moisture-density (ASTM D-698), and permeability of remolded specimens. The tests were performed on four separate bulk soils specimens obtained in the field from the auger spoils as directed by personnel from

Jensen Engineering. Results of the laboratory tests and descriptions of the test procedures are presented in the appendix of this report.

SITE DESCRIPTION AND SUBSURFACE CONDITIONS

The site of the proposed landfill is located near Hepco in White Oak Township in Haywood County, North Carolina. The site covers an area of approximately 108.9 acres south of Waterville Lake. At the time the soil test borings were made, the site was open pasture land bordered by forest. The site consists of gently rolling hills and shallow hollows. The site lies within the Blue Ridge Belt of the Blue Ridge Physiographic Province of North Carolina. The rocks underlying this area are of sedimentary and igneous origin but have been profoundly altered by the high heat and pressure associated with deep burial and tectonic movements which have affected them since their formation in late Precambrian time. The rocks most commonly encountered in the local area are mapped as metasediments of the Ocoee Supergroup. Chemical weathering of the rocks has produced soils which normally consist of silt with variable amounts of fine sand, and minor amounts of clay and fine mica.

Weathering of the bedrock may be accelerated by the presence of joints, fractures, or zones of easily weathered minerals in the rock. For this reason, the upper surface of the rock may be irregular and isolated boulders, pinnacles, and ledges composed of the more resistant materials may be encountered above the general soil/rock contact.

In some areas, the natural surface soils may consist of alluvium which has been formed by the deposition of water borne sediments on flood plains or in stream channels. The alluvial soils may consist of organic material, boulders, gravel, sand, clay, or

silt, either singly or in any combination. Because these materials have been deposited from either flowing or quiet waters, alluvial soils may vary greatly in consistency, composition, and character in both the horizontal and vertical directions.

Moderate to very high consistency residual soils were encountered from the surface to the total depth explored in each boring. The residual soils have been formed by means of chemical weathering of the metasedimentary rocks of the Ocoee Supergroup which forms the bedrock in this portion of the Blue Ridge Physiographic Province of North Carolina. The residual soils consisted of mottled reddish brown, purple, and grey SILT which contained variable amounts of sand and traces of fine mica and of silty SAND which contained traces of fine mica. The lines on the boring logs denote color or textural changes in the residuum. However, the residual soils are laterally discontinuous with textural changes expected with short distances. The penetration resistances ("N" values) ranged from 8 blows per foot to 50 blows per 6 inches.

Laboratory classification tests performed indicated that the residual soils are relatively fine grained with 100 to 98 percent of the material fine than the U.S. No. 4 sieve and 46.5 to 83.0 percent of the material consisted of silts and clays finer than the U.S. No. 200 sieve. The liquid limits ranged from 29 to 49 and the fines are nonplastic. The soils were classified as either a ML (low plasticity silt), or a SM (silty sand) by the Unified Soil Classification System. Maximum dry density as determined by a standard Proctor ranged from 101.5 to 110.2 pounds per cubic foot with the optimum moisture contents ranging from 15.8 to 20.0 percent. Natural moisture contents ranged from 13.5 to 20 percent. Permeability tests performed on remolded specimens compacted to densities ranging from 94.9 to 101.4 percent of the individual soil specimens respective Standard Proctor maximum dry density provided averaged permeability values ranging from 2.9×10^{-7} to 5.1×10^{-7} centimeters per second. The permeabilities were determined by an average of three tests on each remolded specimen.

ROCK - Weathered bedrock was encountered in borings B-1, B-3, and B-8 and depths of 35, 26, and 35 feet, respectively. The penetration resistances ("N" values) ranged from 50 blows per six inches to 50 blow per 1 inch penetration. Unweathered rock, as defined by rock which can not be drilled with auger drilling equipment, was encountered at boring B-3 at a depth of 37 feet.

Ground Water - Ground water was not encountered at the time the soils test borings were performed and not long term ground water observations were performed.

LIMITATIONS

This report has been prepared in accordance with generally accepted soil and foundation engineering practices for the exclusive use of Haywood County Board of Commissioners and their agents in the design of the proposed Haywood County Landfill to be constructed on the south side of Waterville Lake in the White Oak Township in Haywood County, North Carolina. No other warranty, expressed or implied. is made. Our conclusions and recommendations are based upon design information furnished to us, the information obtained in the previously described subsurface exploration, and our previous experience. These conclusions and recommendations do not reflect variations in subsurface conditions which may exist between boring locations or in unexplored portions of the site. Should such variations become apparent during construction, it will be necessary to reevaluate our findings based upon on-site observation of the conditions.

In the event that changes are made in the design or location of the proposed landfill site, the recommendations presented in this report shall not be considered valid unless the changes are reviewed by our firm and the conclusions of this report modified or verified in writing. We should also be given the opportunity

to review the design, grading plans, and applicable portions of the project specifications when the design is finalized.

We recommend that this report, in its entirety, should be made available to the prospective contractors for informational purposes. The Test Boring Records should not be separated from this report.

ACKNOWLEDGMENT

Froehling and Robertson, Inc. appreciates the opportunity to work with you on this project. If there are any questions regarding the information presented in this report, please do not hesitate to contact us.

Respectfully submitted,

FROEHLING AND ROBERTSON, INC.

Richard O. Ricks, E.I.T.
Geotechnical Staff

William H. Duhling, Jr., P. E.
Geotechnical Engineer

NORTH CAROLINA PROFESSIONAL ENGINEER WILLIAM H. DUHLING, JR.

Appendix

A P P E N D I X

Laboratory Test Results

Site Plan

Test Boring Records

Proctor Test Reports

Graphs

Descriptive Terms

Procedures

F&R File No. P-70-613
Report No. 1

LABORATORY TEST RESULTS

CLASSIFICATION TESTING

Sample No.	Depth ft.	Nat. W%	Limits LL	Limits PI	Sieve #4	Sieve #10	(% finer) #40	(% finer) #200	Classification
B-5	9-14	17.6	34	NP	99.0	95.6	74.4	55.1	ML
B-6	1.5-10	14.3	34	NP	99.7	94.7	76.9	46.5	SM
B-7A	0-10	13.5	29	NP	98.0	94.3	74.4	48.7	SM
B-7B	15-25	20.0	49	NP	100.0	98.5	94.9	83.0	ML

PERMEABILITY RESULTS

SAMPLE NO. Boring B-5, 9-14' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1900.5

Moist.: 20.6% DRY DENSITY (pcf): 104.3 COMP.: 98.2

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	10,440	5.5	3.0	$3.6 * 10^{-7}$
2	21	4,500	4.1	5.0	$3.7 * 10^{-7}$
3	21	3,720	3.5	5.0	$3.8 * 10^{-7}$
				k (ave)=	$3.7 * 10^{-7}$

F&R File No. P-70-613
Report No. 1

PERMEABILITY RESULTS (Cont.)

SAMPLE NO. Boring B-6, 9-14' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1896.0

Moist.: 19.9% DRY DENSITY (pcf): 104.6 COMP.: 94.9%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	28,140	13.2	3.0	$3.2 * 10^{-7}$
2	20	5,700	2.2	3.0	$2.6 * 10^{-7}$
3	20	52,920	21.6	5.0	$2.8 * 10^{-7}$
				k (ave)=	$2.9 * 10^{-7}$

SAMPLE NO. Boring B-7A, 0-10' TYPE OF TEST: Constant Head

AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1918.7

Moist.: 20.7% DRY DENSITY (pcf): 105.4 COMP.: 100.5%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	10,380	7.7	3.0	$5.0 * 10^{-7}$
2	21	1,481	1.8	5.0	$5.0 * 10^{-7}$
3	21	3,240	4.2	5.0	$5.3 * 10^{-7}$
				k (ave)=	$5.1 * 10^{-7}$

F&R File No. P-70-613
Report No. 1

PERMEABILITY RESULTS (Cont.)

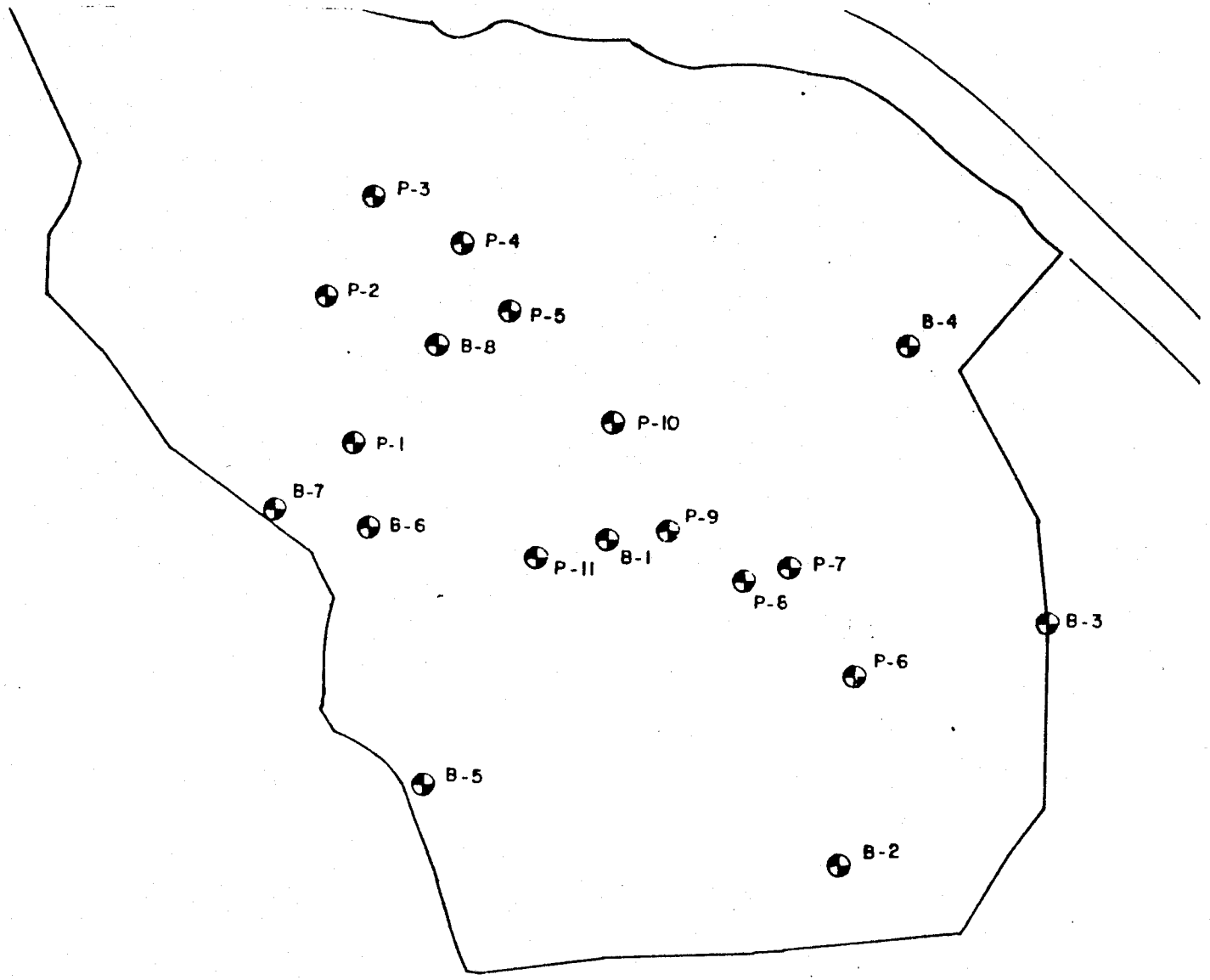
SAMPLE NO. Boring B-7B, 15-25' TYPE OF TEST: Constant Head

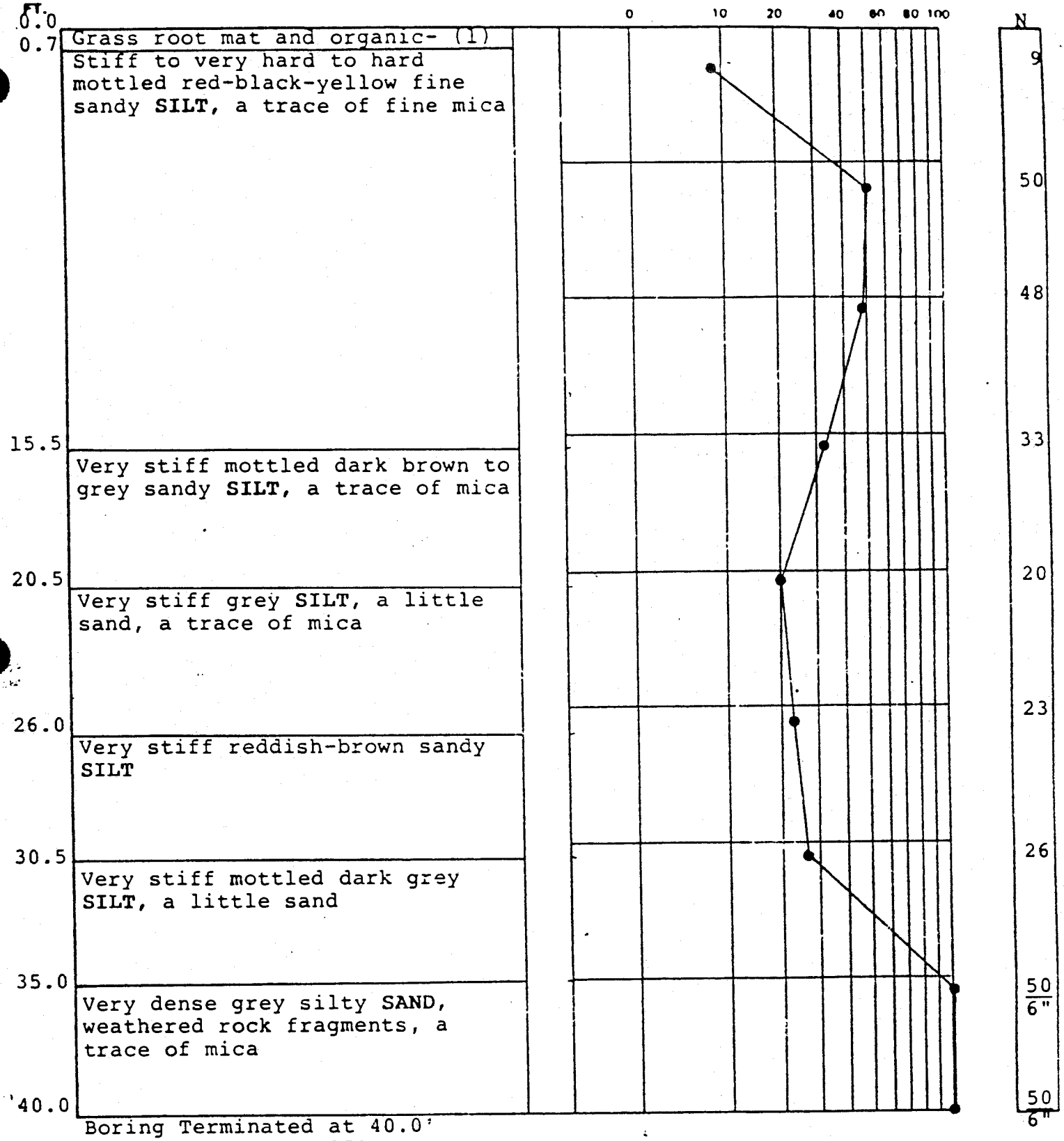
AREA (cm^2): 81.07 DIA. (cm): 10.16 LENGTH ($cm^)$: 11.63

VOL. (cm^3): 942.88 WT. OF SAMPLE (gm): 1859.7

Moist.: 23.8% DRY DENSITY (pcf): 99.4 COMP.: 97.9%

TEST No.	C^O	ELAPSE TIME (sec)	FLOW (cc)	HEAD (psi)	K (cm/sec)
1	21	22,260	15.6	3.0	$3.8 * 10^{-7}$
2	20	5,820	3.3	3.0	$3.9 * 10^{-7}$
3	20	53,040	27.4	3.0	$3.5 * 10^{-7}$
				k (ave)=	$3.7 * 10^{-7}$


P-3
P-4
P-2
P-5
B-8
B-4
P-10
P-1
B-7
B-6
P-9
P-11
B-1
P-7
P-8
B-3
P-6
B-5
B-2



Boring Terminated at 40.0'
Weathered rock at 35'
No water at completion

(1)- laden soil

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

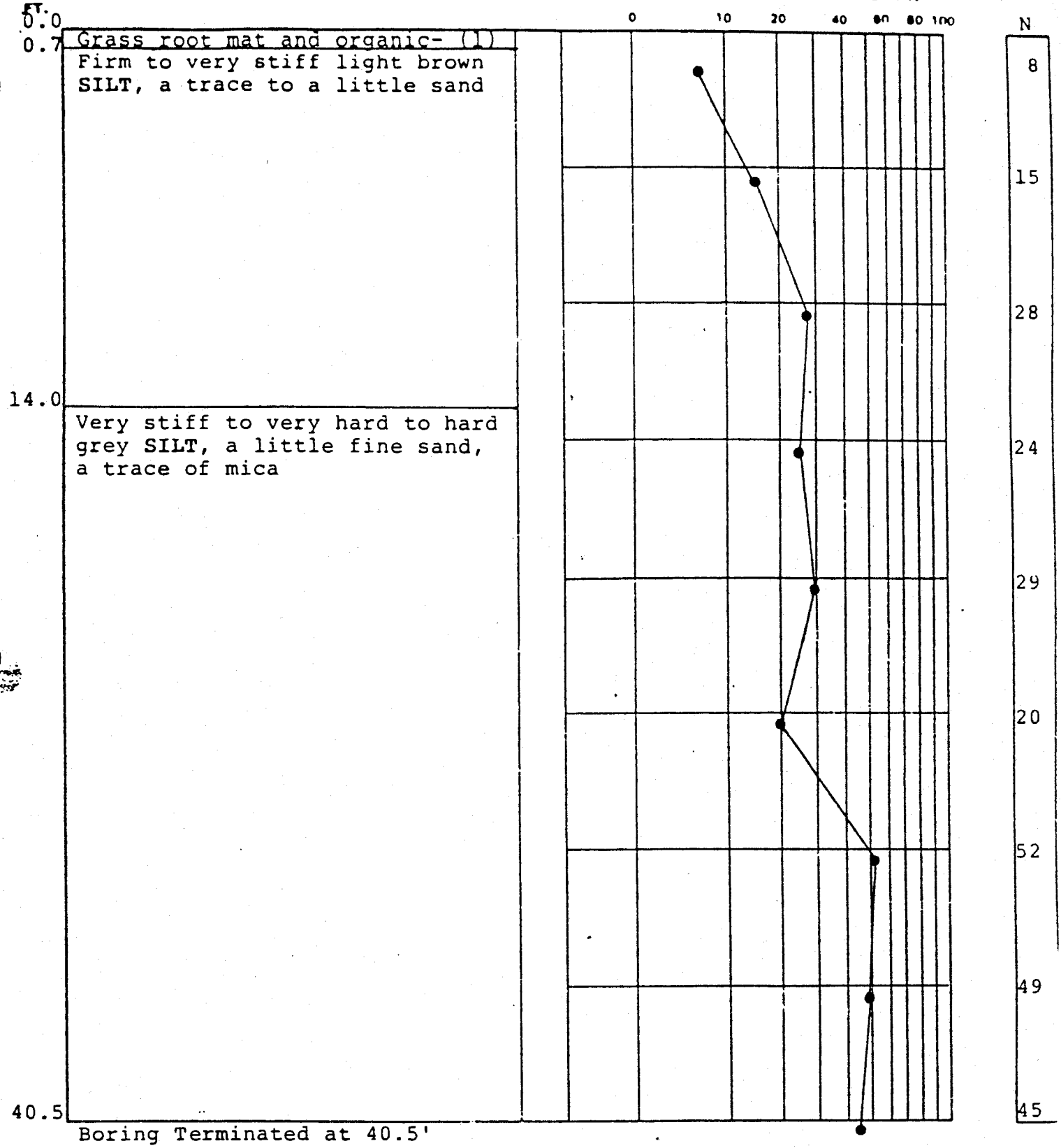
WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-1
DATE DRILLED 11-7-88
LAB NO. _____
JOB NO. P-70-561



Boring Terminated at 40.5'
No rock encountered
No water at completion

(1)- laden soil

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

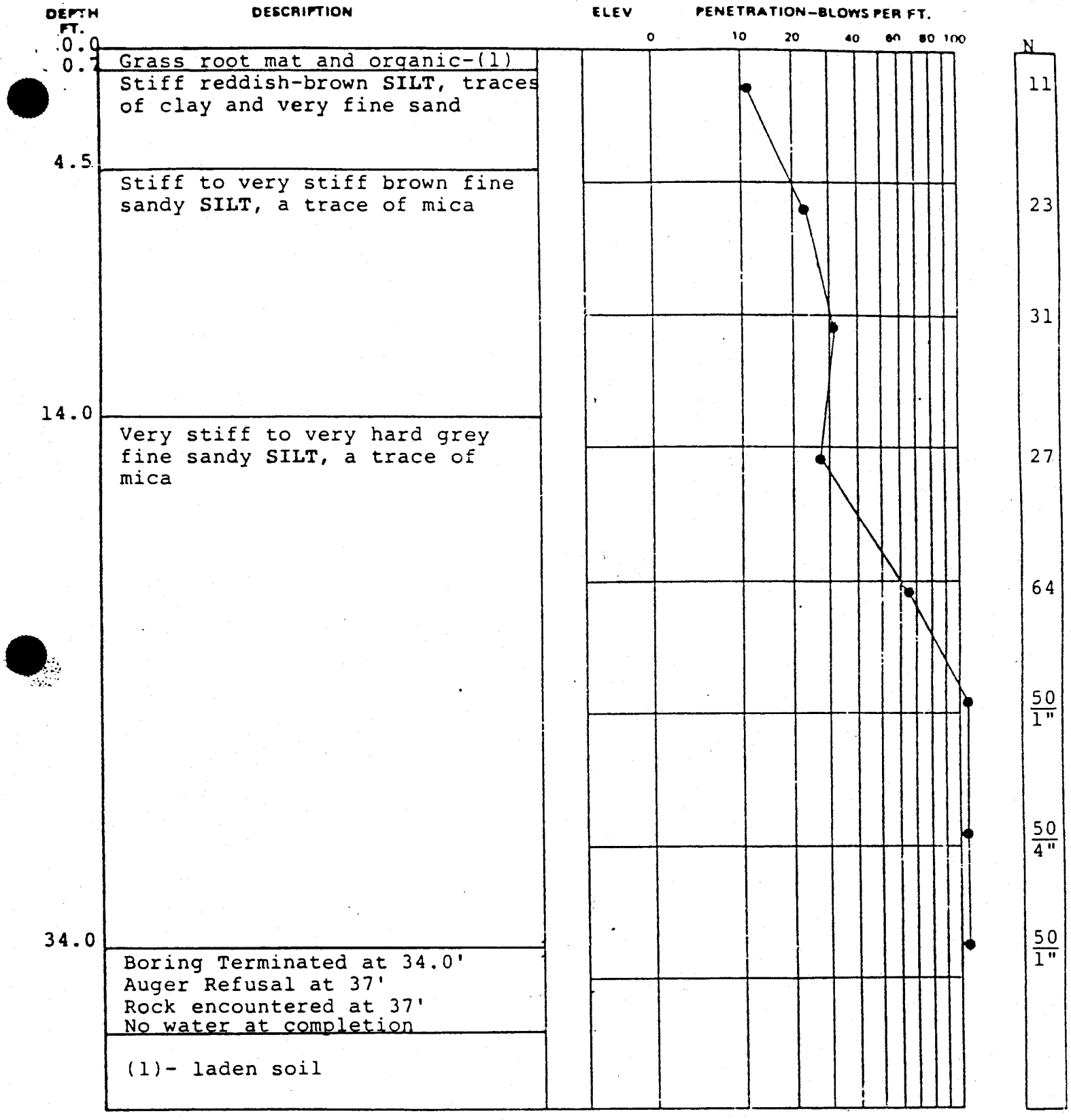
WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-2
DATE DRILLED 11-4-88
LAB NO.
JOB NO. P-70-561



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-3
DATE DRILLED 11-7-88
LAB NO. _____
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100	N
0.0				
0.7	Grass root mat and organic-(1)			
	Firm mottled reddish-brown and black fine sandy SILT, a trace of mica			8
4.0				
	Very stiff reddish-brown sandy SILT, traces of rock fragments			19
6.0				
	Very stiff to hard grey SILT, traces of fine sand and mica			17
				39
21.0				32
	Very hard mottled yellow and black sandy SILT, a trace of mica			60
29.0				
	Very hard to very stiff to hard grey SILT, traces of fine sand and mica			84
				28
40.5				
	Boring Terminated at 40.5'			38

No rock fragments
No water at completion
(1)- laden soil

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

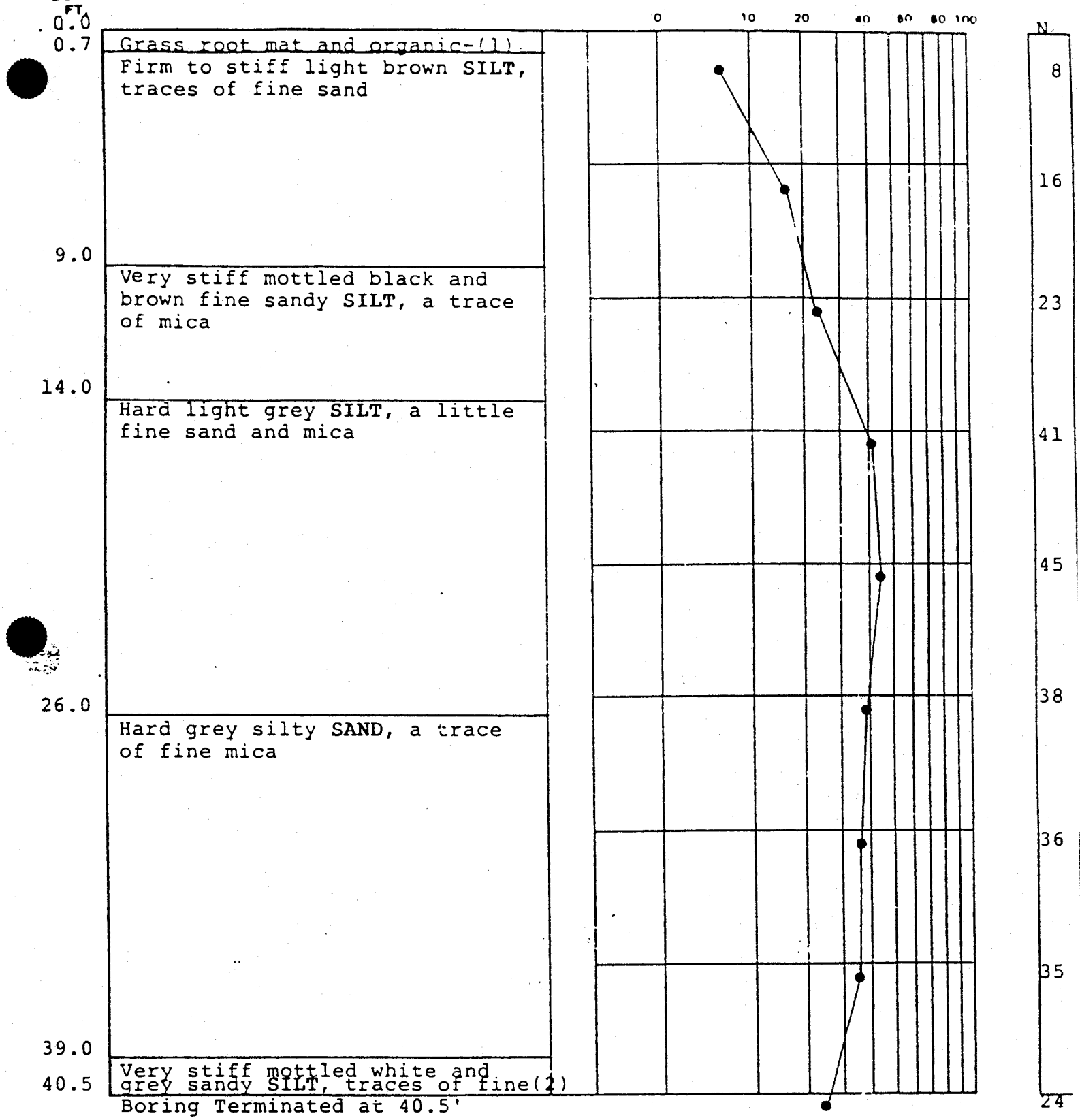
WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-4
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

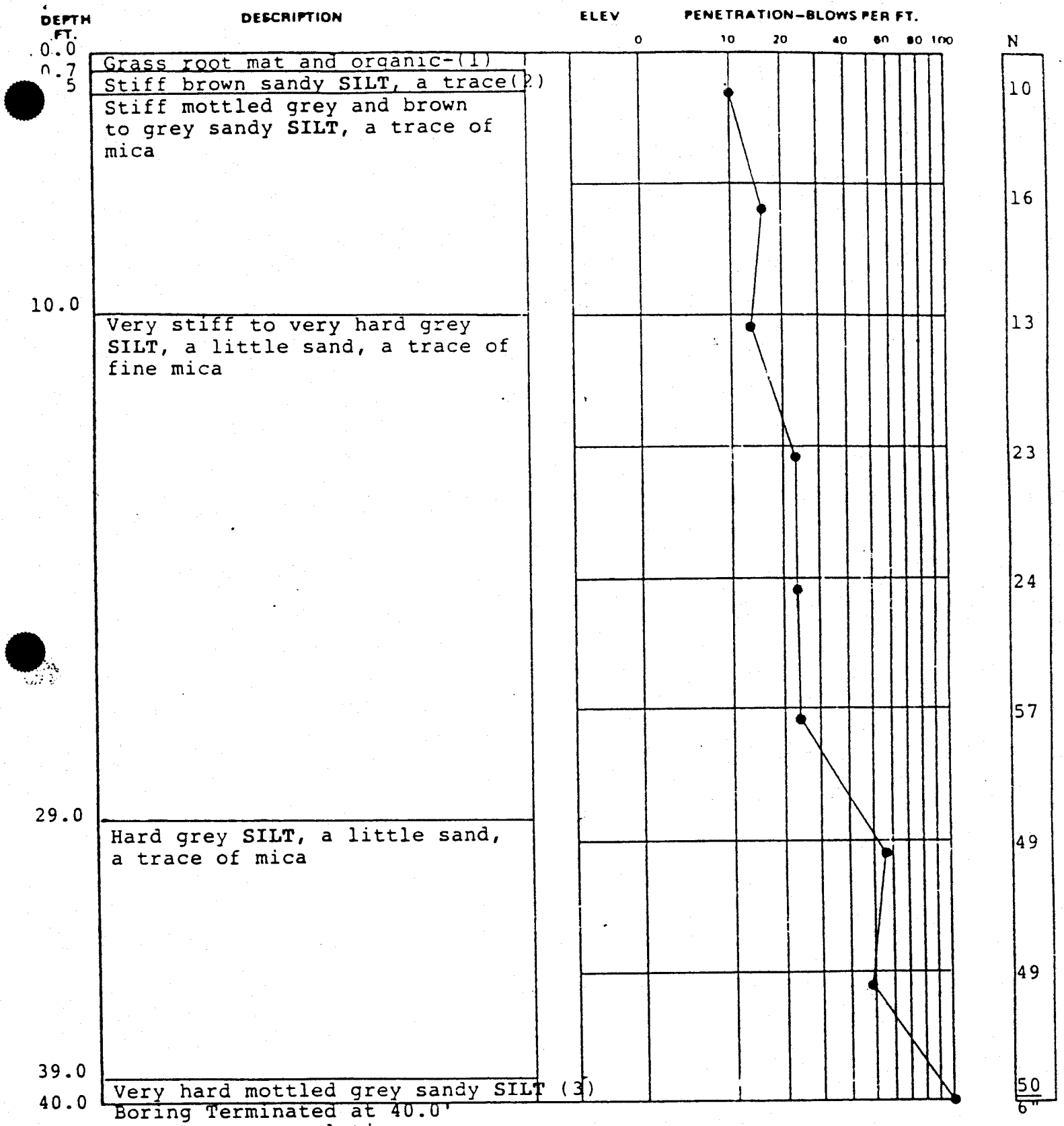
TEST BORING RECORD

BORING NO. B-5

DATE DRILLED 11-7-88

LAB NO. _____

JOB NO. P-70-561



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

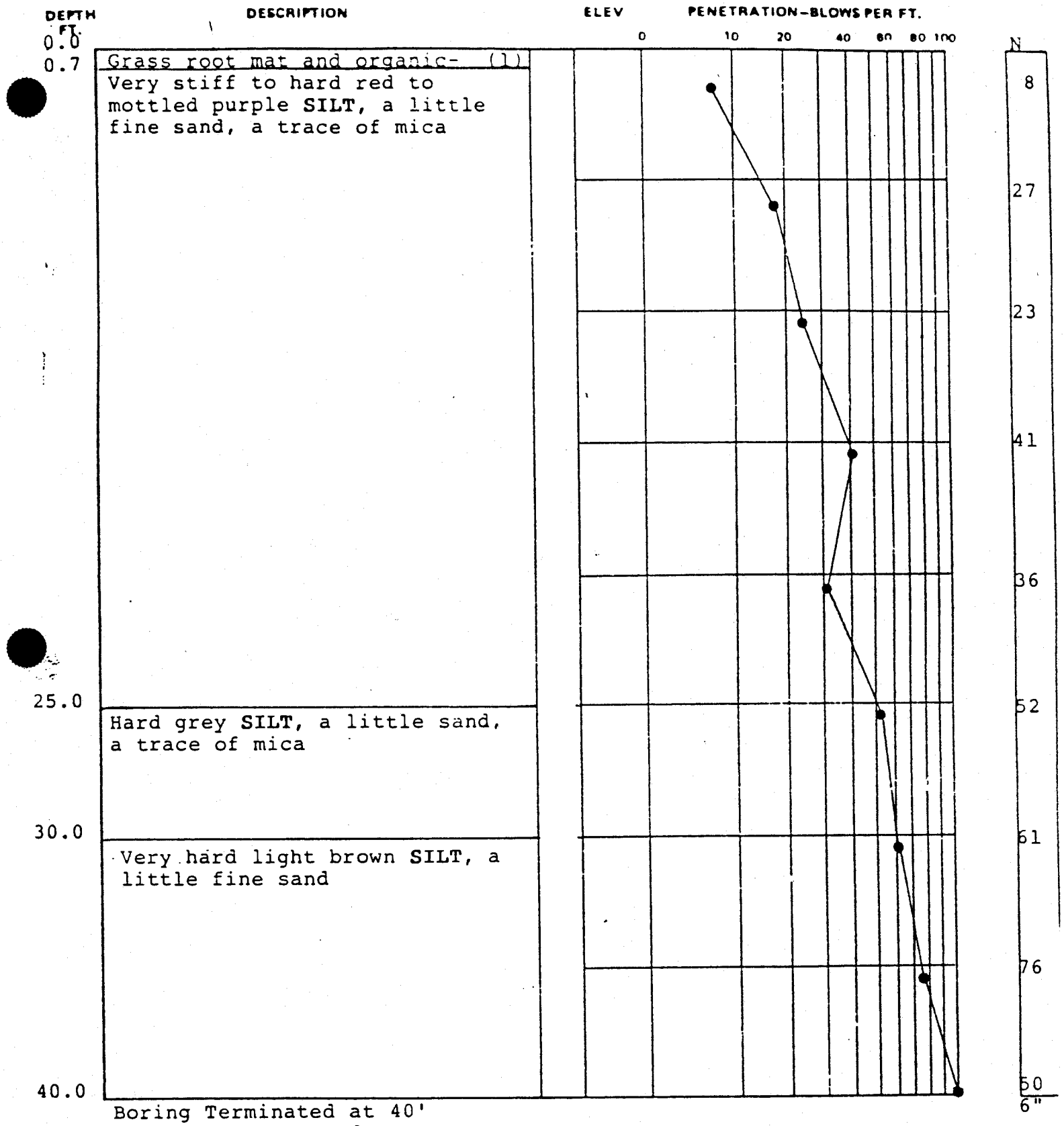
WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-6
DATE DRILLED 11-5-88
LAB NO.
JOB NO. P-70-561



FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

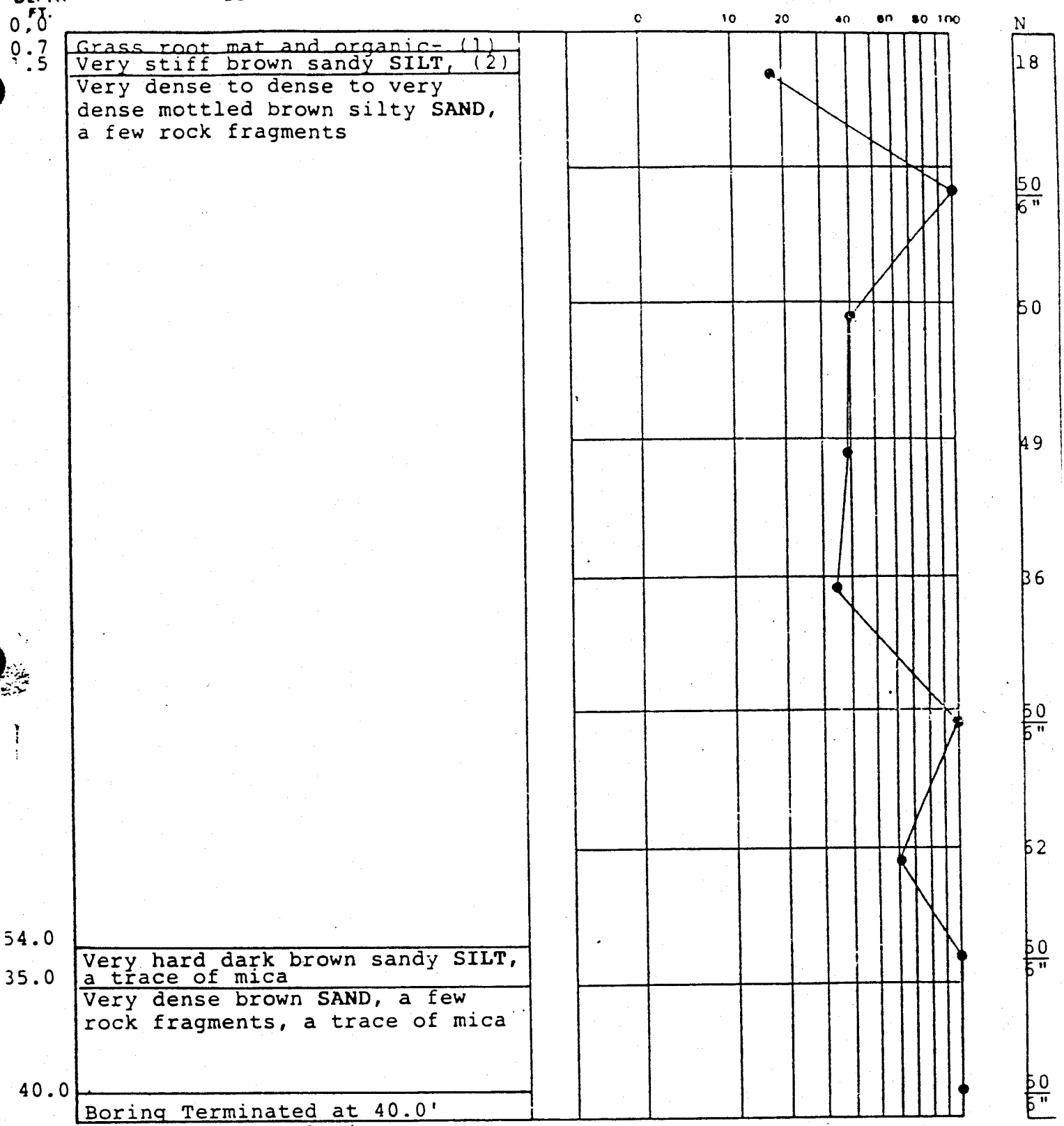
TEST BORING RECORD

BORING NO. B-7

DATE DRILLED 11-5-88

LAB NO. _____

JOB NO. P-70-561



No water at completion

(1)- laden soil
(2)- a trace of mica

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. B-8
DATE DRILLED 11-4-88
LAB NO.
JOB NO. P-70-561

DEPTH	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-1
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Small rock fragments from 5 to 10'		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-2
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-3
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0	Small rock fragments from 5 to 10'		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

TEST BORING RECORD

BORING NO. P-4
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Rock fragments from 5 to 10'		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-5
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Small rock fragments from the surface to a depth of 10'		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-6
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-7
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-8
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT.	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0	Small rock fragments from 5 to 10 feet		
10.0	Boring Terminated at 10.0' No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 50 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-9
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.

WATER TABLE, 1 HR.

◀ LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-10
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

DEPTH FT	DESCRIPTION	ELEV	PENETRATION–BLOWS PER FT. 0 10 20 40 60 80 100
0.0			
10.0	Boring Terminated at 10.0' No rock encountered No water at completion		

FROEHLING & ROBERTSON, INC.

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE

| 60 | % ROCK CORE RECOVERY

WATER TABLE, 24 HR.
WATER TABLE, ? HR.
LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. P-11-
DATE DRILLED 11-7-88
LAB NO.
JOB NO. P-70-561

RESPOND TO 40 CFR PARTS 258.13 & 258.14:

Part 258.13: Fault Areas

- Per Subtitle "D" Regulations, a new MSWLF unit shall not be located within 200 feet (60 meters) of a fault that has had displacement in Halocene time (recent epoch of the Quaternary period) unless the owner demonstrates to the Director of an approved State that an alternate setback distance of less than 200 feet will prevent damage to the structural integrity of the MSWLF unit and will be protective of the human health and environment.

- As documented by Law Engineering, Inc. in the "Final Report of Hydrogeological Study" in Section 4.7 Seismic Considerations, that Halocene Faults were not observed in the immediate vicinity of the proposed landfill site nor were they shown on any published maps or discussed in the literature reviewed.

Part 258.14: Seismic Impact Zones

- Per Subtitle "D" Regulations, a new MSWLF unit shall not be located in seismic impact zones, unless the owner demonstrates to the Director of an approved State, that all containment structures, including liners, leachate collection systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earthen material for the site.

  Seismic Impact Zones: an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earthen material, expressed as a percentage of the earth's gravitational pull, will **exceed** 0.10g in 250 years.

- As indicated by Law Engineering, Inc. in the previously mentioned study and section, and as documented by the U.S. Geological Survey in Open-File Report 82-1033, the probable acceleration in rock in the area of the proposed landfill site with a 90 percent probability of not being exceeded in a 250 year period is **less** than 0.10g.

  In light of this, the site should not be subjected to this design requirement. The slope stability calculations indicate that the design of the MSWLF unit is sound.

Appendix C

Design Calculations

Spring Relief

Project _____ Acct. No. _____ Page _____ of _____

Subject SPRING RELIEF DESIGN. Comptd. By NED Date 30 MAR 12

Detail _____ Ck'd. By _____ Date _____

OBJECT: TO EFFECTIVELY CAPTURE FLOW CURRENTLY CONVEYED FROM THE SPRING HEADS LOCATED BY LAW ENGINEERING AND DIVERT THE FLOW TO A DISCHARGE POINT DOWNGRADIENT FROM THE LANDFILL.

DESIGN PARAMETERS:

- FLOW RATES HAVE BEEN GAGED BY LAW ENGINEERING LAW CONSTRUCTED "A" WEIR AT THE SPRING HEADS. THIS LOCATION IS SHOWN ON THE PLAN AS WP-3.

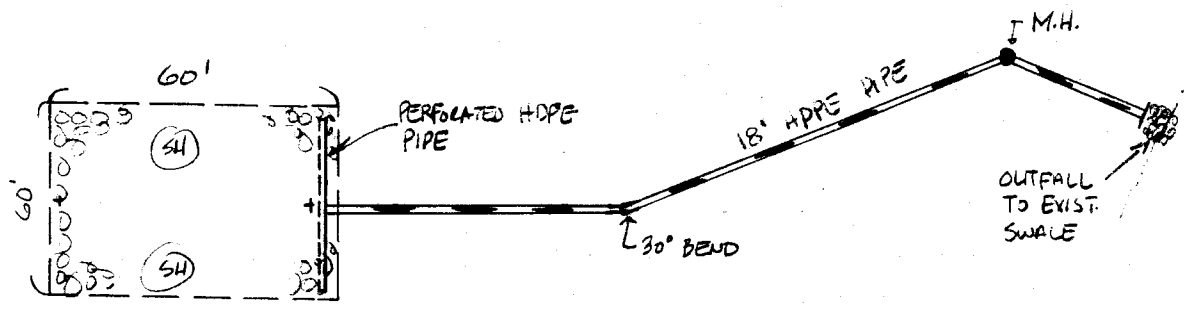
  THE FLOW GAGED AT WEIR POINT #3 WAS. 6.2 gallons/minute OR 0.0138 cfs. (0.42 cm/sec).

- DISCHARGE MUST BE MONITORED AS SURFACE WATER AT OUTFALL.

- MUST PROVIDE MEANS OF TRANSPORT TO LEACHATE POND IF CONTAMINATION OCCURS.

TRIBBLE & RICHARDSON INC.

PROPOSED DESIGN:



DESIGN FLOW = 6.2 gal/min = 372 gal/hr.

Project _____ Acct. No. _____ Page _____ of _____

Subject Spray Field Design Comptd. By _____ Date _____

Detail N/A Ck'd. By _____ Date _____

PERFORATIONS REQD. FOR DESIGN FLOW

DESIGN FLOW = 6.2 gal/min (0.0138 cfs)

- USING THE ORIFICE EQN:

$$Q = C A \sqrt{2gh}$$

where:

Q = DESIGN FLOW ft^3/sec

C = coefficient of discharge

A = Area of orifice, (ft^2)

g = acceleration due to gravity, (ft/s^2)

h = head from ℄ (ft)

Input:

Q = 6.2 gal/min (0.0138 cfs)

C = 0.6 (Std.)

g = 32.2 ft/s^2

h = 3 ft. (provides 1 FT FREEBOARD, SEE DETAIL IN CONST DWGS.)

$$A = \frac{Q}{C\sqrt{2gh}}$$

$$= \frac{0.0138}{0.6\sqrt{2(32.2)(3)}}$$

$$A = 0.0017\ ft^2 = 0.25\ in^2$$

∴ Propose 1 - 3/4" HOLE EVERY 5 FEET from end to end ALONG ℄ OF 18" HDPE PIPE

Area of 1 - 3/4" HOLE = 0.44 in^2

18 HOLES PROVIDED @ 0.44 in^2 EACH =

0.0306 ft^2

TRIBBLE & RICHARDSON INC.

Project [illegible] Acct. No. _____ Page [illegible] of _____
Subject Spring Relief Design Comptd. By NED Date 30 Mar [illegible]
Detail N/A Ck'd. By _____ Date _____

OUTFALL PIPING:

USING MANNINGS FORMULA, DESIGN OUTFALL CAPABLE OF CONVEYING DESIGN FLOW TO OUTFALL SWALE.

DESIGN:

18" OUTFALL PIPE @ 7.90%

EQN:

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

AND

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

Where:

A = CROSS-SECTIONAL AREA OF PIPE

n = Coefficient for pipe friction

R = hydraulic Radius

S = pipe slope

INPUT:

$$Q = \frac{1.486}{0.10} (1.77 ft^2) (0.38)^{2/3} (0.0790)^{1/2}$$

Q_{full} = 38.4 cfs

V_{Full} = 21.7 fps.

Where Q = 6.2 gpm (0.0138 cfs)

Velocity = 0.82 fps.

Normal depth = 0.05'

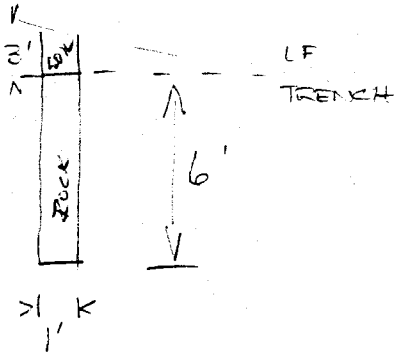
TRIBBLE & RICHARDSON INC.

Project _____ Acct. No. _____ Page _____ of _____

Subject Drain Detail Comptd. By [illegible] Date [illegible]

Detail _____ Ck'd. By _____ Date _____

from Skaggs (Kerry Valley



1'x6' TRENCH DOWN WILL CARRY 5 gpm [illegible]

Rock is #57 stone wrapped in Supac filter fabric

Haywood spring flow from 2 springs is 6.2 gpm from Saw Weir measurement

use factor of safety of 4.0

Design for 24.8 & 25 gpm

∴ x sectional area should equal 24 FT²

NONREPRODUCIBLE GRID

Tribble & Richardson Inc. TR

Volcaly Mixture Study

SANITARY LANDFILL
HAYWARD COUNTY,N.C.

AMERICAN COLLOID COMPANY

SOIL LABORATORY

ENGINEERING REPORT

AMERICAN COLLOID COMPANY • 1500 WEST SHURE DRIVE • ARLINGTON HEIGHTS, ILLINOIS 60004

PHONE: 708/392-4600

FAX 708-506-6199

AMERICAN COLLOID COMPANY

1500 WEST SHURE DRIVE
ARLINGTON HEIGHTS ILLINOIS 60004

ENGINEERING REPORT - SOILS ANALYSIS

DATE: 06-Aug-91

SAMPLE IDENTIFICATION: Sanitary Landfill -- Sample 2
Hayward County, NC

SUBMITTED BY: Tribble and Richardson Inc.

SAMPLE SUBMITTED IS DETERMINED TO HAVE THE FOLLOWING ANALYSIS:

% RETAINED ON 325 MESH (WET SCREENING):	76.7
VOIDS IN RETAINED SOIL:	45.8
% CLAY-SILT FINES PASSING 325 MESH:	23.3
VOIDS FILLED BY NATURAL CLAY-SILT FINES:	8.2
NET VOIDS:	37.6

The analysis indicates that the Volclay should be applied at a minimum rate of 6.2 pounds per square foot as a 6 inch thick mixed blanket compacted at optimum moisture to a minimum of 90% of Standard Proctor to attain a permeability coefficient of $1x10^{-7}$ cm/sec.

To compensate for mechanical imperfections in placement of material and minor variations in soil characteristics, a safety factor is included in the recommended application rate below.

RECOMMENDATIONS:

Application rate: 8.5 lbs./sq.ft. Grade: SLS-71

Comments: Due to the high mica content, the above rates should be considered preliminary until confirmed by permeability testing.

Due to the high net voids of this sample, seal thicknesses of less than 6 inches are not recommended.

CAUTION: The application rate indicated above is predicated upon the specific base clay used to produce SLS-71, and its polymer and chemical treatments. The extrapolation of this product's high efficiency application rate and contamination resistance to other Volclay products or products treated solely with polymers is strongly discouraged and will likely result in the failure of the proposed project.

Conductivity: 12 umhos/cm Gravel (per ASTM D653): 8.7 %

DI: -- SW: -- SCI: 0

Lab Report No: 5170-2 Analyst: MRG

AMERICAN COLLOID COMPANY

1500 WEST SHURE DRIVE

ARLINGTON HEIGHTS ILLINOIS 60004

ENGINEERING REPORT - SOILS ANALYSIS

DATE: 06-Aug-91

SAMPLE IDENTIFICATION: Sanitary Landfill -- Sample 1
Hayward County, NC

SUBMITTED BY: Tribble and Richardson Inc.

SAMPLE SUBMITTED IS DETERMINED TO HAVE THE FOLLOWING ANALYSIS:

% RETAINED ON 325 MESH (WET SCREENING):	76.1
VOIDS IN RETAINED SOIL:	44.2
% CLAY-SILT FINES PASSING 325 MESH:	23.9
VOIDS FILLED BY NATURAL CLAY-SILT FINES:	8.7
NET VOIDS:	35.5

The analysis indicates that the Volclay should be applied at a minimum rate of 5.9 pounds per square foot as a 6 inch thick mixed blanket compacted at optimum moisture to a minimum of 90% of Standard Proctor to attain a permeability coefficient of 1×10^{-7} cm/sec.

To compensate for mechanical imperfections in placement of material and minor variations in soil characteristics, a safety factor is included in the recommended application rate below.

RECOMMENDATIONS:

Application rate: 7.6 lbs./sq.ft. Grade: SLS-71

Comments: Due to the high mica content, the above rates should be considered preliminary until confirmed by permeability testing.

Due to the high net voids of this sample, seal thicknesses of less than 6 inches are not recommended.

CAUTION: The application rate indicated above is predicated upon the specific base clay used to produce SLS-71, and its polymer and chemical treatments. The extrapolation of this product's high efficiency application rate and contamination resistance to other Volclay products or products treated solely with polymers is strongly discouraged and will likely result in the failure of the proposed project.

Conductivity: 11 umhos/cm Gravel (per ASTM D653): 3.1 %

DI: -- SW: -- SCI: 0

Lab Report No: 5170-1 Analyst: MRG

ROBERT L. CARLSON, INC. — *Manufacturers' Representative*

WATER, WATER POLLUTION AND INDUSTRIAL PLANT EQUIPMENT

P. O. BOX 11031
CHARLOTTE, N. C. 28220
TEL: 704-527-5644

RECEIVED
AUG 21 1991
Tribble & Richardson, Inc.

August 20, 1991

Mr. Richard Wood
Tribble & Richardson, Inc.
4020 Westchase Blvd., Suite 515
Raleigh, NC 27607

SUBJECT: VOLCLAY Seepage Control Liner
Haywood County Landfill
Haywood Co., NC

Dear Richard:

Per our telephone conversation today, in order to translate an application rate for 1 x 10^{-7} cm/sec to 1 x 10^{-8} cm/sec permeability you add 20% to the application rate.

Sample 1 - 7.6 lbs/ft² SLS-71 @ 1 x 10^{-7} cm/sec -->
9.1 lbs/ft² @ 1 x 10^{-8} cm/sec.

Sample 2 - 8.5 lbs/ft² SLS-71 @ 1 x 10^{-7} cm/sec -->
10.2 lbs/ft² @ 1 x 10^{-8} cm/sec.

PRICING: VOLCLAY SLS-71 in 100 lbs. bags/palletized ** $135.00 per net ton (for quantities greater than 15 tons)

PALLETS: Cost is included in the 100# bag price. Pallets can also be stretchwrapped for an additional $8.00 per ton. Truck pallets are 42 x 42. There is no credit for returned pallets.

TERMS: Net 30 Days

F.O.B.: Point of shipment. No freight allowed. Shipments made at freight rates in effect at time of shipment. (See reference freight rates below)

SHIPMENT: 4 to 6 weeks after receipt of purchase order and complete information.

For your information we have obtained the following reference freight rates today from carriers:

FLATBED TRUCK (bagged material): Belle Fourche, SD to Haywood

Co., NC $110.20/ton with a 21 ton minimum.

The following information may be helpful to you in completing this project:

1. Generally $.10 - $.18/ft^2. installation cost will be incurred for labor and equipment. The larger the ratio of side slope area to bottom area the closer the cost to the $.18 figure.

2. Using the manual method of laying off a grid with (1) 100 lb. bag per grid a (1) acre area can be spread in 2 hrs. by 4 men. This work consist of breaking the bags and evenly spreading the VOLCLAY over the area by hand raking.

3. The stretchwrapping only covers the sides of the bags and not the top. This would not provide good protection from the weather.

If you have any questions, please do not hesitate to contact us. Thank you for your interest in our products.

Very truly yours,

AMERICAN COLLOID CO.

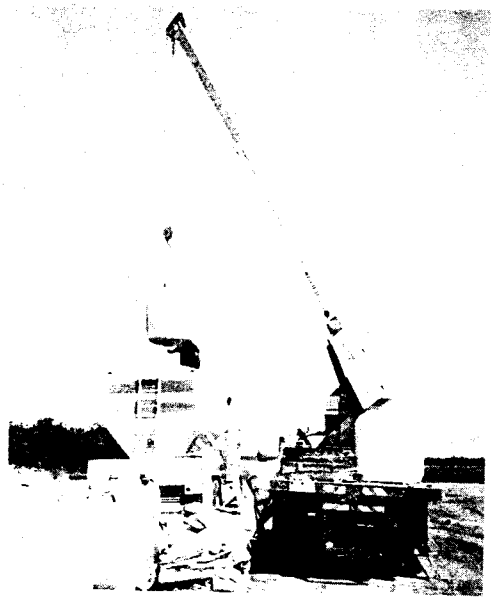
Douglas L. Carlson
President
ROBERT L. CARLSON, INC.

cc: Tom Stam, ACC

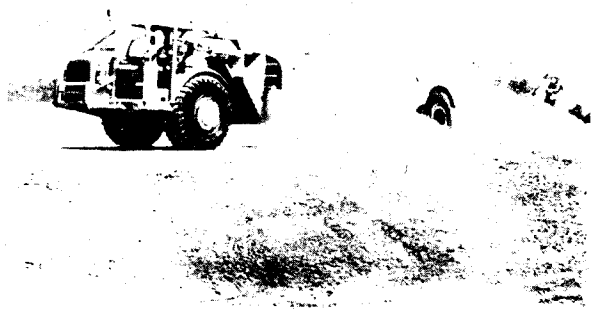
liner and cap Application Methods

Volclay Delivery

Volclay can be delivered in 100# bags, in bulk, or in Jumbo Sacks as shown at right.

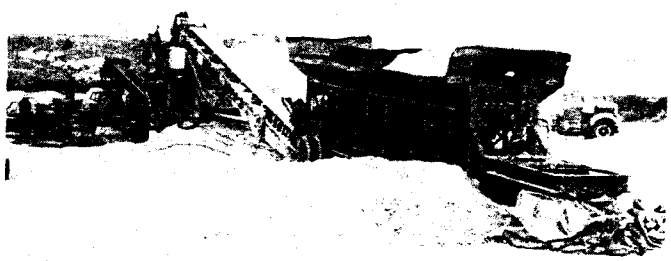


Mixing and Spreading

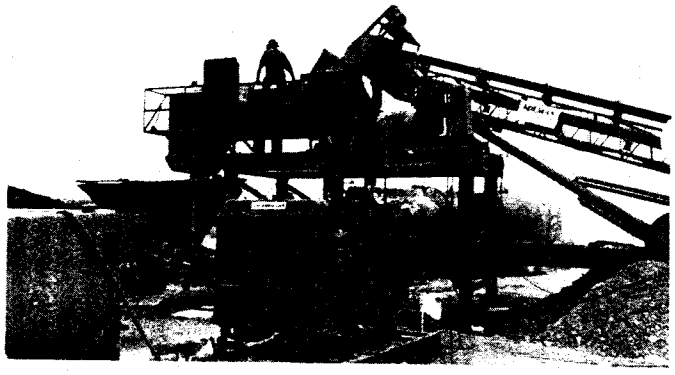


Soil Conditioning After the job site has been excavated and finish graded, the top soil should be loosened and all large rocks over 2" diameter removed. The surface should then be sprayed to adjust the soil to a water content at least 3% wet of optimum.

Mixing and Spreading (Option B—Pugmill Method)



Combining Volclay and Soil A high accuracy method of preparing a Volclay-soil mix has been developed utilizing a split hopper, metering slide valves and a pugmill. It is also helpful in areas where native soil is not suitable. Soil and Volclay are loaded into the split hopper as shown and metered onto a conveyer belt in the desired proportion.

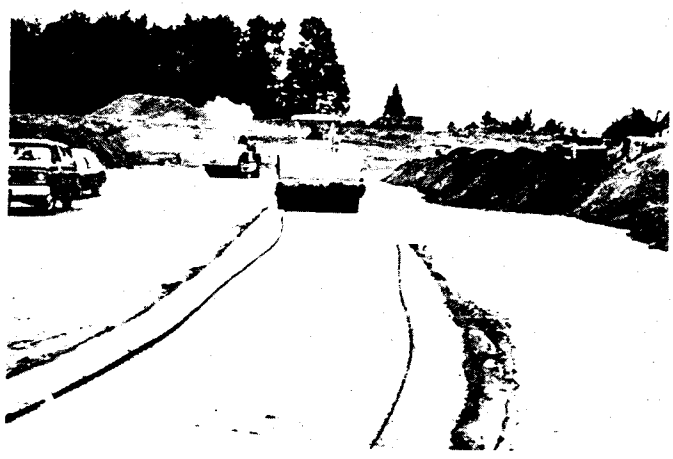


Pugmill Mixing The Volclay/soil combination is conveyed to a pugmill where intensive mixing takes place. The mixing operation can take place some distance from the job site. Moisture is adjusted to at least 3% wet of optimum in the pugmill.

Compaction The Volclay/soil mixture is compacted with a wobble wheel or steel wheel vibratory roller to a minimum of 90% Standard Proctor. A sheep's foot roller should not be used.

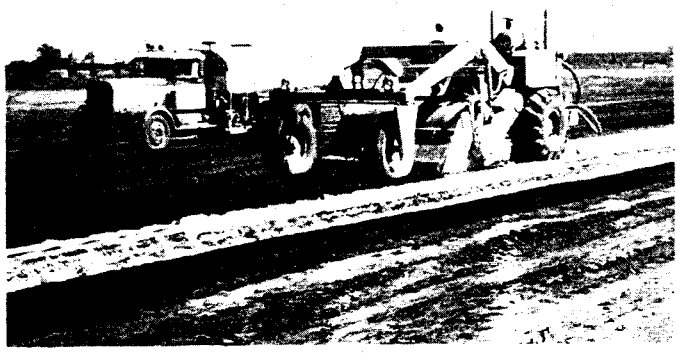
Quality Assurance/Quality Control Proper density and moisture are important to the sealing quality of the resulting Volclay/soil membrane liner. Continuous monitoring with a nuclear density gauge should be performed to maintain sufficient density and moisture, thus assuring sealing quality of the liner. Construction of a small test pad adjacent to the landfill is an excellent QA/QC technique. In-situ permeability testing can be performed on the test pad without disrupting the integrity of the actual landfill liner.

Protective Cover A 12" to 18" porous cover of native soil should be applied over the Volclay/soil lift to protect the sealing membrane from surface damage. Drainage pipes and collection lines should be buried in the protective material to facilitate leachate collection. An 18" soil layer should be applied over Volclay/soil landfill caps.



(Option A—Mix In Place Method)

Spreading Volclay The Volclay is evenly distributed over the conditioned soil at the application rates specified by the landfill design engineer. American Colloid Company can assist in determining the proper application rates.



Mixing Volclay and Soil Mechanical equipment such as this road reclaimer rotating blade machine can be used to uniformly incorporate the Volclay into the conditioned soil.

Truck to Job Site The accurately mixed Volclay/soil mixture is hauled to the job site.

Continuous Spreader The Volclay/soil mixture is loaded into a bituminous-type paving spreader and laid down in accurately-controlled lifts. Compaction and protective covering steps follow as described below.

Liner Slope Stability

Project _____ Acct. No. _____ Page _____ of _____

Subject SLOPE STABILITY Comptd. By NED Date _____

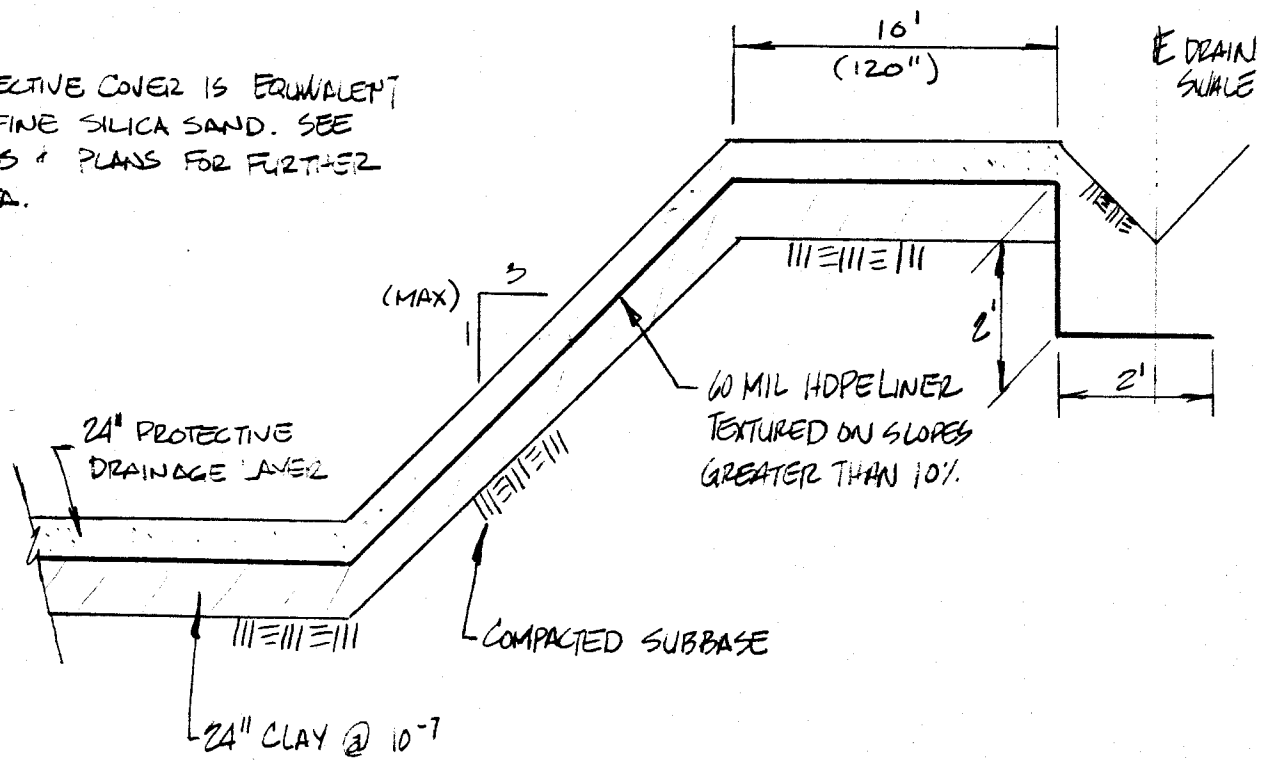
Detail N/A Ck'd. By _____ Date _____

TRIBBLE & RICHARDSON INC.

SLOPE STABILITY: STABILITY OF THE SIDE SLOPE WAS DETERMINED BY COMPARING THE MAXIMUM SIDE SLOPE ANGLE AND THE MINIMUM FRICTION ANGLE. THE MINIMUM FRICTION ANGLE IS LOCATED BETWEEN THE TEXTURED 60 MIL HDPE LINER AND THE COMPACTED CLAY BASE LINER. SINCE THIS ANGLE IS APPROXIMATELY 32 DEGREES (PER SLT OF NO AMERICA, INC.) AND IS GREATER THE MAXIMUM STABLE SLOPE ANGLE OF 18.4 DEGREES (3:1), the slope is considered stable. THE FACTOR OF SAFETY IS:

$$\frac{\text{TAN } 32^\circ}{\text{TAN } 18.4^\circ} = 1.88$$

* PROTECTIVE COVER IS EQUIVALENT TO FINE SILICA SAND. SEE SPECS & PLANS FOR FURTHER DATA.



PROPOSED LINER & ANCHOR TRENCH

Project [illegible] Acct. No. [illegible] Page 5 of [illegible]

Subject SLOPE STABILITY Comptd. By NED Date [illegible]

Detail N/A Ck'd. By [illegible] Date [illegible]

OBJECT: CALCULATE ANCHOR CAPACITY FOR HDPE LINER PLACED IN CRITICAL SLOPE (3:1)

DEFINE ANCHOR TRENCH GEOMETRY: USING "GEOSYNTHETIC DESIGN GUIDANCE FOR HAZARDOUS WASTE LANDFILLS & SURFACE IMPOUNDMENTS" PG III-21-25

T = tension trench can withstand before failure

β = side slope angle

L = Embedment Length

d_{cs} = depth of soil cover

d_{AT} = depth of anchor trench

ϕ = soil friction angle between liner and clay

δ = Soil / HDPE friction angle

γ_{cs} = unit wt of cover material

K_A = coefficient of active earth pressure

K_p = " " passive " "

K_o = " " earth pressure at rest

$\beta = 18.4°$ (3:1)

$L = 5'$

$d_{cs} = 2'$

$d_{AT} = 2'$

$\phi = 32°$ (PER SLT OF AMERICA)

$\delta = 35°$ (PER SLT OF No. America, Inc.)

$\gamma_{cs} = 120$ lbs / ft^3 (unsaturated)

$$K_A = \tan^2[(45 - \phi/2)] = 0.31$$

$$K_p = \tan^2[45 + \phi/2] = 3.25$$

$$K_o = 1 - \sin\phi = 0.47$$

$$q = (\gamma_{cs})(d_{cs}) = (120)(2) = 240 \text{ lb/ft}^2$$

TRIBBLE & RICHARDSON INC.

Project _____ Acct. No. _____ Page 3 of _____

Subject SLOPE STABILITY Comptd. By NED Date _____

Detail N/A Ck'd. By _____ Date _____

DETERMINE ANCHOR CAPACITY:

$K = K_p$ or K_o

- TENSION UNDER PASSIVE EARTH PRESSURE:

$$T_{KP} = \frac{[(2)(L)(\tan\delta)] + (K + K_A)\tan\delta\left[0.5\,\gamma_{CS}\,d_{AT}^2 + q\,d_{AT}\right]}{\cos\beta - [\sin\beta \cdot \tan\delta]}$$

$$= \frac{[(240)(5)(\tan 35)] + (3.25 + 0.31)\tan 35\left[0.5\,(120)(2) + 240/2\right]}{\cos 18.4° - \sin 18.4° \tan 35°}$$

$$= \frac{840.25 + 598.26}{0.73}$$

$$= 1970.56 \text{ lb/FT.}$$

- TENSION WHEN EARTH AT REST.:

$$T_{Ko} = \frac{[(240)(5)(\tan 35)] + (0.47 + 0.31)\tan 35\left[0.5\,(120)(2) + 240/2\right]}{\cos 18.4° - \sin 18.4° \tan 35°}$$

$$= \frac{840.25 + 131.08}{0.73}$$

$$= 1330.59 \text{ lb/FT.}$$

$T = 1970.6$ lb/FT.

TRIBBLE & RICHARDSON INC.

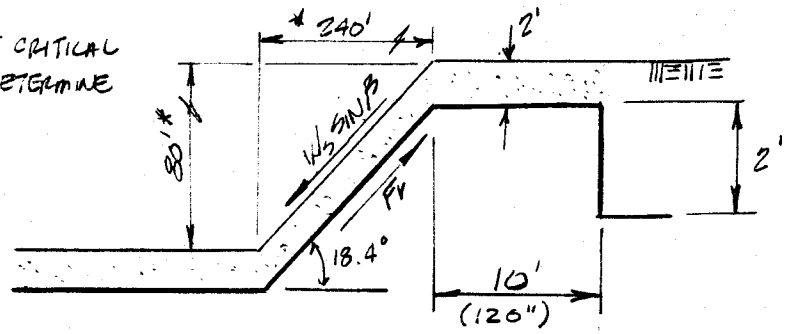
Project [illegible] Acct. No. [illegible] Page 4 of ____

Subject SLOPE STABILITY Comptd. By NED Date ____

Detail N/A Ck'd. By ____ Date ____

DETERMINE LOADING MOVEMENT ON LINER:

*USED MOST CRITICAL SLOPE TO DETERMINE STABILITY.



W_L = WEIGHT OF LINER

W_S = WEIGHT OF SOIL

D = DEPTH = 80'

t = FML THICKNESS = $\frac{0.06}{12}$

60 MIL LINER - FML SPEC. GRAVITY = 0.940

FRICTION ANGLE: $\delta_L = 30°$ SAND. (PER SLT OF NORTH AMERICA, INC.)

$\beta = 18.4°$

- LINER WT.

$$W_L = (G\,\gamma_w\,t)(1.0/\sin\beta)$$

$$= (0.940 \cdot 62.4\ lb/FT \cdot \tfrac{0.06}{12})(1.0\ 80/\sin 18.4°)$$

$$= 74.33\ lb/FT$$

- SOIL WEIGHT:

$AREA_S = 2 \times 240' = 480$ SQ. FT

$\gamma_S = 120$ PCF (UNSATURATED)

$W_S = 480\ SF \times 120\ PCF = 57,600.\ lb/FT.$

$\therefore (W_S + W_L)\sin\beta = (57,600 + 74.33)\sin 18.4° = 18,204.85\ lb/FT$

$\therefore F_R = (W_S + W_L)\cos\beta \tan\delta$

$= (57674.33)(\cos 18.4°)(\tan 30°)$

$= 31,595.95\ lb/FT.$

- FACTOR OF SAFETY = $F.S. = \dfrac{T + F_R}{(W_S + W_L)\sin\beta} = \dfrac{(1970.6 + 31,595.95)}{(57674.33)\sin 18.4°}$

$F.S. = 1.84$ (AT WORST CASE SITUATION)

TRIBBLE & RICHARDSON INC.

For environmental lining solutions...the world comes to SLT.
For environmental lining solutions...the world comes to SLT.
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For environmental lining solutions...the world comes to SLT.

FrictionFlex™ Application Data

FrictionFlex™ is the industry's first textured HDPE liner. It is the only geomembrane to date to be granted a U.S. Patent.* FrictionFlex™ is the result of over five years of SLT research and development committed to the innovation of new high-performance geomembrane materials. Offering design and construction advantages for composite lining design on steep slopes, FrictionFlex™ provides increased facility design capacity, service life and thereby total revenue potential. Containment slopes, vertical expansions and perimeter slopes in closures share the benefits of greater airspace and superior cover stability.

Most importantly, the advantages of FrictionFlex™ are available without compromise of any performance property or other issue of secure containment. A proprietary manufacturing process enables SLT to produce a textured liner (on one or both sides) exhibiting the same mechanical and chemical properties demanded of SLT's HyperFlex,™ the industry's premium grade smooth HDPE geomembrane. Non-textured edges facilitate welding and thickness measurements for superior quality control. Standard installation equipment and procedures ensure expedient construction.

The following reflects independent data confirming superior FrictionFlex™ performance in contact with soils and synthetics:

- Highest coefficient of friction with soils
- Highest coefficient of friction with synthetics
- Premium grade mechanical and chemical properties

SLT FrictionFlex™				Typical Smooth HDPE
Material	Coefficient of Friction	Adhesion (psf)	Average Friction Angle (degrees)	Comparable Friction Angle
Sandy Glacial Till	0.74	27	36	20
Sandy Clay	0.70	65	35	18
Smooth Clay	0.62	39	32	16
Ottawa Sand	0.59	21	30	19
Nonwoven Polyester Geotextile	0.54	116	28	11
Nonwoven Polypropylene Geotextile	0.65	133	33	12

NOTE: The above data is approximate. SLT recommends that specific data be developed for all application designs. Shear box testing of the specific geosynthetic and natural components of the composite is necessary to establish an appropriate design basis. SLT will be pleased to provide any necessary material samples for such purposes and invites comparative procedures.

FrictionFlex™ material properties are presented on the reverse side of this document.

*U.S. Patent No. 4,885,201

SLT NORTH AMERICA, INC.
Subsidiary of SLT Environmental, Inc.
Four Greenspoint Plaza 16945 Northchase, Suite 1750 Houston, Texas 77060
(800) 955-8085 (713) 874-2150 FAX (713) 874-2168

6-90/2.5M

FrictionFlex™ Textured HDPE Lining Material

SLT FrictionFlex™, the industry's leading textured liner, is uniquely produced from a specially formulated virgin HDPE geomembrane resin. FrictionFlex™ has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. FrictionFlex™ contains approximately 97.5% polymer and 2.5% carbon black, anti-oxidants, heat stabilizers, and contains no additives, fillers and extenders. FrictionFlex™ has excellent resistance to UV radiation and is suitable for exposed conditions.

PROPERTY	TEST METHOD	NOMINAL VALUE		
Thickness	ASTM D751/1593/374	60mil	80mil	100mil
Density (g/cc)	ASTM D792/1505	0.944	0.944	0.944
Melt Flow Index (g/10 Minutes)	ASTM D1238-E	$\leq$ 1.0	$\leq$ 1.0	$\leq$ 1.0
Tensile Properties Either Direction	ASTM D638 Type IV Dumbell, 2 ipm			
Tensile Strength at Break (lb/in Width)	Gauge length per	300	400	500
Tensile Strength at Yield (lb/in Width)	N.S.F. Std. 54	180	240	300
Elongation at Break (Percent)		800	800	800
Elongation at Yield (Percent)		15	15	15
Modulus of Elasticity (psi)		80,000	80,000	80,000
Tear Resistance Initiation (Pounds)	ASTM D1004 Die C	70	94	117
Low Temperature Brittleness	ASTM D746 B	-120°F	-120°F	-120°F
Dimensional Stability Percent Each Direction	ASTM D1204 248°F 1 hr.	±1	±1	±1
Volatile Loss (Max. Percent)	ASTM D1203 Meth. A	0.10	0.10	0.10
Resistance To Soil Burial	ASTM D3083			
Tensile Strength at Break or Yield	Percent Change	±5	±5	±5
Elongation at Break or Yield	Percent Change	±10	±10	±10
Ozone Resistance	ASTM D1149 7 days 100 pphm 104°F	No Cracks	No Cracks	No Cracks
Environmental Stress Crack Resistance (Minimum Hrs.)	ASTM D1693 Cond. C	5000	5000	5000
Puncture Resistance (Pounds)	FTMS 101C Method 2065	90	120	160
Water Adsorption (Percent Weight Change)	ASTM D570	0.0079	0.0079	0.0079
Coef. Linear Thermal Expansion 10^{-4}/°C	ASTM D696	1.2	1.2	1.2
Moisture Vapor Transmission (g/m²day)	ASTM E96	0.001	0.0009	0.00085
Oxidative Induction Time (Minimum Minutes)	ASTM D3895			
Compressed O_2 at 800 psi	130°C	2300	2300	2300
Pure O_2 at 1 Atmosphere	200°C	100	100	100
Tensile Impact Strength (Ft Lb/in²)	ASTM D1822	381	381	381

SLT FrictionFlex™ is manufactured 32.83 feet wide and up to 900 feet long and is the world's largest monolithic geomembrane lining material.

This data is provided for informational purposes only and is not intended as a warranty or guarantee. SLT assumes no liability in connection with the use of this data.

Leachate Collection/Removal

HELP MODEL DOCUMENTATION

Leachate generation for this landfill was modeled using the Hydrologic Evaluation of Landfill Performance (HELP) model developed for the EPA Municipal Environmental Research Laboratory by the Corps of Engineers Waterways Experiment Station at Vicksburg, MS. The program models the effects of precipitation, surface storage, runoff, infiltration, percolation, evaporation, soil moisture, and lateral drainage on this specific landfill design.

Six years of precipitation data were used for these runs. The HELP Model can synthetically generate up to 20 years of precipitation data for various locations, including Asheville, NC. However, the annual rainfall totals for synthetically generated precipitation at Asheville were low and the data set contained few big storms (>2" in 24 hrs.) Therefore, the historical data set for Knoxville, TN (74-78) was used in lieu of the synthetically generated set for Asheville. A 6th year was added by entering a year of historical records for the Catahoochee, NC rainfall gauge, the nearest gauge to this landfill site. Additionally, one of the larger storms in that year was replaced with a 25 year, 24 hour design storm of 5.8". Total precipitation that year exceeded 70".

Default soil textures within the HELP Model were used to approximate conditions for this landfill. Final cover is 6" native soil and 18" of 1×10^{-7} cm/sec clay. The geonet parameters are based on data provided by Gundle. Two feet of 2×10^{-4} cm/sec native soil is above it to model conditions in the cell bottoms. This is conservative modelling of actual conditions because a 50 ft. strip of 10^{-2} sand will be placed along leachate collection lines to enchance lateral drainage and inhibit build-up of head on the liner.

Leachate generation was modeled in two stages. The first stage modeled worst-case open conditions, the lower half covered and the upper half open. The second stage modeled six years of closed conditions using the final soil water contents from Stage 1 as initial conditions. Although the closed landfill would continue to generate leachate for a much longer period than six years, this was considered adequate modeling of worst-case conditions because of the initial saturation of the layers and the heavy precipitation modeled. The final water storage values confirm this, since they are less than initial values.

The results are as follows:

	Open	Closed
Head On Liner - Peak Value	0.10"	0.008"
Leachate Generated - Peak Daily Value	7,377 gal	755 gal
Leachate Generated - Monthly High Average	93,135 gal	23,405 gal
Average Monthly	84,643 gal	21,271 gal

Pond is sized for 30 days of storage for 1,000 gpd/ac, approximately 250,000 gallons. The results of the HELP Model indicate that this pond will provide adequate 30-day storage. During extreme conditions of a very rainy season or 25-year storm during a period when runoff could be trapped within the landfill, the pond would still provide about two weeks of storage. In no case should head on the liner exceed 1'.

DESIGN CALCULATIONS:

1. Leachate Piping System: Design of the thickness of the HDPE leachate pipes are based on procedures outlined in the Driscopipe Systems Design Manual. The collection and header pipes were designed for both static and live loadings.

A. Leachate Header Pipe: The leachate header pipes are placed along the access roads to drain the collection pipes from the fill areas. These 8 inch pipes are buried between 10 and 20 feet in a bedded trench along the edge of the roadbed. A H20 live loading was assumed.

1) $P_t = P_s + P_L + P_i$

Where:

P_t = Total External Pressure

a) P_s = Static Load Pressure

b) P_L = Dynamic Load Pressure

c) P_i = External Pressure Due to Vacuum

a) $P_s = P_{DE} + P_{WE} + P_B$

Where: P_{DE} = Moist Earth Load Pressure
P_{WE} = Saturated Load Pressure
P_B = Surface Structure Load Pressure

P_{DE}: Assume moist earth load $= 120\ ^{lb}/ft^3$

@ 20' depth; $P_{DE} = 120(20) = 2{,}400$ PSF

@ 10' depth; $P_{DE} = 120(10) = 1{,}200$ PSF

P_{WE}: Assume pipe is not below maximum seasonal water table.
Thus, $P_{WE} = 0$

P_B: Assume pipe is not below permanent surface structure.
Thus, $P_B = 0$

$\therefore p_s = 2{,}400$ PSF @ 20' depth or 1,200 PSF @ 10' depth

b) P_L = Dynamic Load Pressure
-> an H20 loading is assumed

$$P_L = \frac{3Wz^3}{2\pi R^5}$$

Where: W = 1.5 times the dynamic load
Z = vertical distance from pt. load to the top of pipe
R = straight line distance from pt load to top of pipe

@ 20' depth

$P_{L1} = \frac{3Wz^3}{2\pi R_1^5}$ $P_{L2} \frac{3Wz^3}{2\pi R_2^5}$

Where: W = 16,000 lbs x 1.5 = 24,000 lbs.

$R_1 = \sqrt{x^2+y^2+z^2} = \sqrt{0+20^2}$

= 20' for inside wheel

$R_2 = \sqrt{6^2+20^2}$ = 20.9' for outside wheel

$P_{L1} = \frac{3(24,000)(20)^3}{2\pi(20)^5}$ $P_{L2} = \frac{3(24,000)(20)^3}{2\pi(20.9)^5}$

P_{L1} = 28.6 psf P_{L2} = 23.0 psf

$P_L = P_{L1} + P_{L2}$ = 51.6 psf @ 20' depth

@ 10' depth
Z = 10'
R_1 = 10'

$R_2 = \sqrt{6^2 10^2}$ = 11.7'

$P_{L1} = \frac{3(24,000)(10)^3}{2\pi(10)^5}$ $P_{L2} = \frac{3(24,000)(10)^3}{2\pi(11.7)^5}$

P_{L1} = 114.6 psf P_{L2} = 52.3 psf
P_L = 166.9 psf @ 10' depth

c) P_i = external pressure due to vacuum
= 0 due to gravity flow

Thus, $P_t = P_s + P_L + P_i$
@ 20' depth: P_t = 2,400 + 51.6
= 2,451.6 psf

@ 10' depth: P_t = 1,200 + 166.9 = 1,366.9 psf

Worst case is @ 20' depth:

P_t = 2,451.6 psf
or 17.0 psi

For a full cell:
@ Z = 70', P_t ~ 0 psf

2) Design for Wall Crushing

$$S_A = \frac{(SDR-1)}{2} P_t$$

Where: S^A = Actual compressive stress
SDR = Standard dimension ratio
P_t = External pressure

Try SDR21:

$$S_A = \frac{(21-1)}{2} 17.0 = 170 \text{ psi}$$

$$\text{Safety factor} = \frac{1500 \text{ psi}}{S_A}$$

Where 1500 psi is compressive yield strength of Driscopipe

$$S.F. = \frac{1500}{170} = 8.8 \text{ OK}$$

3) Design for Wall Buckling

$$P_c = \frac{2.32\ E}{(SDR)^3}$$

Where: P_c = Hydrostatic, critical collapse differential pressure
E = Tensile modulus of elasticity

From Chart 25 pg 53 @ S_A = 170 psi,
E = 30,000 psi @ 170 psi
or 50 years @ 73.4°F

$$P_c = \frac{2.32(30,000)}{(21)^3} = 7.5 \text{ psi}$$

$$P_{cb} = 0.8 \sqrt{E' x P_c}$$

Where: P_{cb} = Critical buckling pressure
E' = Soil Modulus

Assume E'_{min} = 1,000 psi

$$P_{cb} = 0.8\sqrt{1000 \times 8} = 71.6 \text{ psi}$$

$$\text{Safety Factory} = \frac{P_{cb}}{P_t} = \frac{71.6}{17.0} = 4.2 \text{ OK}$$

4) Design for Ring Deflection

Pipe deflection equals soil strain, E_s

$$E_s = \frac{P_t}{E'_{min}} \times 100\% = \frac{17.0}{1000} \times 100 = 1.7\%$$

From Chart 27, page 55 allowable ring deflection for SDR21 equals 5.2%.

$$\text{Thus, Safety factor} = \frac{5.2}{1.7} = 3.1 \text{ OK}$$

Thus, use SDR21 for Leachate Header Pipes

B. Leachate Collection Pipes: The collection pipes are placed in the center of each lined cell. The 8-inch perforated pipe will be surrounded by 6 inches of #57 gravel. Twelve inches of sand will be placed over this prior to the placement of waste. A H2O live loading was assumed.

1) $P_t = P_s + P_L + P_i$

Where: P_t = total external pressure
a) P_s = Static load pressure
b) P_L = Dynamic load pressure
c) P_i = External Pressure due to vacuum

a) $P_s = P_{DE} + P_{WE} + P_{SW}$

Where: P_{DE} = Moist earth load pressure
P_{WE} = Saturated earth load pressure
P_{SW} = Waste load pressure

For an empty cell: -> assume sand is saturated ($132^{lb/ft^3}$) and gravel's unit weight is ($120^{lb/ft^3}$)

P_{DE}= 0.5'($120^{lb/ft^3}$) + 1.0'($132^{lb/ft^3}$)
= 192 psf

For a full cell:
Unit weight of saturated garbage is $70^{lb/ft^3}$

$P_s = P_{Sempty} + P_{SW}$
$= 192 + 70'(70^{lb/ft^3}) = 5,092$ psf

b) P_L = Dynamic Load Pressure
-> and H2O loading is assumed

$$P_L = \frac{3WZ^3}{2\pi R^5}$$

Where: W = 1.5 times the dynamic load
Z = vertical distance from pt. load to the top of pipe
R = straight line distance from pt. load to top of pipe

For empty cell:

W = 24,000 lbs.
Z = 1.5'
R_1 = 1.5' for inside wheel

$$R_2 = \sqrt{x^2+y^2+z^2}$$

$R_2 = \sqrt{6^2+1.5^2} = 6.2'$ for outside wheel

$$P_{L1} = \frac{3(24,000)(1.5)^3}{2\pi(1.5)^5} \quad P_{L2} = \frac{3(24,000)(1.5)^3}{2\pi(6.2)^5}$$

$P_{L1} = 5,093.0$ psf $P_{L2} = 4.2$ psf
$P_L = P_{L1} + P_{L2} = 5,097.2$ psf

c) P_i = external pressure due to vacuum = 0

Thus, $P_t = P_s + P_L + P_i$

for an empty cell:

$P_t = 192 + 5,097.2 + 0 = 5,289.2$ psf

For a full cell:

P_t = 5,092 psf

Worst case is a empty cell:

. . P_t = 5,289.2 psf or 36.7 psi

2) Design for Wall Crushing

$$S_A = \frac{(SDR-1)}{2} P_t$$

Where: S^A = Actual compressive stress
SDR = Standard dimension ratio
P_t = External pressure

Try SDR21:

$$S_A = \frac{(21-1)}{2} 36.7 = 367 \text{ psi}$$

$$\text{Safety factor} = \frac{1500 \text{ psi}}{S_A}$$

Where 1500 psi is compressive yield strength of Driscopipe

$$\text{S.F.} = \frac{1500}{367} = 4.1 \text{ OK}$$

3) Design for Wall Buckling

$$P_c = \frac{2.32 E}{(SDR)^3}$$

Where: P_c = Hydrostatic, critical collapse differential pressure
E = Tensile modulus of elasticity

From Chart 25 page 53 @ S_A = 367 psi,
E = 22,500 psi @ 367 psi for 50 years @ 73.4°F

$$P_c = \frac{2.32(22,500)}{(21)^3} = 5.6 \text{ psi}$$

$$P_{cb} = 0.8 \sqrt{E' \times P_c}$$

Where: P_{cb} = Critical Buckling Pressure
E' = Soil Modulus

Assume E'_{min} = 2000 psi

$$P_{cb} = 0.8\sqrt{2000 \times 5.6}$$
$$= 84.7 \text{ psi}$$

$$\text{Safety Factory} = \frac{P_{cb}}{P_t} = \frac{84.7}{36.7} = 2.3 \text{ OK}$$

4) Design for Ring Deflection

Pipe deflection is equal to soil strain, E_s

$$E_s = \frac{P_t}{E'_{min}} \times 100\% = \frac{36.7}{2000} \times 100$$
$$= 1.8\%$$

From Chart 27, Page 55 ->
Allowable ring deflection for SDR21 is equal to 5.2%

$$\text{Thus, Safety Factor} = \frac{5.2}{1.8} = 2.9 \text{ OK}$$

∴ use SDR21 for Leachate Collection Pipes

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HAYWOOD COUNTY WHITE OAK LANDFILL
OPEN CONDITIONS - CELL NO. 1
MARCH 30, 1992

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BARE GROUND

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000189999992 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	180.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2942 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999980 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4570 VOL/VOL
FIELD CAPACITY	=	0.1309 VOL/VOL

WILTING POINT	=	0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2466 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001000000047 CM/SEC

LAYER 4

LATERAL DRAINAGE LAYER

THICKNESS	=	0.25 INCHES
POROSITY	=	0.9000 VOL/VOL
FIELD CAPACITY	=	0.0520 VOL/VOL
WILTING POINT	=	0.0490 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0520 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	1.000000000000 CM/SEC
SLOPE	=	8.00 PERCENT
DRAINAGE LENGTH	=	340.0 FEET

LAYER 5

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00010000

LAYER 6

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4096 VOL/VOL
FIELD CAPACITY	=	0.2466 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1641 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000009500000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	91.61
TOTAL AREA OF COVER	=	142800. SQ FT
EVAPORATIVE ZONE DEPTH	=	21.00 INCHES
POTENTIAL RUNOFF FRACTION	=	0.800000

UPPER LIMIT VEG. STORAGE	=	10.6920 INCHES
INITIAL VEG. STORAGE	=	7.4437 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	74.5813 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

USER SPECIFIED RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR ASHEVILLE NORTH CAROLINA

MAXIMUM LEAF AREA INDEX	= 3.30
START OF GROWING SEASON (JULIAN DATE)	= 110
END OF GROWING SEASON (JULIAN DATE)	= 296

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.80	39.10	46.40	55.70	63.30	69.80
73.20	72.60	66.90	56.00	46.40	39.30

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 79

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.07	3.67	6.39	4.03	5.88	4.66
	3.81	3.29	4.29	3.17	4.18	4.41
STD. DEVIATIONS	1.65	2.62	2.05	2.40	4.05	2.14
	2.60	1.51	2.84	1.54	0.96	0.93
RUNOFF						
TOTALS	0.657	0.510	0.920	0.842	1.155	0.448
	0.351	0.181	0.471	0.321	0.341	0.685
STD. DEVIATIONS	0.401	0.636	0.953	0.990	1.524	0.344
	0.356	0.312	0.613	0.273	0.245	0.350
EVAPOTRANSPIRATION						
TOTALS	1.301	1.844	2.949	3.306	4.819	4.693
	3.622	3.446	2.506	2.245	1.707	1.251

STD. DEVIATIONS	0.272	0.240	0.070	0.613	1.272	1.260
	1.427	1.586	1.208	0.776	0.408	0.280

LATERAL DRAINAGE FROM LAYER 4

TOTALS	0.6121	0.9173	1.3402	1.5438	1.4944	1.1851
	0.9902	0.8219	0.6796	0.6286	0.5736	0.6164
STD. DEVIATIONS	0.1194	0.2793	0.5720	0.7895	0.6887	0.4842
	0.3465	0.2527	0.1866	0.1793	0.2036	0.3077

PERCOLATION FROM LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION FROM LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 79

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	52.88 (13.501)	629272.	100.00
RUNOFF	6.883 (3.352)	81902.	13.02
EVAPOTRANSPIRATION	33.690 (4.525)	400911.	63.71
LATERAL DRAINAGE FROM LAYER 4	11.4031 (4.1092)	135697.	21.56
PERCOLATION FROM LAYER 5	0.0001 (0.0000)	1.	0.00
PERCOLATION FROM LAYER 6	0.0001 (0.0000)	1.	0.00
CHANGE IN WATER STORAGE	0.904 (3.185)	10760.	1.71

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 79

	(INCHES)	(CU. FT.)
PRECIPITATION	5.80	69020.0
RUNOFF	3.204	38126.1
LATERAL DRAINAGE FROM LAYER 4	0.0828	985.6
PERCOLATION FROM LAYER 5	0.0000	0.0
HEAD ON LAYER 5	0.1	
PERCOLATION FROM LAYER 6	0.0000	0.0
SNOW WATER	2.46	29274.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4305

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1372

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FINAL WATER STORAGE AT END OF YEAR 79

LAYER	(INCHES)	(VOL/VOL)
1	5.00	0.4170
2	62.03	0.3446
3	5.65	0.2354
4	0.04	0.1682
5	10.32	0.4300
6	1.97	0.1641
SNOW WATER	0.00	

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HAYWOOD COUNTY WHITE OAK LANDFILL
CLOSED CONDITIONS
MARCH 30, 1992

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GOOD GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.5010 VOL/VOL
FIELD CAPACITY	=	0.2837 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2837 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000797999965 CM/SEC

LAYER 2

BARRIER SOIL LINER

THICKNESS	=	18.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	180.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL

WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2766 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4096 VOL/VOL
FIELD CAPACITY	=	0.2466 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2466 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000009500000 CM/SEC

LAYER 5

VERTICAL PERCOLATION LAYER

THICKNESS	=	180.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2766 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 6

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4096 VOL/VOL
FIELD CAPACITY	=	0.2466 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2466 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000009500000 CM/SEC

LAYER 7

VERTICAL PERCOLATION LAYER

THICKNESS	=	180.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2766 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 8

LATERAL DRAINAGE LAYER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4096 VOL/VOL
FIELD CAPACITY	=	0.2466 VOL/VOL
WILTING POINT	=	0.1353 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2466 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000009500000 CM/SEC

LAYER 9

LATERAL DRAINAGE LAYER

THICKNESS	=	0.25 INCHES
POROSITY	=	0.9000 VOL/VOL
FIELD CAPACITY	=	0.0510 VOL/VOL
WILTING POINT	=	0.0490 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0510 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	1.000000000000 CM/SEC
SLOPE	=	8.00 PERCENT
DRAINAGE LENGTH	=	340.0 FEET

LAYER 10

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.00010000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	74.98
TOTAL AREA OF COVER	=	435600. SQ FT
EVAPORATIVE ZONE DEPTH	=	21.00 INCHES
UPPER LIMIT VEG. STORAGE	=	3.0060 INCHES
INITIAL VEG. STORAGE	=	2.8461 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	177.9959 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

USER SPECIFIED RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR ASHEVILLE NORTH CAROLINA

MAXIMUM LEAF AREA INDEX = 3.30
START OF GROWING SEASON (JULIAN DATE) = 110
END OF GROWING SEASON (JULIAN DATE) = 296

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
36.80	39.10	46.40	55.70	63.30	69.80
73.20	72.60	66.90	56.00	46.40	39.30

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 79

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.07	3.67	6.39	4.03	5.88	4.66
	3.81	3.29	4.29	3.17	4.18	4.41
STD. DEVIATIONS	1.65	2.62	2.05	2.40	4.05	2.14
	2.60	1.51	2.84	1.54	0.96	0.93
RUNOFF						
TOTALS	3.810	2.016	2.827	1.781	1.540	0.420
	0.177	0.098	0.842	0.552	1.309	3.104
STD. DEVIATIONS	1.704	2.409	2.251	1.991	2.110	0.525
	0.434	0.241	1.443	0.687	1.316	1.144
EVAPOTRANSPIRATION						
TOTALS	1.358	1.888	3.019	3.359	4.391	4.353
	3.579	3.530	2.361	2.346	1.794	1.315
STD. DEVIATIONS	0.306	0.313	0.064	0.618	1.698	0.899
	1.535	1.632	1.072	0.864	0.475	0.295
PERCOLATION FROM LAYER 2						

TOTALS	0.1387	0.1185	0.1309	0.1138	0.0901	0.0528
	0.0353	0.0262	0.0341	0.0964	0.1115	0.1369
STD. DEVIATIONS	0.0010	0.0085	0.0054	0.0144	0.0267	0.0356
	0.0461	0.0399	0.0407	0.0539	0.0320	0.0032

LATERAL DRAINAGE FROM LAYER 9

TOTALS	0.0757	0.0696	0.0774	0.0757	0.0790	0.0772
	0.0804	0.0810	0.0789	0.0820	0.0798	0.0828
STD. DEVIATIONS	0.0173	0.0146	0.0145	0.0127	0.0118	0.0102
	0.0094	0.0083	0.0071	0.0064	0.0055	0.0050

PERCOLATION FROM LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 79

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	52.88	(13.501)	1919543.	100.00
RUNOFF	18.477	(9.493)	670722.	34.94
EVAPOTRANSPIRATION	33.292	(4.232)	1208514.	62.96
PERCOLATION FROM LAYER 2	1.0851	(0.2060)	39390.	2.05
LATERAL DRAINAGE FROM LAYER 9	0.9394	(0.1227)	34101.	1.78
PERCOLATION FROM LAYER 10	0.0001	(0.0000)	5.	0.00
CHANGE IN WATER STORAGE	0.171	(0.199)	6202.	0.32

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 79

	(INCHES)	(CU. FT.)
PRECIPITATION	5.80	210540.0

RUNOFF	4.535	164614.0
PERCOLATION FROM LAYER 2	0.0046	166.1
HEAD ON LAYER 2	6.6	
LATERAL DRAINAGE FROM LAYER 9	0.0028	100.8
PERCOLATION FROM LAYER 10	0.0000	0.0
HEAD ON LAYER 10	0.0	
SNOW WATER	2.46	89298.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5010

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1306

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FINAL WATER STORAGE AT END OF YEAR 79

LAYER	(INCHES)	(VOL/VOL)
1	2.99	0.4989
2	7.74	0.4300
3	49.97	0.2776
4	1.77	0.2947
5	49.71	0.2762
6	1.76	0.2936
7	49.63	0.2757
8	7.04	0.2933
9	0.01	0.0581
10	10.32	0.4300
SNOW WATER	0.00	

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RECEIVED
AUG 1 1991

OFFICE OF TOWN MANAGER

Town of Waynesville

July 31, 1991

Mr. Jack Horton
Haywood County Manager
Haywood County Courthouse
Main Street
Waynesville, NC 28786

Dear Mr. Horton:

Mr. Gary McKay has spoken to me concerning the feasibility of the Town of Waynesville Sewer Plant accepting leachate from the new Haywood County Landfill. This letter is to inform you that the Town is willing to work with the County in this matter.

Our plant has the capability to handle the expected quantities and disposal would be at our standard rate, assuming pretreatment by the Town is unnecessary.

We anticipate no problems in accepting and treating this waste. Let me know if further information or assistance is needed.

Sincerely,

William M. Sutton
Town Manager

WMS:pm

RECEIVED
MAR 9 1992
Tribble & Richardson, Inc.

Soil Loss - Post Closure

Project [illegible] Acct. No. _____ Page _____ of _____

Subject SOIL LOSS CALCULATIONS Comptd. By NED Date 30 MAR 92

Detail N/A Ck'd. By _____ Date _____

OBJECT: APPROXIMATE QUANTITIES OF COVER MATERIAL ANTICIPATED TO BE LOST TO EROSION DURING POST CLOSURE CARE PERIOD.

DESIGN: USING THE UNIVERSAL SOIL LOSS EQUATION, REFERENCING THE EROSION AND SEDIMENT CONTROL HANDBOOK, McGRAW-HILL PUBLISHING CO., 1986.

- UNIVERSAL SOIL LOSS EQN:

$$A = (R)(K)(LS)(C)(P)$$

Where:

A = SOIL LOSS IN TN./ACRE/YEAR

R = RAINFALL EROSION INDEX

K = SOIL ERODIBILITY FACTOR

LS = SLOPE LENGTH AND STEEPNESS FACTOR

C = VEGETATIVE COVER FACTOR

P = EROSION CONTROL PRACTICE FACTOR

- DESIGN INPUT:

R = 250 (REF. PG. 5.9 FIG. 5.2)

K = 0.02 → 0.69 (REF PG. 5.16 SECT. 5.2C)

LS = Assume 3:1 w/ 90' between BENCHS to be conservative (REF. PG. 5.20, 5.21, TABLE 5.5)

C = Assumed 90% COVER, ANNUAL GRASSES, NO MULCHES (REF. PG. 5.23, TABLE 5.6)

P = Assumed COMPACTED AND Smooth Grades. (REF. PG. 5.24, TABLE 5.7)

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Project [illegible] Acct. No. [illegible] Page 1 of

Subject SOIL LOSS CALCULATIONS Comptd. By NEO Date 30 MAY 12

Detail N/A Ck'd. By Date

EQN: $A = (R)(K)(LS)(C)(P)$

$= (250)(K)(8.95)(0.10)(1.30)$

WHERE K EQUALS	* A EQUALS
0.02	5.82
0.10	29.09
0.20	58.18
0.30	87.26
0.40	116.35
0.50	145.44
0.60	174.53
0.70	203.61

* SOIL LOSS IN TN./AC./YR.

TRIBBLE & RICHARDSON INC.

TABLE 5.2 USDA Soil Permeability Classes (14)

Class	Estimated inches/hour through saturated undisturbed cores under ½-in head of water
Very slow	Less than 0.06
Slow	0.06–0.2
Moderately slow	0.2–0.6
Moderate	0.6–2.0
Moderately rapid	2.0–6.0
Rapid	6.0–20
Very rapid	More than 20

5.2 USING THE UNIVERSAL SOIL LOSS EQUATION TO ESTIMATE SOIL LOSS

5.2a The Equation

The general form of the universal soil loss equation is:

$$A = R \times K \times \mathrm{LS} \times C \times P$$

where A = soil loss, tons/(acre) (year)
R = rainfall erosion index, in 100 ft · tons/acre × in/hr
K = soil erodibility factor, tons/acre per unit of R
LS = slope length and steepness factor, dimensionless
C = vegetative cover factor, dimensionless
P = erosion control practice factor, dimensionless

In metric units,

$$A \text{ (in t/ha)} = R \text{ (in J/ha)} \times K \text{ (in t/J)} \times \mathrm{LS} \times C \times P$$

To convert the English units of R (100 ft · tons/acre × in/hr) to a convenient metric equivalent, multiply R by 1.70. This yields R in units of 10^7 J/ha × mm/hr. Multiply English units of K by 1.32. The product will then be in units of tonnes/hectare. Alternatively, to convert A from tons/acre to tonnes/hectare, multiply by 2.24.

The soil loss is an estimated annual average. The rainfall erosion index contains both an energy component and an intensity component. The LS, C, and P factors are ratios of soil loss from the site to soil loss from a unit area of a standard plot with these characteristics: 72.6 ft (22.1 m) long, 9 percent slope, tilled, bare soil.

To calculate soil loss, each of the factors is assigned a numerical value. The

five factors are then multiplied together to produce an estimate of soil eroded from the site in an average year. When an estimate of required sediment storage volume is needed, the units of weight can be converted to volume by assuming a density for the sediment.

Careful evaluation of site characteristics is important to obtain reasonable soil loss estimates. Construction sites may vary from less than one acre to several hundred acres. Because soil erodibility varies greatly over large areas, a soil loss estimate is needed for each drainage area controlled by a sediment basin. A drainage area should be no larger than 100 acres (40 ha) and preferably much smaller. If a drainage area contains more than one soil type, it should be further subdivided into areas of homogeneous soil type. In addition, the length-slope LS, cover C, and surface condition P factors may differ with parts of a site. To produce the most accurate estimate, calculate soil loss separately for each homogeneous area (area of similar K, LS, C, and P) and add the estimates together.

Generally, a site can easily be divided into drainage areas served by a sediment basin or trap. Then, within each drainage area, homogeneous categories can be described, such as house pads, cut and fill slopes between pads, and unpaved road surfaces. Certain erosion control practices are associated with each one of these categories. House pads normally have a very gentle slope and a compacted surface which is not seeded, so LS, C, and P values should be the same for all of them. Slopes between pads are often at a 2:1 gradient, 20 to 40 ft (6 to 12 m) long, trackwalked and seeded. Examples of the use of these factors in the soil loss equation are provided in the following sections.

Note that the USLE assigns different meanings to two letters also used in the rational method runoff equation. The distinctions listed below must be kept clear to avoid miscalculations:

Symbol	Rational method	USLE
A	Acres (hectares)	Tons/acre (tonnes/hectare)
C	Runoff coefficient	Vegetative cover factor

5.2b Rainfall Erosion Index *R*

The rainfall erosion index R is a measure of the erosive force and intensity of rain in a normal year. The two components of the factor are the total energy E and the maximum 30-min intensity I_{30} of storms. The rainfall erosion index is the sum of the product $E \times I_{30}$ for all the major storms in an area during an average year. Values of R have been computed for the continental United States from rainfall records and probability statistics, so R should not be considered a precise factor for any given year or location. Its principal value, and that of the soil loss equation itself, is as a predictive tool and risk evaluator: Construction activities in areas with high R values will require greater attention to erosion

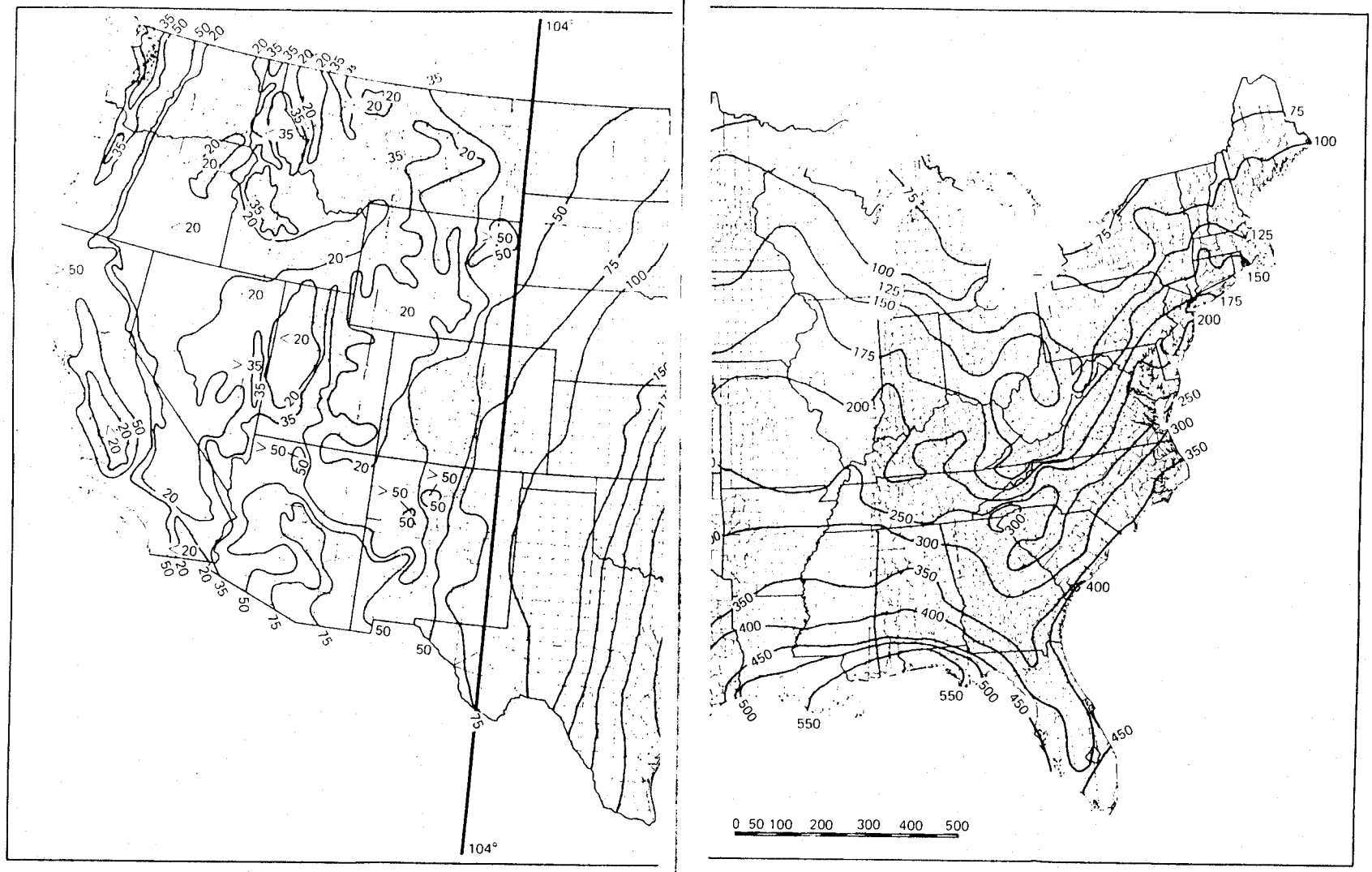

Fig. 5.2 R values for areas east of 104°. Because of irregular topography in the west United States, calculate R values in this region by using local rainfall data. R is in u of 100 ft · tons/acre per in/hr. To convert R to units of 10^7 J/ha per mm/hr, multiply 1.70. (20) Scale is in miles.

Solution: For type IA storm area,

$$R = 10.2p^{2.2} = 28.7$$
$$R_s = 1.5(27.6 \text{ in}) = 41.4 \qquad [0.059(701 \text{ mm}) = 41.4]$$
$$R_t = R_s + R = 28.7 + 41.4 = 70.1$$

5.2c Soil Erodibility Factor *K*

The soil erodibility factor K is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter, and permeability also contribute. K values range from 0.02 to 0.69.

Several methods can be used to estimate a K value for a site, but a nomograph method using analyses of site soils is the most reliable. If a recent soil survey for the area has been published and minimal soil disturbance is anticipated, the K value listed in the survey of the soil series found on the site can be used.

Nomograph Method

The preferred method for determining K values is the nomograph method. Use of the nomograph requires a particle size analysis to determine the percentages of sand, very fine sand, silt, and clay. The size range for each class is listed in Table 5.1. ASTM D-422 (1) is a standard hydrometer analysis for particle size distribution. (Specific particle sizes can be designated in the request for analysis. More typically, values are reported for specified size intervals, such as every 5 or 10 μm. The fee for a particle size analysis is normally only a small fraction of the total fee for a geotechnical report.)

The determination of the K value should be based on the soil exposed during the critical rainfall months. Subsoils exposed during grading will have K values different from the topsoil K value. On large sites, several samples should be taken and analyzed separately to ensure that differences in soil texture are detected. If fill is imported, this material also should be characterized.

The more carefully the site soils are characterized, the more accurate the K values will be. If analysis indicates significant variation in soil erodibility, it might be advisable to use different K values for different parts of the site and to focus erosion control efforts on the most susceptible areas. A simpler and more conservative approach is to use the highest value obtained by analysis for all parts of the site, since it may not be possible to know exactly what soils will be exposed or how varied the soils are.

A nomograph developed by Erickson of the SCS-Utah office (6), based on the original nomograph provided by Wischmeier (21), is reproduced in Fig. 5.6. To use the nomograph, enter the triangle with any two of the particle size percents: total sand and silt; silt and clay; or clay and total sand. Use whole numbers. Follow the dashed straight lines to their point of intersection. From that point, follow parallel to the dotted curves to the right side of the triangle, where the K values are listed.

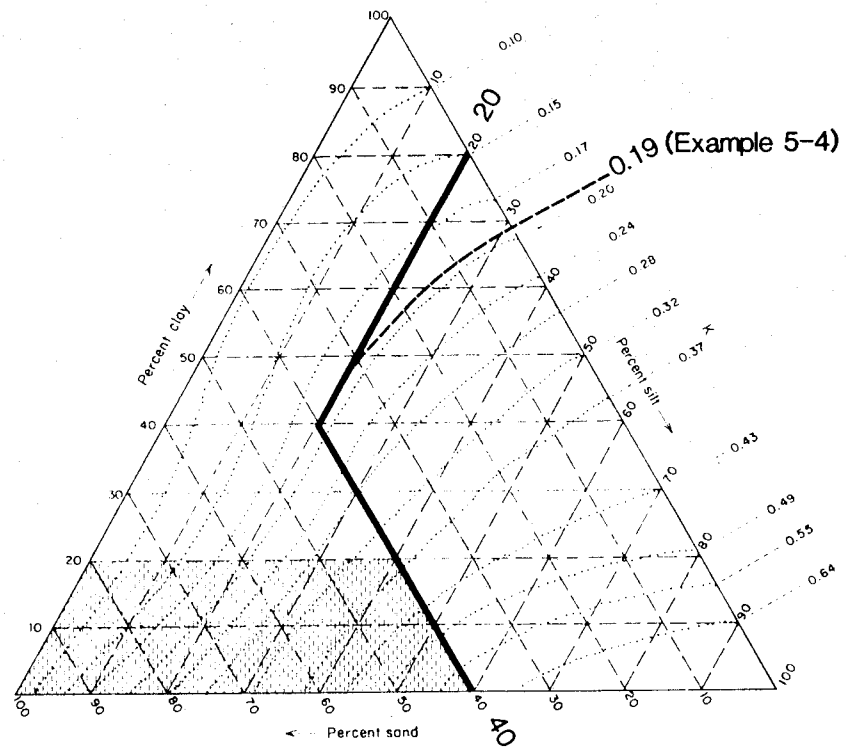

Fig. 5.6 Triangular nomograph for estimating K value. (6) See Table 5.3 for adjustments to K value under certain conditions.

EXAMPLE 5.4

Given: A soil with the following particle size distribution.

Component	Size, mm	Fraction, %
Sand	2.0–0.1	30
Very fine sand	0.1–0.05	10
Silt	0.05–0.002	20
Clay	Less than 0.002	40

Find: Texture and K value.

Solution: Entering Fig. 5.1 with 40 percent total sand and 20 percent silt, the texture is found to be on the border between clay and clay loam. Entering Fig. 5.6 with the same percents (see bold lines), the K value is found to be 0.19.

Table 5.3 describes adjustments to the K factor. Adjustment 1 is a correction for very

TABLE 5.5 LS Values* (10)

Slope ratio	Slope gradient s, %	LS values for following slope lengths l, ft (m)									
		10 (3.0)	20 (6.1)	30 (9.1)	40 (12.2)	50 (15.2)	60 (18.3)	70 (21.3)	80 (24.4)	90 (27.4)	100 (30.5)
	0.5	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.10
100:1	1	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.12
	2	0.10	0.12	0.14	0.15	0.16	0.17	0.18	0.19	0.19	0.20
	3	0.14	0.18	0.20	0.22	0.23	0.25	0.26	0.27	0.28	0.29
	4	0.16	0.21	0.25	0.28	0.30	0.33	0.35	0.37	0.38	0.40
20:1	5	0.17	0.24	0.29	0.34	0.38	0.41	0.45	0.48	0.51	0.53
	6	0.21	0.30	0.37	0.43	0.48	0.52	0.56	0.60	0.64	0.67
	7	0.26	0.37	0.45	0.52	0.58	0.64	0.69	0.74	0.78	0.82
12½:1	8	0.31	0.44	0.54	0.63	0.70	0.77	0.83	0.89	0.94	0.99
	9	0.37	0.52	0.64	0.74	0.83	0.91	0.98	1.05	1.11	1.17
10:1	10	0.43	0.61	0.75	0.87	0.97	1.06	1.15	1.22	1.30	1.37
	11	0.50	0.71	0.86	1.00	1.12	1.22	1.32	1.41	1.50	1.58
8:1	12.5	0.61	0.86	1.05	1.22	1.36	1.49	1.61	1.72	1.82	1.92
	15	0.81	1.14	1.40	1.62	1.81	1.98	2.14	2.29	2.43	2.56
6:1	16.7	0.96	1.36	1.67	1.92	2.15	2.36	2.54	2.72	2.88	3.04
5:1	20	1.29	1.82	2.23	2.58	2.88	3.16	3.41	3.65	3.87	4.08
4½:1	22	1.51	2.13	2.61	3.02	3.37	3.69	3.99	4.27	4.53	4.77
4:1	25	1.86	2.63	3.23	3.73	4.16	4.56	4.93	5.27	5.59	5.89
	30	2.51	3.56	4.36	5.03	5.62	6.16	6.65	7.11	7.54	7.95
3:1	33.3	2.98	4.22	5.17	5.96	6.67	7.30	7.89	8.43	8.95	9.43
	35	3.23	4.57	5.60	6.46	7.23	7.92	8.55	9.14	9.70	10.22
2½:1	40	4.00	5.66	6.93	8.00	8.95	9.80	10.59	11.32	12.00	12.65
	45	4.81	6.80	8.33	9.61	10.75	11.77	12.72	13.60	14.42	15.20
2:1	50	5.64	7.97	9.76	11.27	12.60	13.81	14.91	15.94	16.91	17.82
	55	6.48	9.16	11.22	12.96	14.48	15.87	17.14	18.32	19.43	20.48
1¾:1	57	6.82	9.64	11.80	13.63	15.24	16.69	18.03	19.28	20.45	21.55
	60	7.32	10.35	12.68	14.64	16.37	17.93	19.37	20.71	21.96	23.15
1½:1	66.7	8.44	11.93	14.61	16.88	18.87	20.67	22.32	23.87	25.31	26.68
	70	8.98	12.70	15.55	17.96	20.08	21.99	23.75	25.39	26.93	28.39
	75	9.78	13.83	16.94	19.56	21.87	23.95	25.87	27.66	29.34	30.92
1¼:1	80	10.55	14.93	18.28	21.11	23.60	25.85	27.93	29.85	31.66	33.38
	85	11.30	15.98	19.58	22.61	25.27	27.69	29.90	31.97	33.91	35.74
	90	12.02	17.00	20.82	24.04	26.88	29.44	31.80	34.00	36.06	38.01
	95	12.71	17.97	22.01	25.41	28.41	31.12	33.62	35.94	38.12	40.18
1:1	100	13.36	18.89	23.14	26.72	29.87	32.72	35.34	37.78	40.08	42.24

*Calculated from

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065\right)\left(\frac{l}{72.5}\right)^m$$

LS = topographic factor
l = slope length, ft (m × 0.3048)
s = slope steepness,
m = exponent dependent upon slope steepness (0.2 for slopes < 1%, 0.3 for slopes 1 to 3%, 0.4 for slopes 3.5 to 4.5%, and 0.5 for slopes > 5%)

LS values for following slope lengths l, ft (m)												
150 (46)	200 (61)	250 (76)	300 (91)	350 (107)	400 (122)	450 (137)	500 (152)	600 (183)	700 (213)	800 (244)	900 (274)	1000 (305)
0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15
0.14	0.14	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.20
0.23	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.34	0.36	0.37	0.39	0.40
0.32	0.35	0.38	0.40	0.42	0.43	0.45	0.46	0.49	0.51	0.54	0.55	0.57
0.47	0.53	0.58	0.62	0.66	0.70	0.73	0.76	0.82	0.87	0.92	0.96	1.00
0.66	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.31	1.42	1.51	1.60	1.69
0.82	0.95	1.06	1.16	1.26	1.34	1.43	1.50	1.65	1.78	1.90	2.02	2.13
1.01	1.17	1.30	1.43	1.54	1.65	1.75	1.84	2.02	2.18	2.33	2.47	2.61
1.21	1.40	1.57	1.72	1.85	1.98	2.10	2.22	2.43	2.62	2.80	2.97	3.13
1.44	1.66	1.85	2.03	2.19	2.35	2.49	2.62	2.87	3.10	3.32	3.52	3.71
1.68	1.94	2.16	2.37	2.56	2.74	2.90	3.06	3.35	3.62	3.87	4.11	4.33
1.93	2.23	2.50	2.74	2.95	3.16	3.35	3.53	3.87	4.18	4.47	4.74	4.99
2.35	2.72	3.04	3.33	3.59	3.84	4.08	4.30	4.71	5.08	5.43	5.76	6.08
3.13	3.62	4.05	4.43	4.79	5.12	5.43	5.72	6.27	6.77	7.24	7.68	8.09
3.72	4.30	4.81	5.27	5.69	6.08	6.45	6.80	7.45	8.04	8.60	9.12	9.62
5.00	5.77	6.45	7.06	7.63	8.16	8.65	9.12	9.99	10.79	11.54	12.24	12.90
5.84	6.75	7.54	8.26	8.92	9.54	10.12	10.67	11.68	12.62	13.49	14.31	15.08
7.21	8.33	9.31	10.20	11.02	11.78	12.49	13.17	14.43	15.58	16.66	17.67	18.63
9.74	11.25	12.57	13.77	14.88	15.91	16.87	17.78	19.48	21.04	22.49	23.86	25.15
11.55	13.34	14.91	16.33	17.64	18.86	20.00	21.09	23.10	24.95	26.67	28.29	29.82
12.52	14.46	16.16	17.70	19.12	20.44	21.68	22.86	25.04	27.04	28.91	30.67	32.32
15.50	17.89	20.01	21.91	23.67	25.30	26.84	28.29	30.99	33.48	35.79	37.96	40.01
18.62	21.50	24.03	26.33	28.44	30.40	32.24	33.99	37.23	40.22	42.99	45.60	48.07
21.83	25.21	28.18	30.87	33.34	35.65	37.81	39.85	43.66	47.16	50.41	53.47	56.36
25.09	28.97	32.39	35.48	38.32	40.97	43.45	45.80	50.18	54.20	57.94	61.45	64.78
26.40	30.48	34.08	37.33	40.32	43.10	45.72	48.19	52.79	57.02	60.96	64.66	68.15
28.35	32.74	36.60	40.10	43.31	46.30	49.11	51.77	56.71	61.25	65.48	69.45	73.21
32.68	37.74	42.19	46.22	49.92	53.37	56.60	59.66	65.36	70.60	75.47	80.05	84.38
34.77	40.15	44.89	49.17	53.11	56.78	60.23	63.48	69.54	75.12	80.30	85.17	89.78
37.87	43.73	48.89	53.56	57.85	61.85	65.60	69.15	75.75	81.82	87.46	92.77	97.79
40.88	47.20	52.77	57.81	62.44	66.75	70.80	74.63	81.76	88.31	94.41	100.13	105.55
43.78	50.55	56.51	61.91	66.87	71.48	75.82	79.92	87.55	94.57	101.09	107.23	113.03
46.55	53.76	60.10	65.84	71.11	76.02	80.63	84.99	93.11	100.57	107.51	114.03	120.20
49.21	56.82	63.53	69.59	75.17	80.36	85.23	89.84	98.42	106.30	113.64	120.54	127.06
51.74	59.74	66.79	73.17	79.03	84.49	89.61	94.46	103.48	111.77	119.48	126.73	133.59

Length	100 ft (30.5 m)	100 ft (30.5 m)	100 ft (30.5 m)
Slope	3:1	2:1	1.5:1
LS	9.43	17.82	26.68
Factor increase	1	1.9	2.8

The effect of length is not as great as the effect of slope angle: LS increases 30 to 50 percent for each doubling of length. For example, on a 2:1 slope, LS doubles when L is quadrupled:

Slope	2:1	2:1	2:1
Length	30 ft (9.1 m)	60 ft (18.3 m)	120 ft (36.6 m)
LS	9.76	13.81	19.42
Factor increase	1	1.4	2

Thus, very long slopes and especially, long, steep slopes, should not be constructed. Those that already exist should not be disturbed.

Slope length can be shortened by installing midslope diversions. Local building codes often require terraces or drainage ditches at specified intervals. Chapter 70 of the *Uniform Building Code* specifies a 30-ft (9.1-m) interval. (9) Several erosion control manuals recommend 15-ft (4.6-m) intervals between terraces. (2, 18). Because these intervals are defined as vertical rise, the slope length would be somewhat longer.

Decreasing steepness will require use of more land and so must be incorporated early in the project design. To ensure slope stability, a maximum gradient is frequently recommended by the soils engineer.

5.2e Cover Factor *C*

The cover factor C is defined as the ratio of soil loss from land under specified crop or mulch conditions to the corresponding loss from tilled, bare soil. The C is *not* the same as the runoff coefficient C used in the rational method.

In the USLE, the C factor reduces the soil loss estimate according to the effectiveness of vegetation and mulch at preventing detachment and transport of soil particles. On construction sites, recommended control practices include the seeding of grasses and the use of mulches. These measures are often considered "temporary"—they are designed to control erosion primarily during the construction period. Permanent landscaping may be added later, or temporary erosion control plants may be left as a permanent cover. Any product that reduces the amount of soil exposed to raindrop impact will reduce erosion. Table 5.6 lists C factors for various ground covers. The C values for vegetation were obtained from USDA publications (14, 20); those for mulch were obtained from Burgess Kay at the University of California, Davis, who tested materials on experimental plots under a rainfall simulator. (11)

When the soil surface is bare, C is 1.0. At the other end of the scale, undisturbed native vegetation is assigned a value of 0.01; hence the advantage of retaining as much existing vegetation as possible is clear. A C value of 0.1 is used

TABLE 5.6 *C* Values for Soil Loss Equation*

Type of cover	*C* factor	Soil loss reduction, %
None	1.0	0
Native vegetation (undisturbed)	0.01	99
Temporary seedings:		
90% cover, annual grasses, no mulch	0.1	90
Wood fiber mulch, ¾ ton/acre (1.7 t/ha), with seed†	0.5	50
Excelsior mat, jute†	0.3	70
Straw mulch†		
1.5 tons/acre (3.4 t/ha), tacked down	0.2	80
4 tons/acre (9.0 t/ha), tacked down	0.05	95

*Adapted from Refs. 11, 15, and 20

†For slopes up to 2:1.

if a complete cover of newly seeded annual grasses is well established before the onset of rains.

In many areas, seed and wood fiber mulch are applied hydraulically shortly before the rainy season. The early rains cause the seeds to germinate, but a complete grass cover is not established until at least 4 weeks later. During the germination and early growth period, the wood fiber mulch provides only marginal protection. A C value of 0.5 is an appropriate average representing little protection initially and more thorough protection when the grass is well established.

On bare soils mulch can provide immediate reduction in soil loss, and it performs better than temporary seedings in some cases. Straw mulch is more effective than wood fiber mulch; it reduces loss about 80 percent (C value, 0.2) when it is applied at the rate of 3000 lb/acre (3.4 t/ha) and tacked down. Additional reduction is obtained with 8000 lb/acre (90 t/ha) of straw, but this rate may not be cost-effective.

Wood fiber mulch alone (without seed) provides very little soil loss reduction; it primarily helps seeds to become established so that the new grass can provide the erosion control. Other products, such as jute, excelsior, and paper matting, provide an intermediate level of protection; the C value equals approximately 0.3. Test results of various mulch treatments are presented in Chap. 6.

5.2f Erosion Control Practice Factor *P*

The erosion control practice factor P is defined as the ratio of soil loss with a given surface condition to soil loss with up-and-down-hill plowing. Practices that reduce the velocity of runoff and the tendency of runoff to flow directly downslope reduce the P factor. In agricultural uses of the USLE, P is used to describe plowing and tillage practices. In construction site applications, P reflects the roughening of the soil surface by tractor treads or by rough grading, raking, or disking.

TABLE 5.7 *P* Factors for Construction Sites (Adapted from Ref. 15)

Surface condition	*P* value
Compacted and smooth	1.3
Trackwalked along contour*	1.2
Trackwalked up and down slope†	0.9
Punched straw	0.9
Rough, irregular cut	0.9
Loose to 12-in (30-cm) depth	0.8

*Tread marks oriented up and down slope.

†Tread marks oriented parallel to contours, as in Figs. 6.9 and 6.10.

P values appropriate for construction sites are listed in Table 5.7.

- A surface that is compacted and smoothed by grading equipment is highly susceptible to sheet runoff and is assigned a *P* value of 1.3.
- Trackwalking is given a value of 1.2 if the vehicle traverses along the contour. The *P* value is relatively high because the depressions left by cross-slope tracking resemble up-and-down furrows and worsen runoff conditions.
- Trackwalking up and down slope reduces *P* to 0.9. The tread marks act as slope benches; they reduce runoff velocity and trap soil particles (see Fig. 6.10).
- Punched straw is assigned a *P* value of 0.9 because the action of punching the straw into the soil roughens the surface and creates a trackwalking effect.
- When the soil surface is disked or otherwise loosened to a depth of 1 ft, a slightly lower *P* value of 0.8 may be used. This condition is unlikely to occur on a construction site because compaction, not loosening, is required when fill slopes are constructed.

Clearly, changing the surface condition does not provide much direct reduction in soil loss; all the *P* values are close to 1.0. However, roughening the soil surface is essential before seeding because it greatly increases plant establishment (see Chap. 6) and thus also reduces the *C* factor. Vegetation, mulch, slope length, and gradient have far more significant effects on the erosion process and provide greater opportunities to reduce soil loss.

5.2g Combined Effects of LS, *C*, and *P*

Of the five factors in the USLE, the *R*, LS, and *C* factors have the widest range. Although *R* for a site is constant and *K* is essentially a constant, slope length and gradient, cover, and, to a limited extent, surface condition can be manipulated. Slope length and vegetative cover are the most effective and easily implemented measures.

Table 5.8 compares the effect on the soil loss estimates of varying LS, *C*, and *P*. For example, a building pad with a 1 percent slope, smooth surface, and no cover has a fractional soil loss potential. A 2:1 slope, common between terraced

TABLE 5.8 Combined Effects of LS, *C*, and *P* on Soil Loss

Slope gradient	Slope length	Surface condition	Ground cover	LS	*C*	*P*	Product LS × *C* × *P*	Reduction, %[a]
2:1	40 ft (12.2 m)	Smooth	Bare	11.27	1.0	1.3	14.65	—
2:1	40 ft (12.2 m)	Tracked; tread marks oriented up and down slope	Seed and wood fiber mulch, ¼ ton/acre (1.7 t/ha)	11.27	0.5	1.2	6.76	54
2:1	40 ft (12.2 m)	Tracked; tread marks parallel to contours	Seed and wood fiber mulch, ¼ ton/acre (1.7 t/ha)	11.27	0.5	0.9	5.07	65
2:1	20 ft (6.1 m)	Tracked; tread marks parallel to contours	Seed and wood fiber mulch, ¼ ton/acre (1.7 t/ha)	7.97	0.5	0.9	3.95	73
2:1	40 ft (12.2 m)	Tracked; tread marks parallel to contours	Punched straw, 1.5 tons/acre (3.4 t/ha)	11.27	0.2	0.9	2.03	86
2:1	20 ft (6.1 m)	Tracked; tread marks parallel to contours	Punched straw, 1.5 tons/acre (3.4 t/ha)	7.97	0.2	0.9	1.43	90
1%	100 ft (30.5 m)	Smooth	Bare	0.12	1.0	1.3	0.16	—

[a]Compared to the example on the first line (LS × *C* × *P* = 14.65).

Earthwork Calculations

Grid Based Earthworks: DCA DTM 386 Ver 11.0 : Project: 2913
HAYWOOD COUNTY SANITARY LANDFILL

SURFACE 1: BOTTOM GRADES (TOP/LINER)		**SURFACE 2: EXISTING GRADE**	
Min. X:	811794.4009	Min. X:	811393.9061
Min. Y:	720623.9933	Min. Y:	720542.5902
Min. X:	812667.1835	Min. X:	812718.8620
Min. Y:	722254.4810	Min. Y:	722384.8889
Random Points:	-	Random Points:	-
Fault Points:	-	Fault Points:	-
Contour Points:	6411	Contour Points:	30584
Total:	6411	Total:	30584
Min. Elev:	2400.0000	Min. Elev:	2374.0000
Max. Elev:	2648.0000	Max. Elev:	2650.0000
Mean Elev:	2520.7606	Mean Elev:	2523.7205

Grid Volume Status

Fill:	(Cu. Yds.):	35519.8
Cut:	(Cu. Yds.):	264574.7
Net Cut:	(Cu. Yds.):	229054.9
Complete:		100%

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Grid Based Earthworks: DCA DTM 386 Ver 11.0 : Project: 2913
HAYWOOD COUNTY SANITARY LANDFILL

SURFACE 1: TOP COVER **SURFACE 2: BOTTOM GRADES (TOP/LINER)**

Min. X:	811813.9314
Min. Y:	720719.6304
Min. X:	812363.4167
Min. Y:	712654.2318
Random Points:	-
Fault Points:	-
Contour Points:	986
Total:	986
Min. Elev:	2480.0000
Max. Elev:	2640.0000
Mean Elev:	2574.0994

Min. X:	811794.4009
Min. Y:	720623.9933
Min. X:	812667.1835
Min. Y:	722254.4810
Random Points:	-
Fault Points:	-
Contour Points:	6411
Total:	6411
Min. Elev:	2400.0000
Max. Elev:	2648.0000
Mean Elev:	2520.7606

Grid Volume Status

Fill: (Cu. Yds.):	478218.4
Cut: (Cu. Yds.):	0.0
Net Cut: (Cu. Yds.):	478218.4
Complete:	100%

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Appendix D

Erosion Control Notebook

EROSION & SEDIMENT CONTROL NOTEBOOK

FOR

WHITE OAK SANITARY LANDFILL

HAYWOOD COUNTY, NORTH CAROLINA

SEPTEMBER, 1991

TRIBBLE & RICHARDSON INC.

CONSULTING ENGINEERS
4020 WESTCHASE BLVD., SUITE 515
RALEIGH, NC 27607
Phone: (919) 828-4042

PROJ. NO. 2913-011-01

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Appendix B	Supporting Calculations
Appendix C	Supporting Figures and Tables Used from the Erosion and Sediment Control Planning and Design Manual

NARRATIVE

PROJECT DESCRIPTION

The ultimate use of the property will be a synthetically lined Balefill facility equipped with a leachate collection system. Approximately 19.8 acres of the 188-acre site will be disturbed during this construction period.

The site is located in Haywood County and within the Pisgah National Forest. The site is located off of State Road 1338 which is White Oak Road at its intersection with Interstate 40.

ADJACENT PROPERTY

Areas surrounding the site are wooded with residents scattered about.

TOPOGRAPHY

The site is characterized by 4 major ridgelines which are dissected by swales occupied by wet weather springs. The ridgelines are oriented generally in a north-south pattern. Ridgeline and valley elevations differ by as much as 100 to 125 feet across the site. The overall or general slope of the site is toward the north and northwest with increasing steepness as the site nears the Pigeon River. The highest point within the site is located along the southern property line at approximate elevation 2,651 feet (msl). The lowest point topographically is around elevation 2,260 feet along the northern property boundary.

GEOLOGY

The site and immediate vicinity are located in the eastern Blue Ridge Mountains, an area underlain by metamorphic rocks of Pre-Cambrian age. The rock units present include the Pre-Cambrian Basement Complex (which directly underlies the site), the Thunderhead Sandstone of the Great Smoky Group (which is in fault contact with the basement) and the Wading Branch Formation and the Longarm Quartzite of the Snowbird Group which unconformably overlies the basement a short distance west of the site. The Snowbird and Great Smoky Groups are part of the Ocoee Series.

The lithologic descriptions which follow were taken from Hadley and Goldsmith (1963).

The basement is comprised of a complex assemblage of plutonic rocks and layered gneiss (Hadley and Goldsmith, 1963). The plutonic rocks include massive augen gneiss, granitoid gneiss, and little foliated granitic rocks. The layered rocks are paragneiss derived from ancient sedimentary and possibly volcanic rocks and are defined throughout the Blue Ridge and Piedmont as the Carolina Gneiss.

The fill slope in the central portion of the property is the most vulnerable area for erosion on the site. Temporary diversions will be maintained at the top of this fill slope at all times. Filling will be done as a continuous operation until final grade is reached. The top 2 to 6 inches will be left in a loose and roughened condition. Plantings will be protected with mulch, as specified in the Vegetation Plan.

4. Sediment Fence--Practice 6.62

   A sediment fence will be constructed around the topsoil stockpile and South of the fill area access road leading to the access road.

5. Grass-Lined Channel--Practice 6.30

   Grass-lined channels will be constructed to collect and convey site water to the project's sediment basin. See Appendix B for calculations.

   Should the disturbed areas adjoining the channels not be stabilized at the time the channels are vegetated, a sediment fence will be installed adjacent to the channel to prevent channel siltation.

6. Outlet Stabilization Structure--Practice 6.41

   A riprap apron will be located at the outlet of all culverts to prevent scour. See Appendix B for calculations.

7. Surface Roughening--Practice 6.03

   The 3:1 cut slopes will be lightly roughened by disking just prior to vegetating, and the surface 4 to 6 inches of the 2:1 fill slopes will left in a loose condition and grooved on the contour.

8. Rip Rap and Paved Channels--Practice 6.31

   Channels with erosive resistant linings of riprap, paving, or other structural material designed for the conveyance and safe disposal of excess water.

9. Paved Flumes (Chutes)--Practice 6.33

   A small concrete-lined channel to convey water in a relatively steep slope.

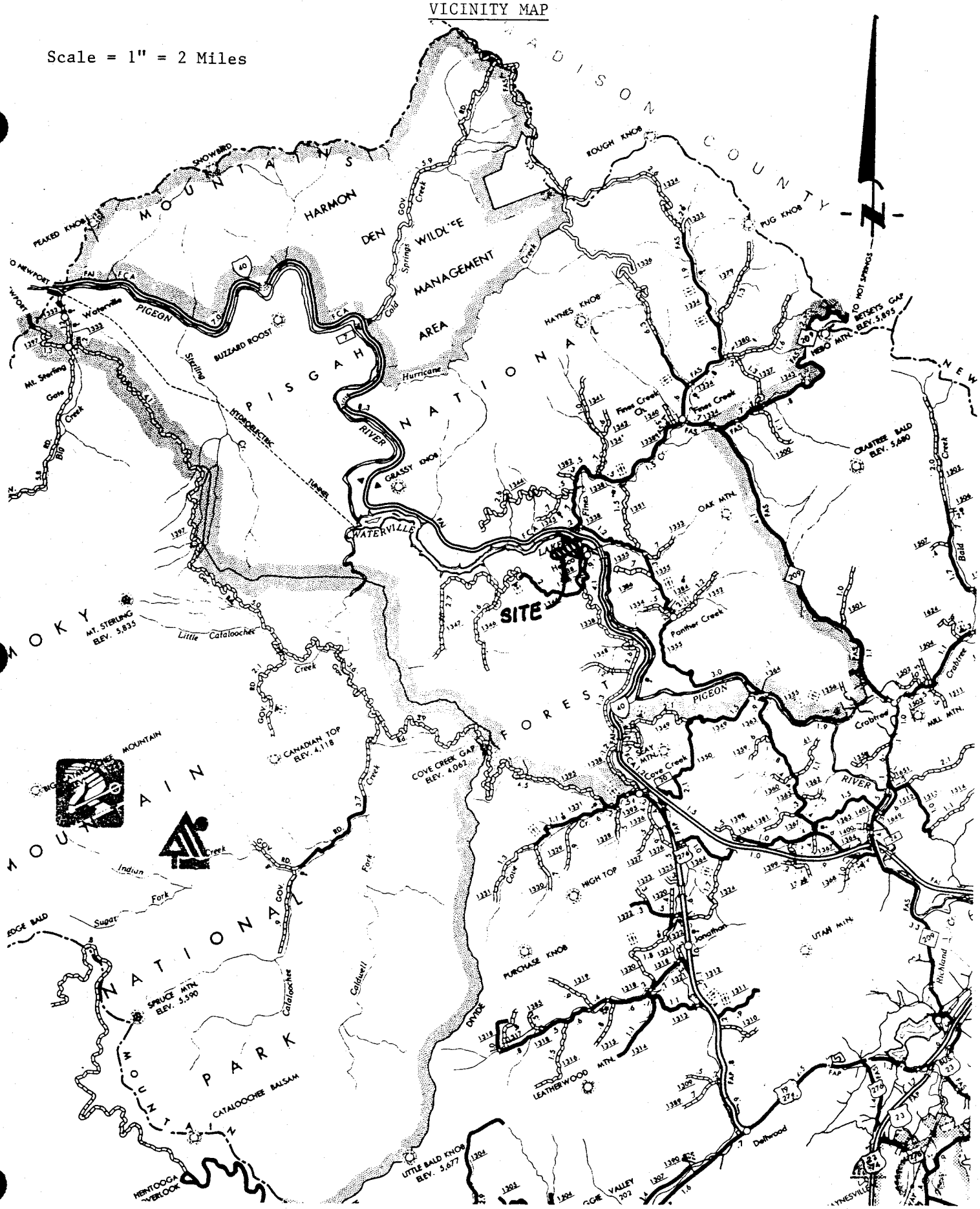
10. Check Dam--Practice 6.83

    Small temporary stone dams constructed across a drainage way.

11. Surface stabilization will be accomplished with vegetation and mulch as specified in the vegetation plan.

VICINITY MAP

Scale = 1" = 2 Miles



CONSTRUCTION SCHEDULE

1. Obtain plan approval and other applicable permits

2. Flag the work limits and buffer area.

3. Hold preconstruction conference at least one week prior to starting construction.

4. Install sediment basin as the first construction activity.

5. Rough grade site, stockpile topsoil, construct channels, and install sediment fence as needed. Maintain diversions along top of fill slope daily. Mulch bare areas should grading be discontinued for more than 3 weeks.

6. Complete final grading of grounds, topsoil critical areas, and permanently vegetate, landscape, and mulch.

7. All erosion and sediment control practices will be inspected weekly and after rainfall events. Needed repairs will be made immediately.

8. After site is stabilized, remove all temporary measures and install permanent vegetation on the disturbed areas.

9. Estimated time before final stabilization--3 months.

MAINTENANCE PLAN

1. All erosion and sediment control practices will be checked for stability and operation following every runoff-producing rainfall but in no case less than once every week. Any needed repairs will be made immediately to maintain all practices as designed.

2. The sediment basin will be cleaned out when the level of sediment reaches one-half pond depth as shown on the site gauge.

3. Sediment will be removed from behind the sediment fence when it becomes about 0.5 ft deep at the fence. The sediment fence will be repaired as necessary to maintain a barrier.

4. All seeded areas will be fertilized, reseeded as necessary, and mulched according to specifications in the vegetative plan to maintain a vigorous, dense vegetative cover.

The Wading Branch formation is the lower-most unit of the Snowbird Group and unconformably overlies the basement rocks. The type area is Wading Branch Ridge northwest of Walters Lake and consists of a 1,500 foot interval of dark fine to coarse-grained poorly sorted clastic rocks ranging from sandy slate to very coarse pebbly sandstone. The Longarm Quartzite conformably overlies the Wading Branch formation and is named for Longarm Mountain in the core of the Cataloochee Anticlinorium a few miles northwest of the site. The formation consists of several thousand feet of clean feldspathic quartzite and arkose. Being the most resistant unit within the Snowbird Group, the Longarm Quartzite forms several major ridges in the area including Longarm and Whiteoak Mountains.

The other prominent rock unit in the area is the Thunderhead Sandstone of the Great Smoky Group. The formation is named for Thunderhead Mountain on the crest of the Great Smoky Mountains west of the study area. The Thunderhead consists of 6,000 to 12,000 feet of medium-to-coarse-grained feldspathic sandstone or arkose but is interbedded with various amounts of arkosic pebble conglomerate, finer-grained feldspathic sandstone, argillaceous metasandstone, dark-gray slate. Within the study area the Thunderhead is apparently in fault contact with the basement complex.

PLANNED EROSION AND SEDIMENTATION CONTROL PRACTICES

1. Sediment Basin--Practice 6.61

   A sediment basin will be constructed in the northern region of the property. All water from disturbed areas, about 19.8 acres, will be directed to the basin before leaving the site. See pages 3 and 4 of the plans for details and Appendix B of this report for supporting calculations.

2. Construction Entrance/Exit--Practice 6.06

   A paved entrance exists at the site. Stormwater from the entrance area will be diverted through the sediment basin. This entrance will be provided by Haywood County during construction of the access road.

3. Land Grading --Practice 6.02

   Heavy grading will be required on approximately 40 acres. The flatter slope after grading will reduce the overall erosion potential of the site.

   All cut slopes will be 2:1 or flatter to avoid instability due to wetness.

   Fill slopes will be 2:1 or flatter with fill depths as much as 12 to 15 ft. Fill will be placed in layers not to exceed 6-8 inches in depth and compacted to 95% Standard Proctor.

VEGETATIVE PLAN

Seedbed Preparation (SP)

SP-1 Fill slopes 3:1 or steeper to be seeded with a hydraulic seeder (permanent seedings)

1) Leave the last 4-6 inches of fill loose and uncompacted, allowing rocks, roots, large clods and other debris to remain on the slope.

2) Roughen slope faces by making grooves 2-3 inches deep, perpendicular to the slope.

3) Spread lime evenly over slopes.

SP-2 Fill slopes 3;1 or steeper (temporary seedings)

(1) Leave a loose, uncompacted surface. Remove large clods, rocks, and debris.

(2) Spread lime and fertilizer evenly at the specified rates.

(3) Incorporate amendments by roughening or grooving soil surface on the contour.

SP-3 High maintenance turf

(1) Remove rocks and debris that could interfere with tillage and the production of a uniform seedbed.

(2) Apply lime and fertilizer evenly. Incorporate to a depth of 2-4" with a farm disk or chisel plow.

(3) Loosen the subgrade immediately prior to spreading topsoil by disking or scarifying to a depth of at least 2 inches.

(4) Spread topsoil to a depth of 2-4 inches and cultipack.

(5) Disk or harrow and rake to produce a uniform and well-pulverized surface.

(6) Loosen surface just prior to applying seed.

SP-4 Gentle or flat slopes where topsoil is not used.

(1) Remove rocks and debris.
(2) Apply lime and fertilizer spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller.
(3) Break up large clods and rake into a loose, uniform seedbed.
(4) Rake to loosen surface just prior to applying seed.

CONSTRUCTION SPECIFICATIONS FOR SEDIMENT POND

1. Remove the existing sediment pond's barrel and riser. Install silt fence as needed to prevent soil from eroding into creek.

2. Excavate pond to proposed grades.

3. Perforate 60" CMP riser with 5 rows of 3/4" holes spaced 3" apart. Secure trash rack to riser top. Maximum opening between bars of rack not to exceed 3". Install 48" CMP barrel.

4. Securely attach the riser to the barrel and all other pipe joints with rod and lug connector bands with rubber gaskets to assure water tightness. Place the barrel and riser on a smooth, firm foundation. Place fill around the pipe in 4" layers and hand compact. Take care not to raise the pipe from firm contact with its foundation when compacting under pipe haunches.

5. Secure one standard corrugated metal anti-seep collar around barrel. Make sure connection is watertight. Hand compact around anti-seep collar.

6. Place a minimum of 2 ft. of hand compacted backfill over pipe before crossing it with construction equipment.

7. Anchor riser in place with 12.7 CY concrete pad poured around riser.

8. Install emergency spillway to the grades shown on the plans.

9. Place class B erosion control stone over filter fabric on level grade riprap apron at pipe outlet. Top of riprap to be same elevation as outlet channel bottom. No overfall.

10. Clear sediment pool area to elevation 2420.0 after the embankment is complete.

11. Vegetate all disturbed areas (except the sediment pool) in accordance with vegetative plan.

12. Sediment to be removed from basin when the level is within one half pond depth.

CONSTRUCTION SPECIFICATIONS FOR THE DEWATERING DITCHES

1. Sediment Pond has been completed.

2. Initial excavation will begin at the entrance to the sediment pond. All material excavated will be used in areas where fill material is required or moved to the area marked "stockpile area."

3. A temporary silt fence will be put in place down slope of all fill areas.

Seeding Methods (SM)

SM-1 Fill slopes steeper than 3:1 (permanent seedings)

Use hydraulic seeding equipment to apply seed and fertilizer, a wood fiber mulch at 90 lb/1,000 ft^2, and mulch tackifer.

SM-2 gentle to flat slopes or temporary seedings

(1) Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.

(2) Rake seed into the soil and lightly pack to establish good contact.

Mulch (MU)

MU-1 Steep slopes (3:1 or greater)

In mid-summer, late fall or winter, apply 100 lb/1,000 ft^2 grain straw, anchor with 0.1 gal/yd^2 (11gal/1,000ft^2 asphalt). In spring or early fall use 90 lb/1,000 ft^2 wood fiber in a hydroseeder slurry.

MU-2 High-maintenance vegetation and temporary seedings

Apply 90 lb/1,000 ft^2 (4000 lb/acre) grain straw and tack with 0.1 gal/yd^2 asphalt (11 gal/1,000 ft^2).

MU-3 Grass-lined channels

Install excelsior mat in the channel, extend up the channel banks to the highest calculated depth of flow, and secure according to manufacturer's specifications.

On channel shoulders, apply 100 lb/1,000 ft^2 grain straw and anchor with 0.1 gal/yd^2 (11 gal/1,000 ft^2) asphalt.

Maintenance (MA)

MA-1 Refertilize in late winter or early spring the following year. Mow as desired

MA-2 Fertilize with 40 lb/acre (1 lb/1,000 ft^2) nitrogen in winter and again the following fall.

MA-3 Inspect and repair mulch and lining. Refertilize in late winter of the following year with 150 lb/acre 10-10-10 (3.5 lb/1,000 ft^2) nitrogen in March. If cover is needed through the following summer, overseed with 50 lb/acre.

CHANNEL CONSTRUCTION SPECIFICATIONS

1. Excavate the channel and shape it to an even cross-section as shown. When staking indicate a 0.2' overcut around the channel perimeter for silting and bulking.

2. Grade soil away from channel so that surface water may enter freely.

3. Apply lime, fertilizer and seed to the channel and adjoining areas in accordance with the vegetation plan.

4. Spread straw mulch at the rate of 100 lb/1,000 ft^2.

5. Hold mulch in place immediately after spreading with 0.1 gal/CY asphalt (11 gal/1,000 ft^2).

CONSTRUCTION SPECIFICATIONS FOR INSTALLING RIPRAP

1. Excavate below channel outlet and widen channel to the required riprap thickness for each apron. Foundation to be cut to zero grade and smoothed.

2. Place filter cloth on bottom and sides of prepared foundation. All joints to overlap a minimum of 1.0'.

3. Exercise care in riprap placement to avoid damage to filter fabric.

4. Place riprap on zero grade - top of riprap to be level with existing outlet - no overfall at ends.

5. Riprap to be hard, angular, well graded erosion control stone.

6. Immediately after construction stabilize all disturbed areas with vegetation as shown in vegetative plan.

Appendix A

FINANCIAL RESPONSIBILITY/OWNERSHIP FORM
SEDIMENTATION POLLUTION CONTROL ACT

No person may initiate any land-disturbing activity on one or more contiguous acres as covered by the Act before this form and an acceptable erosion and sedimentation control plan have been completed and approved by the Land Quality Section, N.C. Department of Natural Resources and Community Development. (Please type or print and, if question is not applicable, place N/A in the blank.)

Part A.

1. Project Name WHite Oak Sanitary Landfill

2. Location of land-disturbing activity: County Haywood, City or Township White Oak, and Highway / Street White Oak Road

3. Approximate date land-disturbing activity will be commenced: December 1991

4. Purpose of development (residential, commercial, industrial, etc.) : Balefill

5. Approximate acreage of land to be disturbed or uncovered : 10 - 19.8

6. Has an erosion and sedimentation control plan been filed ?Yes X No ____

7. Person to contact should sediment control issues arise during land-disturbing activity.

Name Mr. Jack Horton, County Manager Telephone (704) 452-6625

8. Landowner (s) of Record (Use blank page to list additional owners.):

Haywood County Board of Commissioners
Name (s)

Haywood County Courthouse Annex
420 N Main Street
Current Mailing Address

Waynesville, N.C. 28786
City State Zip

Current Street Address

City State Zip

9. Recorded in Deed Book No. ____ Page No. ____

Part B.

1. Person (s) or firms (s) who are financially responsible for this land-disturbing activity (Use the blank page to list additional persons or firms):

Haywood County Board of Commissioners
Name of Person (s)or Firm (s)

Haywood County Courthouse Annex
420 N. Main Street
Mailing Address

Waynesville, NC 28786
City State Zip

Telephone (704) 452-6625

Street Address

City State Zip

Telephone ____

APPENDIX B

Project HAYWOOD COUNTY LANDFILL Acct. No. 243-0 Page 1 of

Subject RUNOFF CALCULATIONS Comptd. By BNC Date 3-27-92

Detail N/A Ck'd. By Date

METHOD: PEAK DISCHARGE METHOD SCS TR-55 URBAN HYDROLOGY FOR SMALL WATERSHEDS.

A.) CALCULATE PEAK RUNOFF FOR SITE DURING DEVELOPMENT

- SITE DATA:

A.) LOCATION - HAYWOOD COUNTY, NC

B.) TOTAL WATERSHED - 30 ACRES

C.) HYDRAULIC LENGTH - 1950'

D.) AVG. WATERSHED SLOPE - STEEP - OVER 8%

E.) HYDROLOGIC SOIL GROUP - C (APPROX)

- WATERSHED CURVE NO. (TABLE 8.03a)

LAND USE	PERCENT	CN	PRODUCT
LANDFILL TYPE "D" (COVER, GOOD GRASS)	28.3	80	22.64
GRAVEL ROADS	4.3	85	3.66
GOOD MEADOWS	67.3	78	52.49
			78.79 ∴ 78.8

USE CURVE NO 79

- RAINFALL (FIG 8.03h & 8.03J)

2 YR, 24hr STORM : 3.4 IN
10 YR, 24hr STORM 5.5 IN
25 YR, 24hr STORM 6.3 IN
100 YR, 24 hr STORM 7.0 IN

- RUNOFF (TABLE 8.03c)

RUNOFF DEPTH: 2 yr 24 hr = 1.99 IN
" 10 YR 24 hr = 3.24 IN
" 25 yr 24 hr = 3.95 IN
" 100 yr 24 hr = 4.58 IN

- CALCULATE PEAK RUNOFF RATE

A) NO ADJUSTMENT FOR WATERSHED SHAPE, IMPERVIOUS AREA, CHANNEL IMPROVEMENTS OR PONDS ARE REQUIRED.

B) ADJUSTMENTS FOR STEEP SLOPES (> 8%) = 40 cfs/INCH OF RUNOFF FROM DRAINAGE AREA = 30 AC. (FIG. 8.03g)

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Project HAYWOOD COUNTY LANDFILL Acct. No. 291.5 Page 2 of

Subject RUNOFF CALCULATIONS Comptd. By BNC Date 3-27-92

Detail N/A Ck'd. By Date

C) DETERMINE ADJUSTED PEAK RUNOFF:

$Q_{2,24}$ = 40 cfs/INCH RUNOFF x 1.77 IN = 71 cfs

$Q_{10,24}$ = 40 cfs/INCH RUNOFF x 3.24 IN = 130 cfs

$Q_{25,24}$ = 40 cfs/INCH RUNOFF x 3.95 IN = 158 cfs

$Q_{100,24}$ = 40 cfs/INCH RUNOFF x 4.58 IN = 183 cfs

- ADJUST PEAK DISCHARGES FOR WATERSHED SLOPE (TABLE 8.03d)

$Q_{2,24}$ = 71 cfs x 1.12 = 80 cfs

$Q_{10,24}$ = 130 cfs x 1.12 = 146 cfs

$Q_{25,24}$ = 158 cfs x 1.12 = 177 cfs

$Q_{100,24}$ = 183 cfs x 1.12 = 205 cfs

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SEDIMENT BASIN CALCULATIONS

Project [illegible] CO SANITARY LANDFILL Acct. No. 2718-SIT-01 Page ___ of ___

Subject SEDIMENT BASIN DESIGN Comptd. By BNC Date 3-20-92

Detail N/A Ck'd. By ___ Date ___

I. ALL RUNOFF WILL BE DIVERTED TO THE BASIN. DETERMINE PEAK FLOWS FOR THE 25 YR, 24 HR STORM ($Q_{25,24}$)

A.) SEE RUNOFF CALCULATIONS:

$Q_{25,24}$ = 177 cfs

II. DETERMINE BASIN VOLUME REQD.:

A.) MIN. VOL. REQUIRED = 1800 ft^3/DISTURBED ACRE (STD & SPEC. 6.61)

V_R = 19.5 AC x 1800 ft^3/DIST ACRE

V_R = 35,100 ft^3

III DETERMINE VOL. PROVIDED

A.) HORIZONTAL AREA = 20,889 ft^2 @ EMBANKMENT ELEV.

B.) PER CONTOURS DETERMINE VOL. PER DEPTH

ELEV (ft)	AREA (ft^2)	DEPTH (FT)	ACCUM. STORAGE (ft^3)	
08.5	0	0	0	
10.0	8715	1.5	13073	
12.0	10905	3.5	32493	← EQUALS REQD VOL.
14.0	12990	5.5	55988	
16.0	15284	7.5	84062	
18.0	17836	9.5	117182	
20.0	20889	11.5	136545	

REQUIRED VOLUME WILL BE PROVIDED AT APPROX. ELEV 313.0 WHICH WILL BECOME CLEARED SEDIMENT POOL FOR THE 25 YR, 24 HR EVENT.

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Project [illegible] Acct. No. [illegible] Page 2 of ____

Subject SEDIMENT POND DESIGN Comptd. By BNC Date 3-26-92

Detail ____ Ck'd. By ____ Date ____

IV PRINCIPAL SPILLWAY DESIGN

A) MIN. CAPACITY SHOULD EQUAL 0.2 cfs PER DRAINAGE AREA ACRE

$Q_{MIN} = 30 AC \times 0.2 \text{ cfs/AC} = 6.0 \text{ cfs}$

B) DETERMINE PIPE FLOW

- ASSUME HEAD OF 2.15' ABOVE RISER INLET, TAILWATER ASSUMED AT SPRINGLINE OF PIPE.
- PROPOSE 100 YR EVENT FLOW BECAUSE THE EMBANKMENT WILL BE CONSTRUCTED WITH FILL MATERIAL.

∴ TRY 54" CMP BARREL

$$Q_P = A (2 \times g \times H)^{1/2} / (1 + k_m + K_P L)^{1/2}$$

$$Q_P = 15.9 (2 \times 32.2 \times 14)^{1/2} / (1 + 1 + [0.025 \times 120])^{1/2}$$

$Q_P = 213$ cfs > 205 cfs OK

C) DETERMINE RISER REQUIRED

- FROM FIG. 8.07b RISER 66" EQUALS 54" BARREL (EXTRAPOLATED)

RISER HEIGHT = 2 X DIA BARREL = $2 \times 54" = 9'$

D) DETERMINE CAPACITY OF RISER:

FROM FIG 8.07b FOR HEAD OF 2.27'

$Q_{RISER} = 220$ cfs > 205 cfs OK

$Q_{RISER} > Q_{PIPE} \Rightarrow Q_{PIPE}$ GOVERNS.

E) ANTI-SEEP COLLARS

1) NO CLOSER THAN 2' TO A PIPE JOINT
2) MUST PROVIDE MIN. 1.5' PROJECTION AROUND PIPE

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Project HAYWOOD CO. SANITARY LANDFILL Acct. No. 2918-01-03 Page — of —

Subject SEDIMENT POND DESIGN Comptd. By BNC Date 3-29-92

Detail — Ck'd. By — Date —

F) PRINCIPAL SPILLWAY ANCHOR:

DOWNWARD FORCE = 1.5 X UPWARD FORCE

$$\text{REQ'D. NET} = 1.5 \times 13\,ft \times \left((66in \times 12in/ft)^2/4\right) \times \pi \times 62.4 \frac{lbs}{ft^3}$$

$$= 28909\ lbs$$

CONCRETE WEIGHS 87.6 lbs/ft^3

$$\text{PAD SIZE} = 28909\ lbs / 87.6\ lbs/ft^3 = 330\ cuft = 12.2\ CY$$

$\therefore$ USE 13' X 13' X 2' SLAB = 338 cf = 12.5 CY

G) BASIN DEWATERING:

- RISER SIZE = 66"
- DETERMINE # OF HOLES, A_o = DEWATERING POOL SURFACE AREA

$$A_o = \frac{A_s (2h)}{T \cdot C_d \cdot 20428}$$

WHERE:

A_o = DEWATERING HOLE AREA

A_s = SURFACE AREA OF BASIN

h = MAXIMUM HEAD OF WATER ABOVE HOLES

T = DETENTION TIME (8 hrs RECOMMENDED)

C_d = ORIFICE COEF. (0.6)

A_s = 12990 ft^2

h = 5.5'

T = 8 hrs

C_d = 0.6

$$A_o = \frac{(12,990)(2)(5.5)}{(8)(0.6)(20428)}$$

$$= 1.43\ ft^2 = 206.6\ in^2$$

1 - 3/4" HOLE = 0.44 in^2

$$\frac{206.6}{0.44} = 470 \text{ HOLES (MIN)}$$

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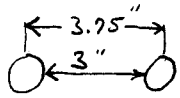
- 470 HOLES (MIN)

CIRCUMFERENCE OF 66" RISER = 207.4 IN

∴ HAVE 3/4" HOLES SPACED 3" APART

$\frac{207.4}{3.25}$ = 55 HOLES/ROW

$\frac{470}{55}$ = 8.5 ROWS OF 3/4" HOLES SPACED 3" APART



V EMBANKMENT:

- 10' MIN. TOP WIDTH
- 3:1 SIDE SLOPES
- SETTLED TOP ELEV = 2420
- CONSTRUCTED TOP ELEV = 2421 (ALLOWS FOR 10% SETTLEMENT)
- CUT-OFF TRENCH & CORE (SEE SHEET 14 OF 19 IN PLANS)

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Project _____ Acct. No. _____ Page _____ of _____

Subject _____ Comptd. By NED Date _____

Detail N/A Ck'd. By _____ Date _____

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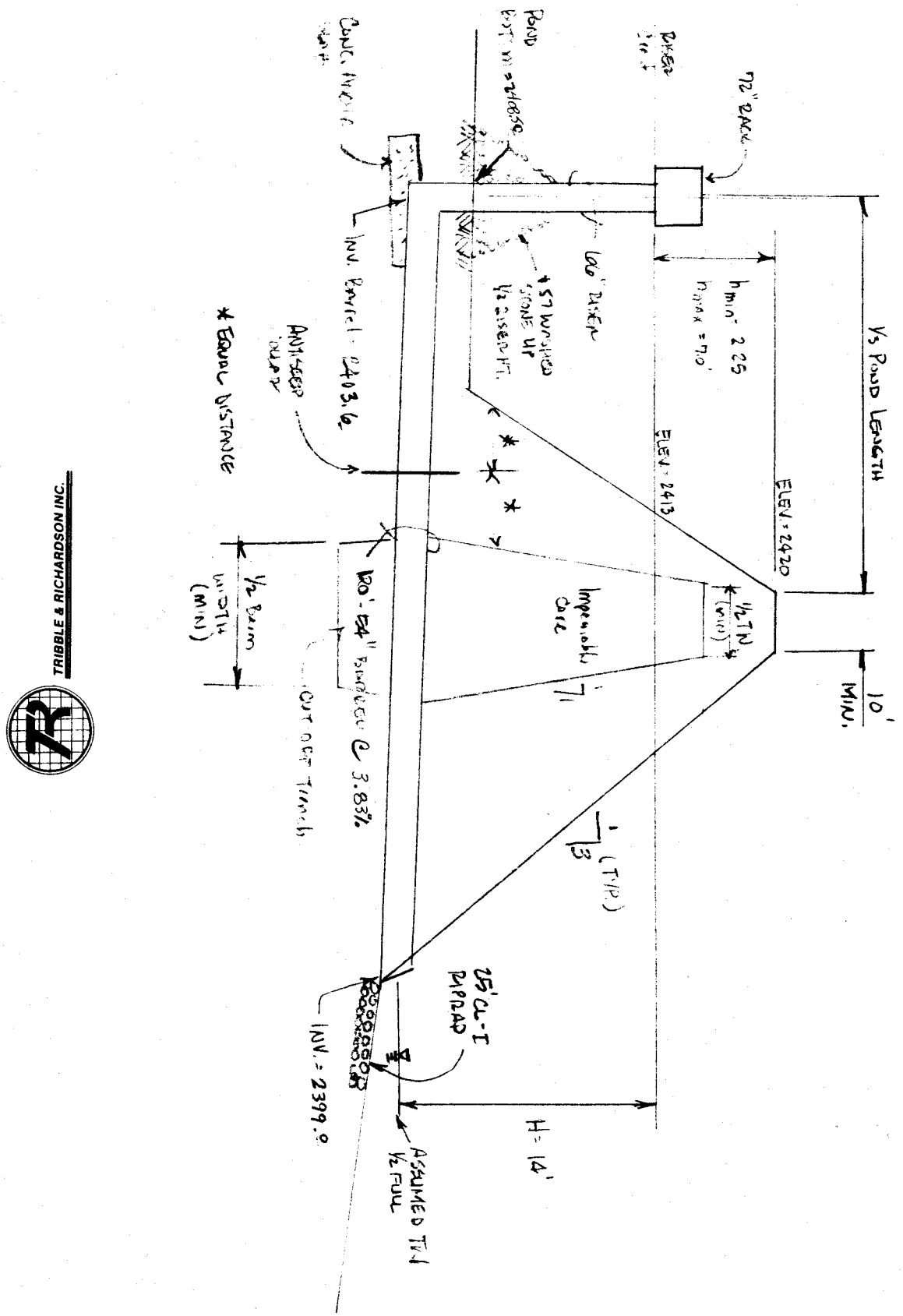

Project _____ Acct. No. _____ Page _____ of _____

Subject RUNOFF CALCULATIONS Comptd. By NED Date 5 SEP

Detail N/A Ck'd. By _____ Date _____

METHOD: PEAK DISCHARGE METHOD SCS - TR-55, Urban Hydrology for Small Watersheds.

A) CALCULATE PEAK RUNOFF FOR SITE DURING DEVELOPMENT.

- SITE DATA:

A.) Location - Haywood County
B.) Total Watershed - 30 AC.
C.) Hydraulic Length - 1950'
d.) Avg Watershed Slope - Steep. over 8%.
e) Hydrologic Soil Group - C (Approx.)

- Weighted Curve No. (Table 8.036)

LAND USE	Percent	CN	Product
LAND FILL Type I Cover, Good Grass Cover	28.3	80	22.64
Gravel Roads	4.3	85	3.66
Good Meadow	67.3	78	52.49
			78.79 ∴ 79

CURVE NO. : 79

- RAINFALL (FIG. 8.03h & 8.03j)

2yr, 24 hr. Storm: 3.0 in
10yr., 24hr Storm 5.0 in
100 yr., 24hr Storm : 7.0 in

- Runoff (Table 8.03c)

Runoff Depth: 2, 24 = 1.77 in
" : 10, 24 = 2.80 in
" : 100, 24 = 4.58 in

- CALCULATE PEAK RUNOFF RATE

A) No adjustment for watershed shape, impervious area, channel improvements or ponding are required.

b.) Adjustment for steep slopes (>8%) = 40 cfs/inch of Runoff From drainage area = 30 Ac. (Fig. 8.03g)

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Project [illegible] Acct. No. [illegible] Page ____ of ____

Subject runoff [illegible] Comptd. By NED Date 5 SEPT [illegible]

Detail N/A. Ck'd. By ____ Date ____

c) determine adjusted peak runoff:

$Q_{2,24}$ = 40 cfs/inch runoff x 1.77 in = 71 cfs

$Q_{10,24}$ = 40 cfs/inch runoff x 2.80 in = 112 cfs

$Q_{100,24}$ = 40 cfs/inch runoff x 4.58 in = 183 [illegible]

- Adjust peak discharge for watershed slope (Table 3.03d)

$Q_{2,24}$ = 71 cfs x 1.12 = 80 cfs

$Q_{10,24}$ = 112 cfs x 1.12 = 125 cfs

$Q_{100,24}$ = 183 cfs x 1.12 = 205 cfs

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Project _____ Acct. No. _____ Page _____ of _____

Subject Sediment Basin Design Comptd. By NBJ Date 6 SEPT

Detail N/A Ck'd. By _____ Date _____

I. ALL RUNOFF WILL BE DIVERTED TO THE BASIN. DETERMINE PEAK FLOWS FOR THE 10-YEAR, 24 HOUR STORM ($Q_{10,24}$).

A) SEE RUNOFF COMPUTATIONS:

$Q_{10,24}$ = 125 cfs.

II DETERMINE BASIN VOLUME REQ'D:

A) MIN. VOL. REQUIRED = 1800 ft^3/dist. acre.
(Std. Spec. 6.61)

V_R = 19.5 AC. x 1800 ft^3/dist acre.

V_{req} = 35,100 ft^3

III DETERMINE VOL PROVIDED:

A.) = HORIZONTAL AREA = 20,889 ft^2 @ EMBANKMENT ELEV.

B.) = Per Contours determine Vol. per depth thru end/area method:

ELEV. (ft.)	AREA (ft^2)	DEPTH (ft)	Accum. STORAGE (ft^3)	
08.5	0	0	0	
10.0	8,715	1.5'	13,073.	
12.0	10,705	3.5'	32,493.	← EQUALS REQ'D VOL.
14.0	12,790	5.5	55,988.	
16.2	15,284	7.5'	84,062.	
18.2	17,836	9.5'	117,132.	
20.2	20,889	11.5'	136,545.	

- REQUIRED VOL. WILL BE PROVIDED at Approx. Elev. 313.2 Which will become cleared Sediment Pool for the 10 year, 24 hour event.

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Project _____ Acct. No. _____ Page _____ of _____

Subject SEDIMENT POND DESIGN Comptd. By NEB Date _____

Detail _____ Ck'd. By _____ Date _____

IV. Principal Spillway design

A.) MIN. CAPACITY should equal 0.2 cfs per drainage area (ac)

Q_{min} = 30 AC. x 0.2 cfs/ac. = 6. cfs

B.) DETERMINE PIPE FLOW

- Assume HEAD of 2.15' above riser inlet. TAILWATER Assumed at spring line of pipe
- propose 100 year event flow, because the embankment will be constructed w/ fill matrl.

∴ Try 54" CMP BARREL

$$Q_p = a(2 \times g \times H)^{1/2} / (1 + Km + Kp1)^{1/2}$$

$$Qp = 15.9(2 \times 32.2 \times 14)^{1/2} / (1 + 1 + [(0.25 \times 120)])^{1/2}$$

Qp = 216 cfs > 205 cfs O.K.

C.) DETERMINE RISER REQUIRED.

- From Fig. 8.07b Riser 66" equals 54" barrel (interpolated)
- Riser ht. = 2 x dia/barrel = 2 x 54" = 9'

D.) Determine appropriate RISER:

- From Fig. 8.07b For head of 2.27',

Q_{riser} = 220 cfs. > 205 cfs O.K.

$Q_{riser} > Q_{pipe}$ = Q_{pipe} governs.

E.) ANTI-SEEP Collars:

1.) No closer than 2' to a pipe joint

2.) Must provide minimum 1.5' projection around pipe.

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Project [illegible] Acct. No. [illegible] Page ____ of ____
Subject Sediment Pond Design Comptd. By NES Date [illegible]
Detail ____ Ck'd. By ____ Date ____

F) Principal Spillway Anchor:

Downward Force = 1.5 x upward force

Req. net = 1.5 x 13 ft x ((66 in / 12 in / Ft)^2 / 4) x pi x 62.4 lbs/ft

= 23,409 lbs.

Concrete [illegible] 87.6 lbs/Ft^3

Pad Size = 23,409 lbs / 87.6 lbs/Ft^3 = 330 cu.Ft. = 12.2 cu.yds

∴ use 13' x 13' x 2' Slab = 338 cu.ft = 12.5 cu.yds.

G.) Basin Dewatering:

- Riser Size = 66"
- Determine # of holes, A_o = Dewatering pool surface area

$$A_o = \frac{A_s (2h)}{T \cdot C_d \cdot 20{,}428}$$

Where:

A_o = dewatering hole area (Ft2)
A_s = surface area of basin (ft^2)
H = maximum head of water above holes (ft)
T = detention time (8 hrs recommended)
C_d = orifice coefficient (0.6)

A_s = 12,790 Ft^2
H = 5.5'
T = 8 hr.
C_d = 0.6

$$A_o = \frac{(12{,}790)(2)(5.5)}{(8)(0.6)(20{,}428)}$$

= 1.43 = 206.6 in^2

1 - 3/4" hole = 0.44 in^2

$\frac{206.6}{0.44}$ = 470 Holes (min.)

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Project _____ Acct. No. _____ Page _____ of _____

Subject Sediment [illegible] Comptd. By NED Date [illegible]

Detail _____ Ck'd. By _____ Date _____

- 470 holes min.

Circumference of 66" Riser = 207.4 in

∴ have 3/4" holes space 3 in apart

$$\frac{207.4}{3.75} = 55 \text{ holes/row}$$

$$\therefore \quad \frac{470}{55} = 8.5 \text{ rows of } 3/4\text{" holes spaced 3" apart}$$

V Embankment:

- 10' min top width
- 3:1 side slopes.
- settled top elevation = 2420
- constructed top elevation = 2421 (allows for 10% settlement)
- cut off trench + core (see sheet 14 of 17 in the plans)

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CULVERT COMPUTATIONS

Project HARWOOD COUNTY LANDFILL Acct. No. _____ Page _____ of _____

Subject CULVERT CALCULATIONS Comptd. By _____ Date _____

Detail CMP - CULVERTS Ck'd. By _____ Date _____

CULVERT #1 - 25 YR, 24 HR. STORM DESIGN

CULVERT #2 RECEIVES FLOW FROM CHANNEL #7 AND DOWNDRAIN #6.

$Q_{\text{CHANNEL \#7}} = 36.25$ CFS

$Q_{\text{DOWNDRAIN \#6}} = 9.39$ CFS

$Q_T = 45.64$

$Q_T = 45.64$ CFS

USE BERNOULI EQUATION TO CALCULATE HEAD.

$$H = \left(1 + K_e + \frac{29n^2L}{R^{1.33}}\right)\frac{Q^2}{2A^2g}$$

$K_e = 0.5$
$L = 52'$
$n = 0.024$
$R = (0.25)D$
$Q = 22.8$

FOR 2-30" CMP $H = 1.05'$

FROM CHART FOR CMP OF HEADWATER DEPTH FOR C.M. PIPE CULVERTS WITH INLET CONTROL

$H_W = 48$"

$D = 30$" $\quad \frac{H_W}{D} = 1.6$

USE ENTRANCE TYPE

"MITERED TO CONFORM TO SLOPE"

$Q = 45.64$ CFS

$Q_{\text{ALLOW}} = 34$ CFS

USE 2-30" CMP

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Project	[illegible]	Acct. No.	[illegible]	Page	of
Subject	CULVERT Comps.	Comptd. By	NED	Date	8/29
Detail	1" 50' / 1" 5' [illegible]	Ck'd. By		Date	

- CULVERT CROSSING upper ACCESS road at final cover stage.

  - CARRY FLOW FROM CHANNEL SECT. 1

    $A = 1.77$ Acres

    runoff $c = 0.6$

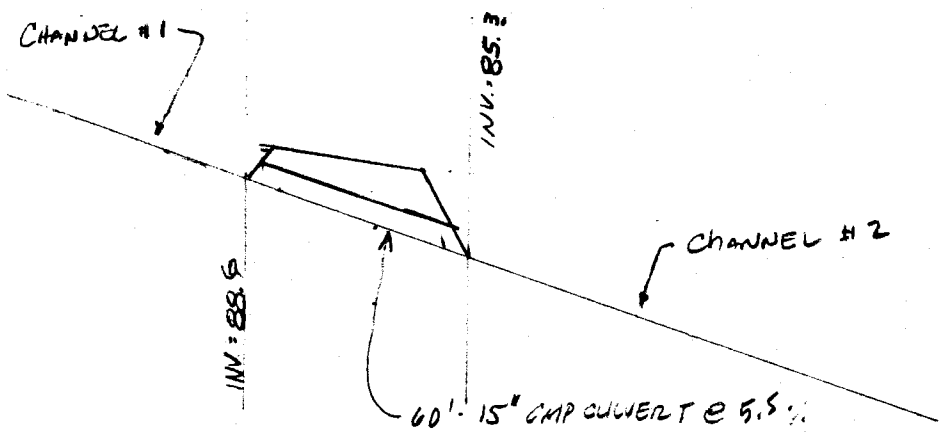
    $T_c = 5$ min

    $I = 6.3$ (FROM FIG. 8.03F of N.C. Eros. & Sed. CONT. Manual)

    $Q = (0.6)(6.3)(1.77)$

    $= 6.7$ cfs

  - Prop culvert =



USE BERNOULLI EQ. TO CALCULATE HEAD

$$H = \left(1 + K_e + \frac{29 n^2 L}{R^{1.33}}\right) \frac{Q^2}{2A^2 g}$$

$K_e = 0.50$
$n = 0.024$
$d_n = 0.86'$
$V_n = 7.5$ fps.
$R_h = 0.37$
$g = 64.4$
$A = 0.90$

FOR 1-15" CMP.

$$H = \left[1 + 0.50 + \frac{29(0.024)^2(60')}{0.37^{1.33}}\right] \frac{6.7^2}{2(0.90)^2(64.4)}$$

$= 5.26 \cdot 0.43$

$H = 2.26'$

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Project _____ Acct. No. 213-00-0 Page ____ of ____

Subject DOWN DRAIN CALCULATIONS Comptd. By M.N.H. Date ____

Detail _____ Ck'd. By _____ Date ____

MAX. HW = 3' 25 YR - 24 HR STORM

C = 0.6

DOWNDRAIN #	DRAINAGE AREA (AC.)	TIME OF CONC. (MIN.)	10 YR INTENSITY	FLOW (CFS)	ADDITIONAL FLOWS (CFS)	TOTAL FLOWS (CFS)	PIPE SIZE (IN)
1	0.74	5	6.3	2.80	—	2.80	12"
2	1.35	5	6.3	5.10	2.80	7.90	18"
3	0.58	5	6.3	2.19	—	2.19	12"
4	0.64	5	6.3	2.42	—	2.42	12"
5	0.66	5	6.3	2.49	—	2.49	12"
6	1.19	5	6.3	4.50	4.89	9.39	18"
7	2.53	5	6.3	9.55	7.90	17.45	24"

NOTE: DD#7 IS SHOWN AS PIPE #1 ON SHEET 3 OF 17 IN THE SANTARY LANDFILL PLANS.

EXAMPLE #1 $Q = C I A$

$C = 0.6$

$T_c = 5$ MIN.

$I = 6.3$ FROM FIGURE 8.03 OF THE N.C. EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL

$A = 0.74$ ACRES

$$Q = (0.6)(6.3)(0.74)$$

$$Q = 2.80 \text{ CFS}$$

CALCULATING FOR HEAD

$$H = \left(1 + Ke + \frac{29 n^2 L}{R^{1.33}}\right) \frac{Q^2}{2A^2 g}$$

USE D = 12"
L = 120'

$H = 1.8' < 3.0'$ O.K.

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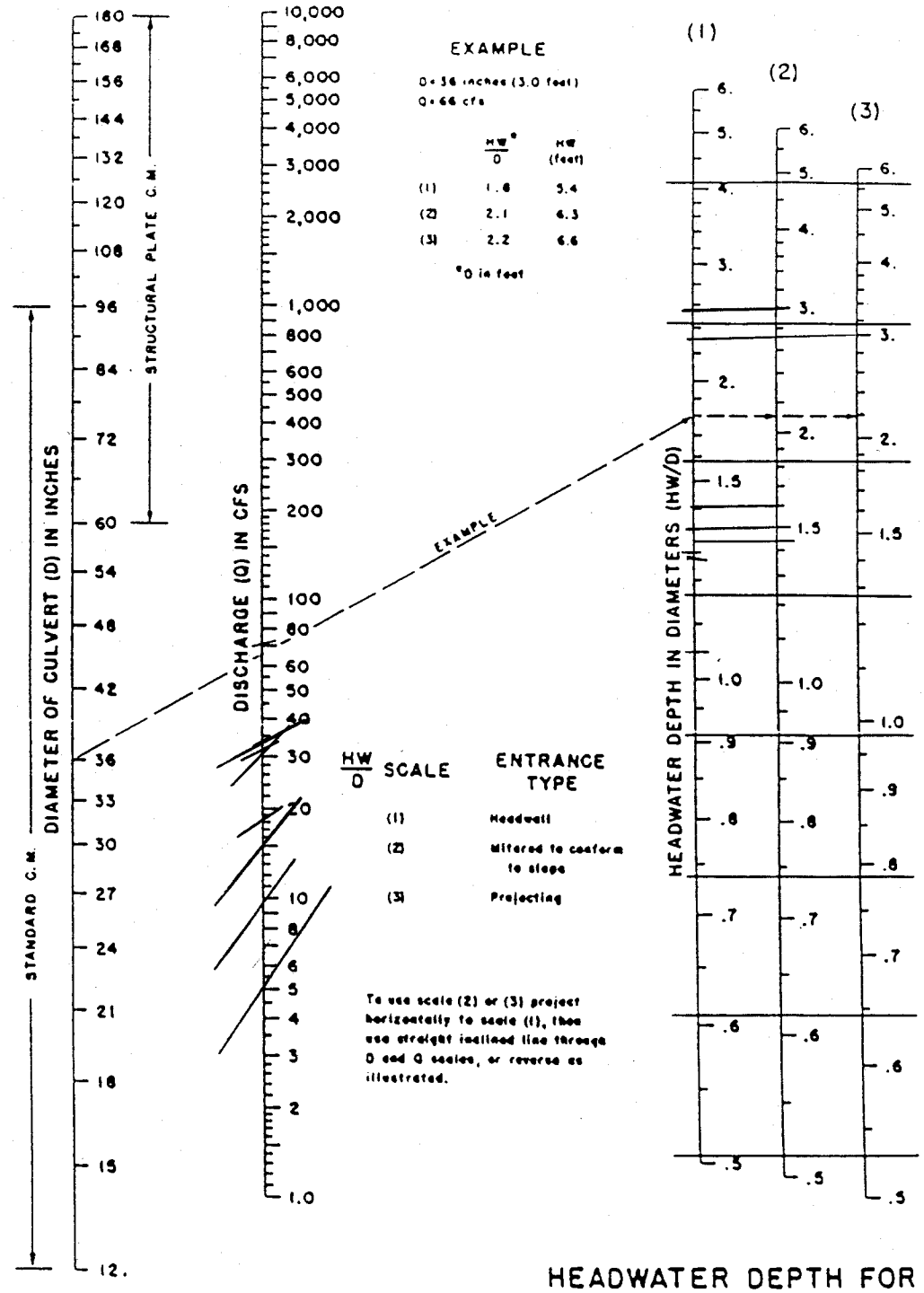
CHART 5



BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

Exhibit 12

CHANNEL COMPUTATIONS

Project HAYWOOD COUNTY LANDFILL Acct. No. _____ Page _____ of _____

Subject CHANNEL CALCULATIONS Comptd. By _____ Date _____

Detail _____ Ck'd. By _____ Date _____

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CHANNEL #1 USE RATIONAL $Q = CIA$

DRAINAGE AREA = 1.77 ACRES

RUNOFF COEFFICIENT "C" = 0.6

T_c = 5 MIN

I = 6.3 (FROM FIGURE 8.03f of N.C. EROSION & SEDIMENT CONTROL MANUAL)

$$Q = (0.6)(6.3)(1.77)$$

$$Q = 6.69 \text{ CFS}$$

PROPOSED CHANNEL GRADE = 3 % = S

PROPOSED VEGETATION = TALL FESCUE

PERMISSIBLE VELOCITY (Vp) = 5.0 FPS (TABLE 8.05a)

MANNING'S "n" = 0.035

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q

$A = Q/V$ $\quad A = bd + zd^2$ $\quad V = \frac{1.49}{n} R^{2/3} S^{1/2}$ $\quad +V<Vp$

$z = 2$ $\quad P = b + 2d\sqrt{z^2+1}$

$b = 2$

$Q = 6.69$ CFS

$d = 0.55$ ft

$A = 1.72$ ft^2

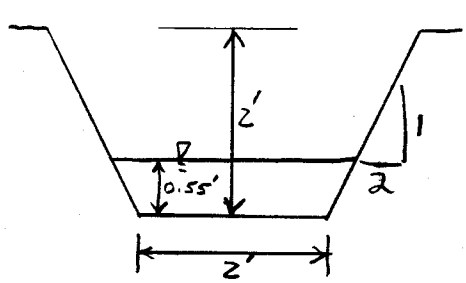
$P = 4.47$ ft

$R = 0.38$ ft

$V = 3.9$ ft/s

A TRAPEZOIDAL CHANNEL WITH A DEPTH OF 0.55 ft WITH 2:1 SIDE SLOPES AND A 2 ft BOTTOM CAN HANDLE 6.69 CFS WHILE KEEPING $V<Vp$.

THEREFORE: CONSTRUCT CHANNEL TO BE 2 FT DEEP, 2 FT BOTTOM W/ 2:1 SIDESLOPES



Project HAYWOOD COUNTY LANDFILL Acct. No. _____ Page _____ of _____

Subject CHANNEL CALCULATIONS Comptd. By _____ Date _____

Detail _____ Ck'd. By _____ Date _____

CHANNEL # 2 USE RATIONAL $Q = CIA$

DRAINAGE AREA = 2.39 ACRES
RUNOFF COEFFICIENT = 0.6 "C"
T_c = 5 MIN

$I = 6.3$

$$Q = CIA$$
$$= (0.6)(6.3)(2.33)$$
$$Q = 9.03 \text{ cfs}$$

PROPOSED CHANNEL GRADE = 10%
PROPOSED VEGETATION = TALL FESCUE
PERMISSIBLE VELOCITY (Vp) = 5.0 FPS
$n = 0.035$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q + $V < Vp$.

$A = Q/V$ $\quad A = bd + zd^2$
$z = 2$
$b = 2$ $\quad P = b + 2d\sqrt{z^2+1}$ $\quad V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$Q = 9.03$ cfs
$d = 0.47$ FT
$A = 1.38$ FT^2
$P = 4.10$ FT
$R = 0.34$ FT
$V = 6.52$ FT/sec

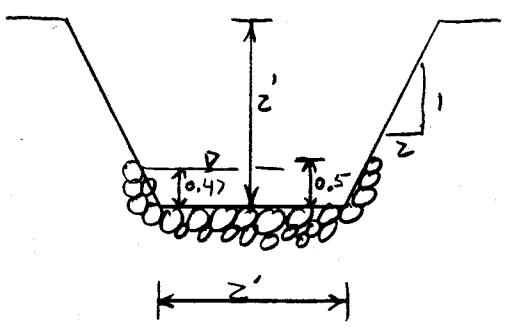
BASED ON VELOCITY USE "CLASS B" EROSION CONTROL RIPRAP.

LENGTH OF CHANNEL IS ± 540 L.F.

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:

B = 2 FT
SIDESLOPE = 2:1
DEPTH = 2 FT

RIPRAP SHALL EXTEND 0.5' UP SIDE SLOPES



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CHANNEL #3

USE RATIONAL $Q = CIA$

DRAINAGE AREA = 0.49 ACRES
RUNOFF COEFFICIENT = 0.6 "C"
T_c = 5 MIN
I = 6.3

$$Q = CIA$$
$$= (0.6)(6.3)(0.49)$$
$$Q = 1.86 \text{ cfs}$$

PROPOSED CHANNEL GRADE = 3.6 %
PROPOSED VEGETATION = TALL FESCUE
PERMISSIBLE VELOCITY (V_p) = 5.0 FPS
$n = 0.035$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q + $V < V_p$

$A = Q/V$ $\quad A = bd + zd^2$ $\quad P = b + 2d\sqrt{z^2+1}$

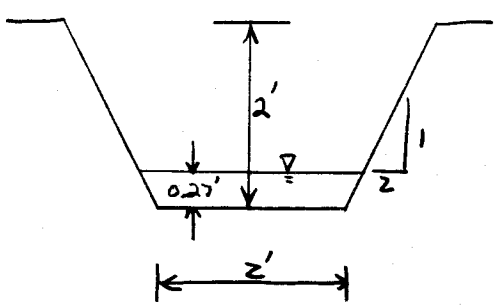
$z = 2$
$b = 2$

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

$Q = 1.86$ cfs
$d = 0.27$ FT
$A = 0.68$ FT^2
$P = 3.20$ FT
$R = 0.21$ FT
$V = 2.73$ FT/sec

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:

B = 2 FT
SIDE SLOPE = 2:1
DEPTH = 2 FT



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CHANNEL #5

USE RATIONAL $Q = CIA$

ORAINAGE AREA = 2.43 ACRES
RUNOFF COEFFICIENT = 0.6 ~ "C"
T_c = 5 min
I = 6.3 min

$$Q = (0.6)(6.3)(2.43)$$
$$Q = 9.19 \text{ cfs}$$

PROPOSED CHANNEL GRADE = 10 %
PROPOSED VEGETATION = TALL FESCUE
PERMISSIBLE VELOCITY (V_p) = 5.0 FPS
$n = 0.035$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET $Q = V_c V_p$

$A = Q/V$ $\quad A = bd + zd^2$
$z = 2$ $\quad P = b + 2d\sqrt{z^2+1}$
$b = 2$

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

$Q = 9.19$
$d = 0.48$ ft
$A = 1.40$ ft^2
$P = 4.13$ ft
$R = 0.34$ ft
$V = 6.55$

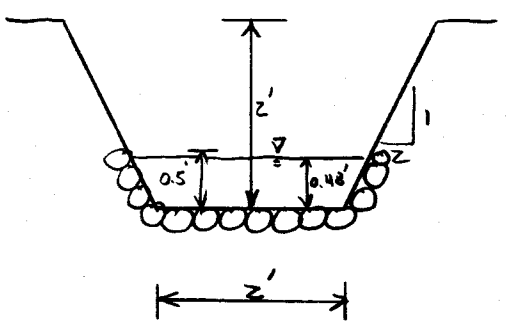
BASED ON VELOCITY USE "CLASS B" EROSION CONTROL STONE FOR RIPRAP

LENGTH OF RIPRAPPED LINED CHANNEL = ± 380 FT

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:

B = 2 ft
SIDESLOPE = 2:1
DEPTH = 2 ft

RIPRAP SHALL EXTEND 0.5' UP SIDESLOPE



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CHANNEL #4

USE RATIONAL EQUATION

$Q = CIA$

DRAINAGE AREA = 0.99 ACRES
RUNOFF COEFFICIENT = 0.6 = "C"
T_c = 5 MIN.

$I = 6.3$

$$Q = CIA$$
$$Q = (0.6)(6.3)(0.99)$$
$$Q = 3.74 \text{ CFS}$$

PROPOSED CHANNEL GRADE = 3.7 %
PROPOSED VEGETATION = TALL FESCUE
PERMISSIBLE VELOCITY (Vp) = 5.0 FPS
$n = 0.035$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET $Q + V < Vp$

$A = Q/V$ $\quad A = bd + zd^2$ $\quad V = \frac{1.49}{n} R^{2/3} S^{1/2}$

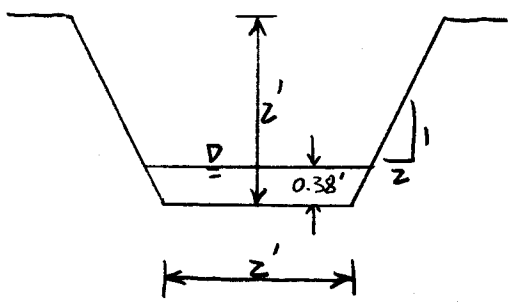
$z = 2$
$b = 2$

$P = b + 2d\sqrt{z^2+1}$

$Q = 3.74$ CFS
$d = 0.38$ FT
$A = 1.05$ FT^2
$P = 3.70$ FT
$R = 0.28$ FT
$V = 3.56$ FT/SEC

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:

b = 2 FT
SIDESLOPE = 2:1
DEPTH = 2 FT



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CHANNEL #7

USE RATIONAL EQUATION

25yR-24HR

DRAINAGE AREA = 1.27 ACRES
RUNOFF COEFFICIENT = 0.6 ~ C
T_c = 5 MIN
I = 6.3

$Q_1 = CIA = (0.6)(6.3)(1.27)$
$= 4.8$ cfs

$Q_{2\ channel\#12} = 14.0$ cfs

$Q_{2\ roundrain\#7} = 17.45$ cfs

$Q_T = 36.25$

PROPOSED CHANNEL GRADE = 10 %
PROPOSED CHANNEL LINING = CLASS B RIPRAP

$n = 0.035$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET $Q + Up$

$A = Q/V$
$z = 2$
$b = 2$

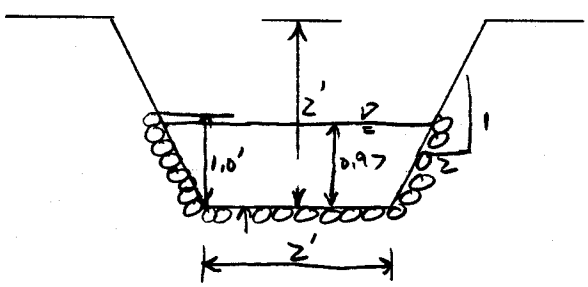
$A = bd + zd^2$
$P = b + 2d\sqrt{z^2+1}$

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$Q = 36.25$ cfs
$d = 0.97$ ft
$A = 3.79$ ft^2
$P = 6.32$ ft
$R = 0.60$ ft
$V = 9.56$ FPS

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:

b = 2 ft
SIDE SLOPE = 2:1
DEPTH = 2 ft



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CHANNEL #8 - CONCRETE FLUME

25yr-24HR

DRAINAGE AREA = 2.56 ACRES
RUNOFF COEFFICIENT = 0.6 - "C"
T_c = 5 min
I = 6.3

$$Q = (0.6)(6.3)(2.56)$$

$$Q = 9.68 \text{ CFS}$$

PROPOSED CHANNEL GRADE = 30 %
CONCRETE LINED CHANNEL

n = 0.013

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q

$A = Q/V$ $\quad A = bd + zd^2$ $\quad P = b + 2d\sqrt{z^2+1}$

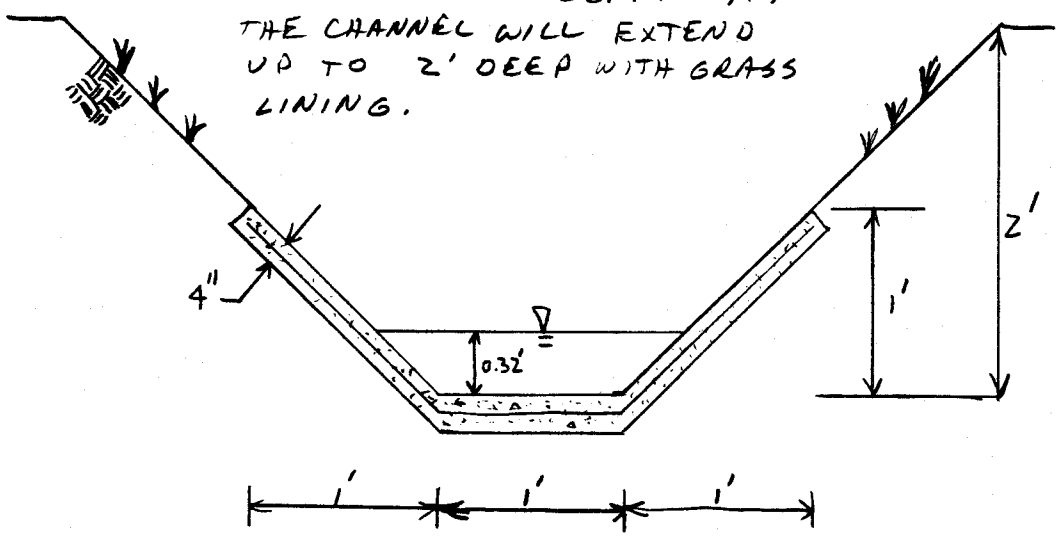
$z = 1$
$b = 1$

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

Q = 9.68
d = 0.32 ft
A = 0.42 ft²
P = 1.90 ft
R = 0.22 ft
V = 23.08 FPS

CONCRETE FLUME WILL HAVE THE FOLLOWING DIMENSIONS: b = 1 ft
SIDESLOPE = 1:1
DEPTH = 1 ft

THE CHANNEL WILL EXTEND UP TO 2' DEEP WITH GRASS LINING.



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CHANNEL #9

USE RATIONAL EQUATION

25YR-24 HOUR STORM

DRAINAGE AREA = 3.46 ACRES
RUNOFF COEFFICIENT = 0.6 ~ "C"
T_c = 5 min
I = 6.3

$$Q = (0.6)(6.3)(3.46)$$

$$Q = 13.08 \text{ CFS}$$

PROPOSED CHANNEL GRADE = 8.3%
PROPOSED LINING = RIPRAP "CLASS B" 5"-15"
$n = 0.035$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q

$A = Q/V$
$z = 2$
$b = 1$

$A = bd + zd^2$

$P = b + 2d\sqrt{z^2+1}$

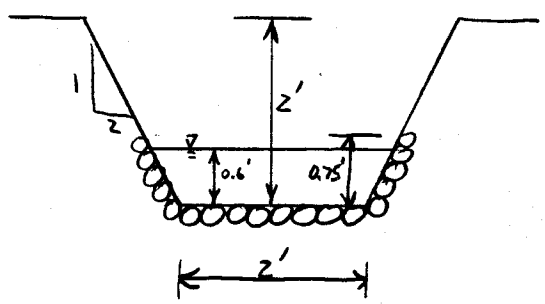
$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

$Q = 13.08$ CFS
$d = 0.60$ ft
$A = 1.93$ ft^2
$P = 4.70$ ft
$R = 0.41$ ft
$V = 6.77$ FPS

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:

b = 2 ft
SIDESLOPE = 2:1
DEPTH = 2 ft

RIPRAP SHALL EXTEND 0.75' UP SIDE SLOPE



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CHANNEL #10 CONCRETE FLUME

25YR-24 HR

DRAINAGE AREA = 3.85 ACRES
RUNOFF COEFFICIENT = 0.6 "C"
T_c = 5 min.
I = 6.3

$Q = (0.6)(6.3)(3.85)$

$Q = 14.55$ CFS

PROPOSED CHANNEL GRADE = 25%
CONCRETE LINED CHANNEL
$n = 0.013$

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q

$A = Q/V$

$b = 1$

$z = 1$

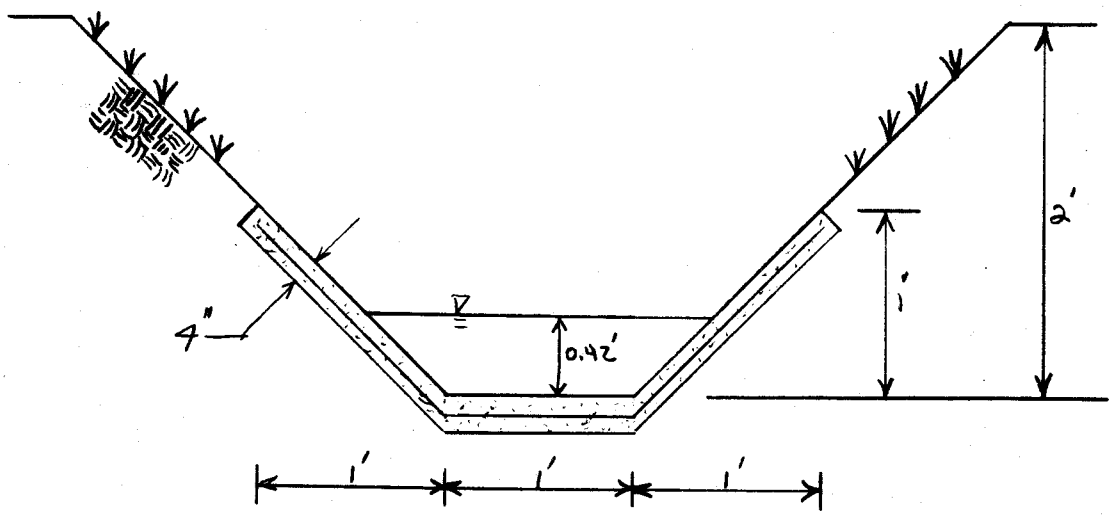
$A = bd + zd^2$

$P = b + 2d\sqrt{z^2+1}$

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$Q = 14.55$ CFS
$d = 0.42$ FT
$A = 0.60$ FT^2
$P = 2.20$ FT
$R = 0.27$ FT
$V = 24.19$ FPS

CONCRETE FLUME WILL HAVE THE FOLLOWING DIMENSIONS: b = 1ft
SIDESLOPE = 2:1
DEPTH = 1ft



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CHANNEL #11

USE RATIONAL METHOD

25YR-24 HR

DRAINAGE AREA = 0.81 ACRES
RUNOFF COEFFICIENT = 0.7 (EXISTING 2:1 SIDESLOPE)
T_c = 5 MIN
I = 6.3

$$Q = (0.7)(6.3)(0.81)$$
$$Q = 3.57 \text{ CFS}$$

PROPOSED CHANNEL GRADE = 10%
PROPOSED LINING = TALL FESCUE
PERMISSIBLE VELOCITY = 5.0 FPS

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET $Q \geq VCVp$

$A = Q/V$ $\quad A = bd + zd^2$ $\quad P = b + 2d\sqrt{z^2+1}$

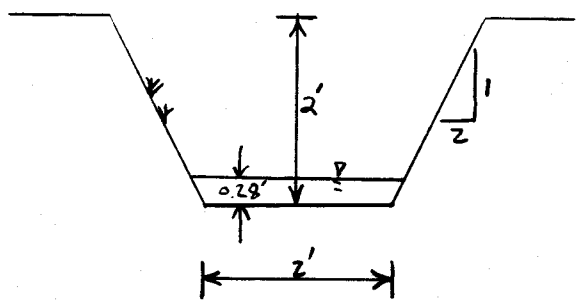
$z = 2$
$b = 2$

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

$Q = 3.57$ CFS
$d = 0.28$ FT
$A = 0.72$ FT^2
$P = 3.26$ FT
$R = 0.22$ FT
$V = 4.95$ FPS

CONSTRUCT CHANNEL TO HAVE THE FOLLOWING DIMENSIONS:

b = 2 FT
SIDESLOPE = 2:1
DEPTH = 2 FT



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CHANNEL #12 USE RATIONAL METHOD

25yr - 24 HR STORM

DRAINAGE AREA = 3.18 ACRES
RUNOFF COEFFICIENT = 0.7
T_c = 5 min
I = 6.3

$$Q = (3.05)(0.7)/6.3)$$

$$Q = 14.0 \text{ CFS}$$

PROPOSED CHANNEL GRADE = 10%
PROPOSED CHANNEL LINING - CLASS B" RIPRAP
n = 0.035

TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q

$A = Q/V$ $A = bd + zd^2$ $V = \frac{1.49}{n} R^{2/3} S^{1/2}$

z = 2
b = 2

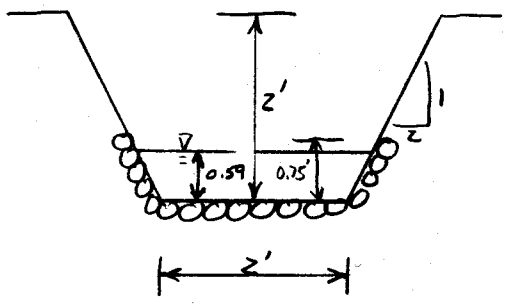
$P = b + 2d\sqrt{z^2+1}$

Q = 14.0 CFS
d = 0.59 ft
A = 1.90 ft^2
P = 4.66 ft
R = 0.41 ft
V = 7.38 FPS

CONSTRUCT CHANNEL TO HAVE THE FOLLOWING DIMENSIONS:

b = 2ft
SIDESLOPE = 2:1
DEPTH = 2 ft

RIPRAP SHALL EXTEND 0.75' UP SIDESLOPE



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CHANNEL A13 USE RATIONAL METHOD $Q = CIA$

DRAINAGE AREA = 9.92 Ac
RUNOFF COEFFICIENT = 0.7 (STEEP SLOPES)
T_c = 5 MIN
I = 6.3
Q = 43.75 CFS

PROPOSED CHANNEL GRADE = 6.7%
PROPOSED CHANNEL LINING = CLASS B RIPRAP
$n = 0.035$

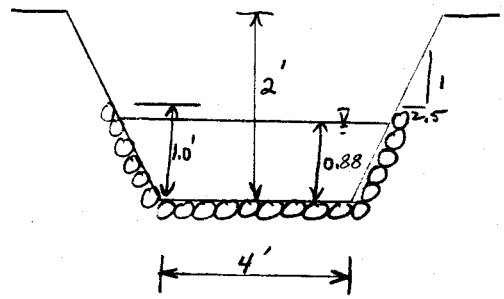
TRAPEZOIDAL CHANNEL DIMENSIONS: DESIGN TO MEET Q
$A = Q/V$
$z = 2.5:1$
$b = 4$

$A = bd + zd^2$
$P = b + 2d\sqrt{z^2+1}$

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

Q = 43.75 CFS
d = 0.88
A = 5.45
P = 8.74
R = 0.62
V = 8.03

CONSTRUCT CHANNEL TO HAVE FOLLOWING DIMENSIONS:
b = 4 FT
SIDESLOPE = 2.5:1
DEPTH = 2 FT



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CHANNEL #14 USE RATIONAL METHOD $Q = CIA$

DRAINAGE AREA = 13.17 Ac
RUNOFF COEFFICIENT = 0.7
T_c = 5 min
I = 6.3

$Q_1 = (0.7)(6.3)(11.0)$
$Q_1 = 58.08$ CFS

Q_2 = FLOW FROM CULVERT #1
= 45.64

$Q_T = Q_1 + Q_2 = 58.08 + 45.64$
$Q_T = 103.72$ CFS

PROPOSED CHANNEL GRADE = 8 %
PROPOSED CHANNEL LINING = CLASS B RIPRAP
n = 0.035

TRAPEZOIDAL CHANNEL
$A = Q/V$
$z = 2.5$
$b = 4$ ft

$A = bd + zd^2$
$P = b + 2d\sqrt{z^2+1}$

$V = \frac{1.49}{n} R^{2/3} S^{1/2}$

Q =
d = 1.31
A = 9.53
P = 11.05
R = 0.86
V = 10.89

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APPENDIX C

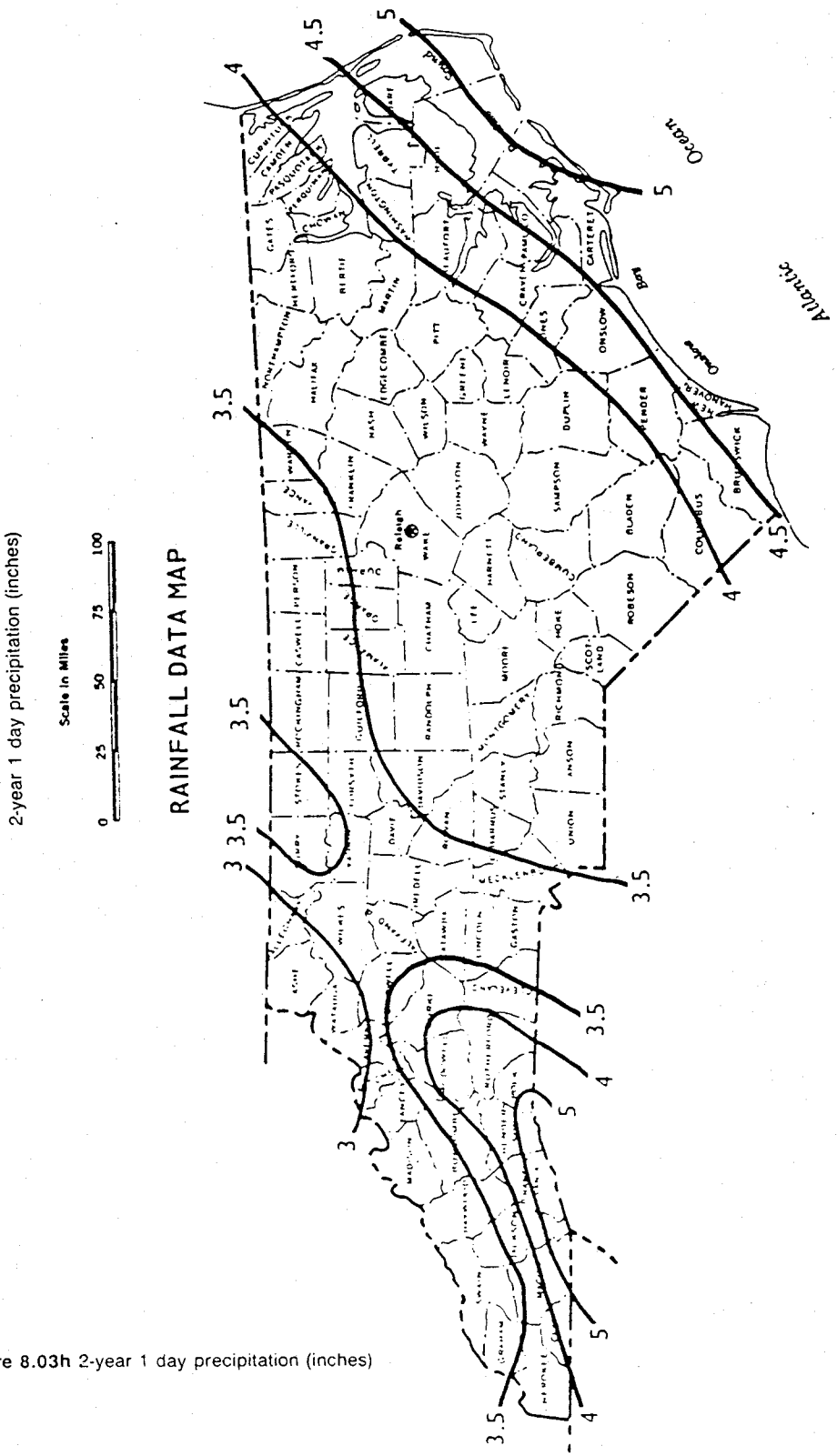


Figure 8.03h 2-year 1 day precipitation (inches)

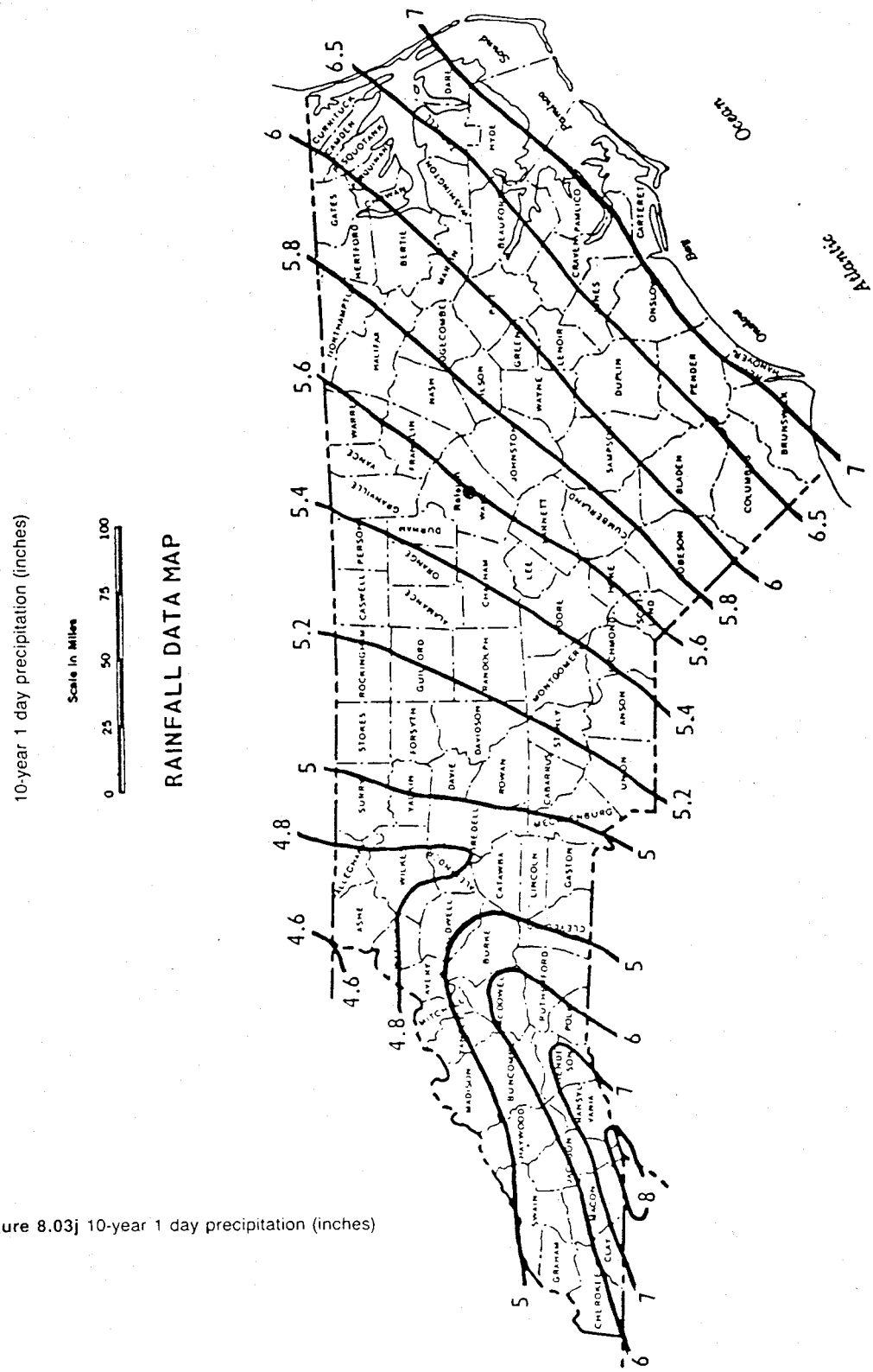


Figure 8.03j 10-year 1 day precipitation (inches)

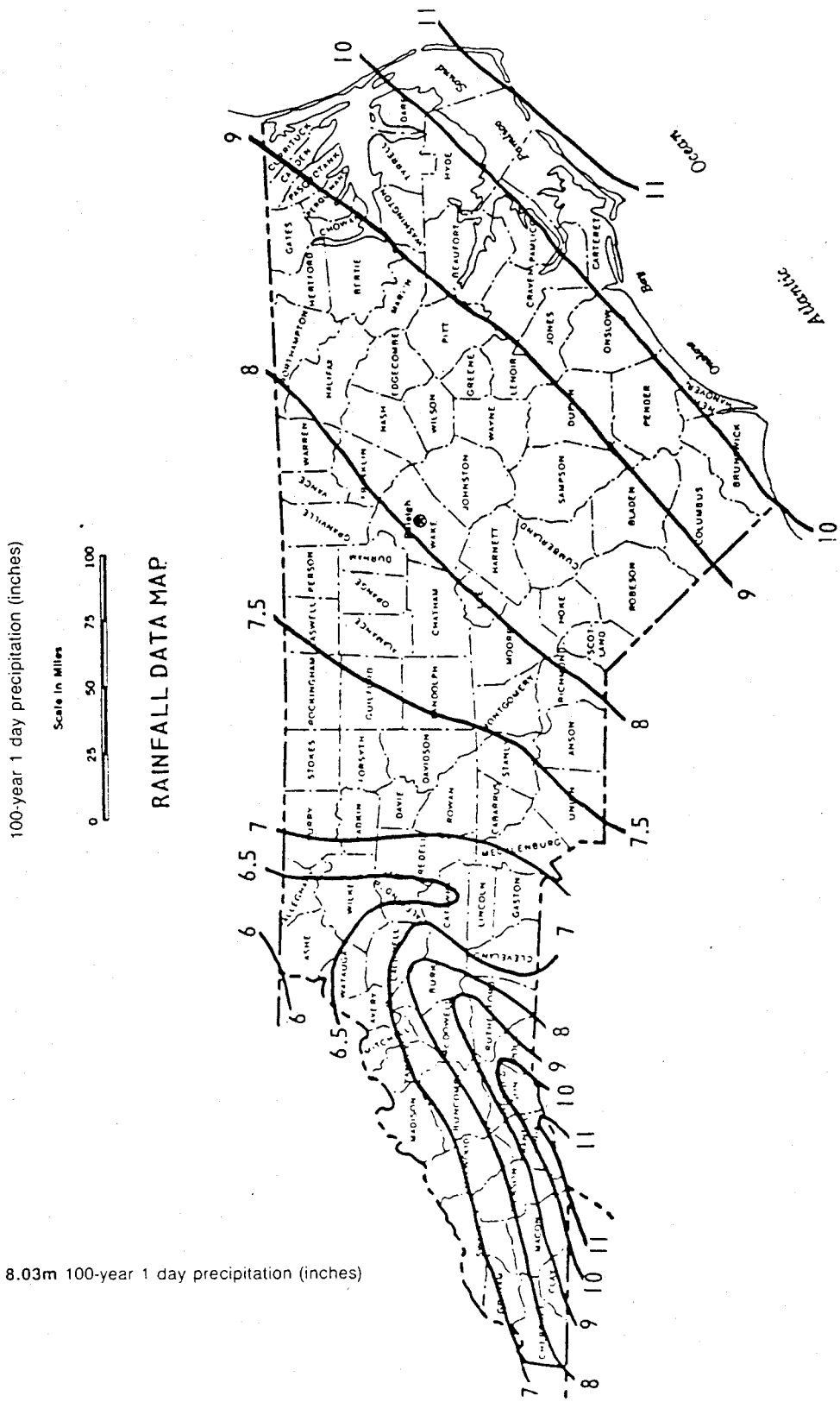


Figure 8.03m 100-year 1 day precipitation (inches)

Table 8.03b
Runoff Curve Numbers (CN)

Land Use/Cover		Hydrologic Soil Group A	B	C	D
Cultivated land					
without conservation		72	81	88	91
with conservation		62	71	78	81
Pasture land					
poor condition		68	79	86	89
good condition		39	61	74	80
Meadow					
good condition		30	58	71	78
Wood or forest land					
Thin stand - poor cover, no mulch		45	66	77	83
Good stand - good cover		25	55	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition:					
grass cover on 75% or more of the area		39	61	74	80
fair condition:					
grass cover on 50 to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential:[1] Development completed and vegetation established					
Average lot size	Average % Impervious				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acre	15	47	66	77	81
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads					
paved with curbs and storm sewers		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89
Newly graded area		81	89	93	95
Residential: Development underway and no vegetation					
Lot sizes of 1/4 acre		88	93	95	97
Lot sizes of 1/2 acre		85	91	94	96
Lot sizes of 1 acre		82	90	93	95
Lot sizes of 2 acres		81	89	92	94

[1]Curve numbers are computed assuming the runoff from the house and driveway is directed toward the street.

source: USDA-SCS

b. Determine runoff depth (in inches) from the curve number and rainfall depth using Table 8.03c.

Table 8.03c
Runoff Depth

Rainfall (inches)	Curve Number (CN)[1]							
	60	65	70	75	80	85	90	95
1.0	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56
1.2	0.00	0.00	0.03	0.07	0.15	0.28	0.46	0.74
1.4	0.00	0.02	0.06	0.13	0.24	0.39	0.61	0.92
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.30
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.97
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.44
4.0	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.42
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.41
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.40
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.40
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.39
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.39
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.39
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39

[1] To obtain runoff depths for CN's and other rainfall amounts not shown in this table, use an arithmetic interpolation.

The volume of runoff from the site can be calculated by multiplying the area of the site by the runoff depth.

Step 4. Determine the peak rate of runoff for the design storm by adjusting for watershed shape as follows:

a. Determine an "equivalent drainage area" from the hydraulic length of the watershed using Figure 8.03n. Hydraulic length is the length of the flow path from the most remote point in the watershed to the point of discharge.

b. Determine the discharge (cfs/inch of runoff) for the equivalent drainage area from Figure 8.03o through 8.03q:

Figure 8.03o - for average watershed slopes 0-3%
Figure 8.03p - for average watershed slopes 3-7%
Figure 8.03q - for average watershed slopes 8-50%

Calculate the peak discharge, Q_1, of the equivalent watershed by multiplying equivalent watershed area by runoff from Table 8.03c in Step 3b.

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS ON A FLAT SLOPE, 24-HOUR STORM, TYPE II DISTRIBUTION

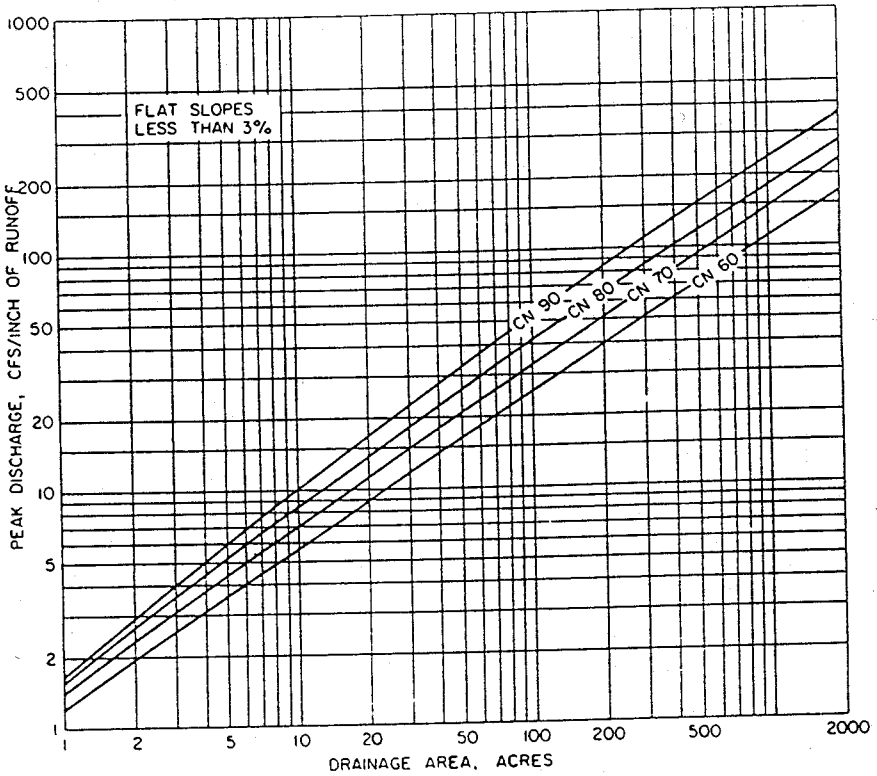


Figure 8.03o Discharge vs equivalent drainage area for average watershed slopes 0 - 3%.

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS ON A MODERATE SLOPE, 24-HOUR STORM, TYPE II DISTRIBUTION

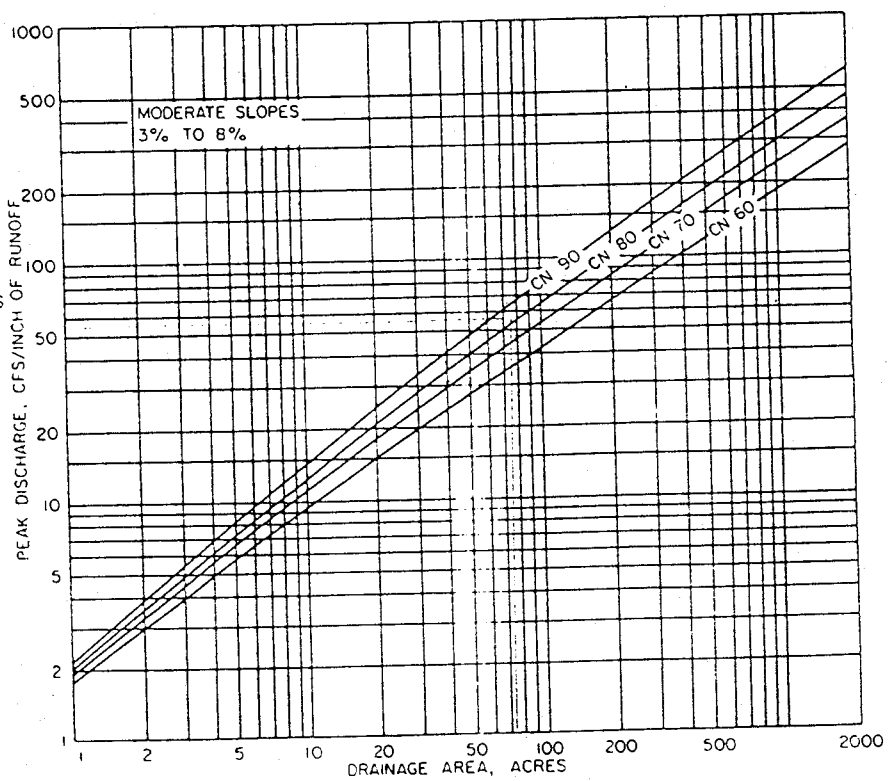


Figure 8.03p Discharge vs equivalent drainage area for average watershed 3 - 8%.

PEAK RATES OF DISCHARGE FOR SMALL WATERSHEDS ON A STEEP SLOPE, 24-HOUR STORM, TYPE II DISTRIBUTION

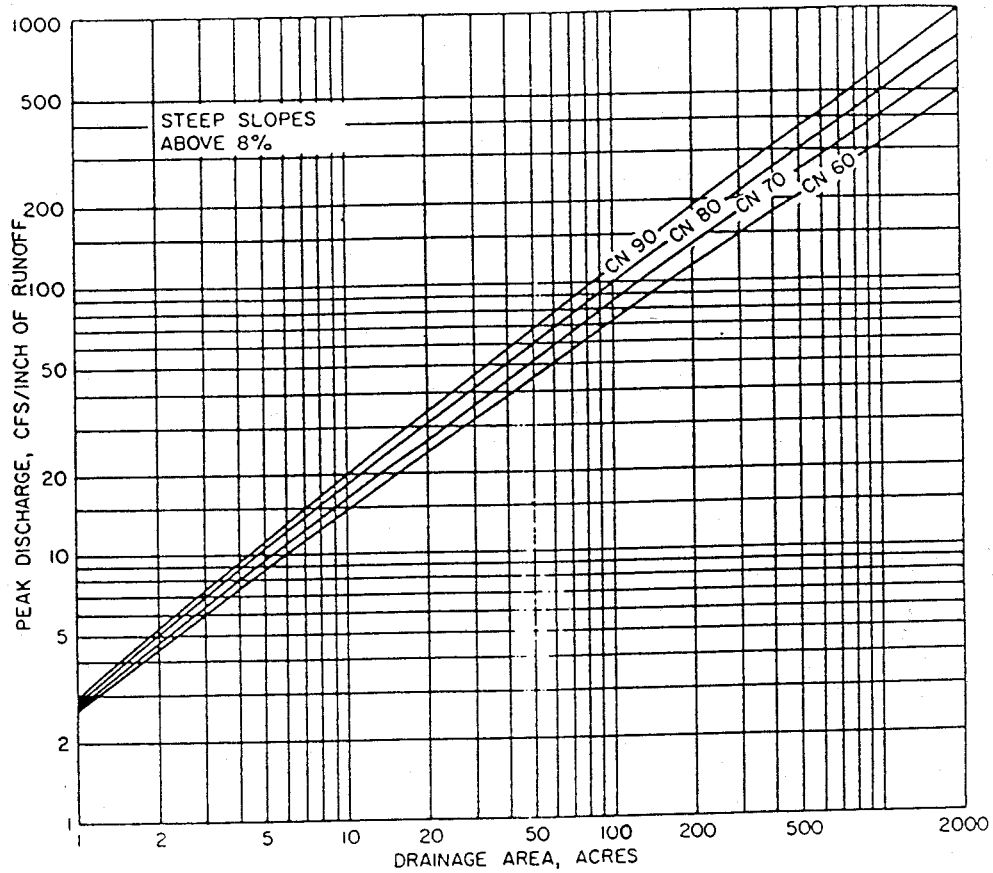


Figure 8.03q Discharge vs equivalent drainage area for average watershed slopes 8 - 50%.

Table 8.05c
Retardance Classification for Vegetal Covers

Retardance	Cover	Condition
A	Reed canarygrass	Excellent stand, tall (average 36")
	Weeping lovegrass	Excellent stand, tall (average 30")
B	Tall fescue	Good stand, uncut, (average 18")
	Bermudagrass	Good stand, tall (average 12")
	Grass-legume mixture (tall fescue, red fescue, sericea lespedeza)	Good stand, uncut
	Grass mixture (timothy, smooth bromegrass or orchardgrass)	Good stand, uncut (average 20")
	Sericea lespedeza	Good stand, not woody, tall (average 19")
	Reed canarygrass	Good stand, cut (average 12-15")
	Alfalfa	Good stand, uncut (average 11")
C	Tall fescue	Good stand (8-12")
	Bermudagrass	Good stand, cut (average 6")
	Bahiagrass	Good stand, uncut (6-8")
	Grass-legume mixture-- summer (orchardgrass, redtop and annual lespedeza)	Good stand, uncut (6-8")
	Centipedegrass	Very dense cover (average 6")
	Kentucky bluegrass	Good stand, headed (6-12")
	Redtop	Good stand, uncut (15-20")
D	Tall fescue	Good stand, cut (3-4")
	Bermudagrass	Good stand, cut (2.5")
	Bahiagrass	Good stand, cut (3-4")
	Grass-legume mixture-- fall-spring (orchard-grass, redtop, and annual lespedeza)	Good stand, uncut (4-5")
	Red fescue	Good stand, uncut (12-18")
	Centipedegrass	Good stand, cut (3-4")
	Kentucky bluegrass	Good stand, cut (3-4")
E	Bermudagrass	Good stand, cut (1.5")
	Bermudagrass	Burned stubble

Modified from: USDA-SCS, 1969. Engineering Field Manual.

Step 10. For grass-lined channels once the appropriate channel dimensions have been selected for low retardance conditions, repeat steps 6 through 8 using a higher retardance class, corresponding to tall grass. Adjust capacity of the channel by varying depth where site conditions permit.

NOTE 1: If design velocity is greater than 2.0 ft/sec., a temporary lining may be required to stabilize the channel until vegetation is established. The temporary liner may be designed for peak flow from the 2-yr storm. If a channel requires temporary lining, the designer should analyze shear stresses in the channel to select the liner that provides protection and promotes establishment of vegetation. For the design of temporary liners, use tractive force procedure.

NOTE 2: Design Tables—Vegetated Channels and Diversions at the end of this section may be used to design grass-lined channels with parabolic cross-sections.

Step 11. Check outlet for carrying capacity and stability. If discharge velocities exceed allowable velocities for the receiving stream, an outlet protection structure will be required (Table 8.05d).

Sample Problem 8.05a illustrates the design of a grass-lined channel.

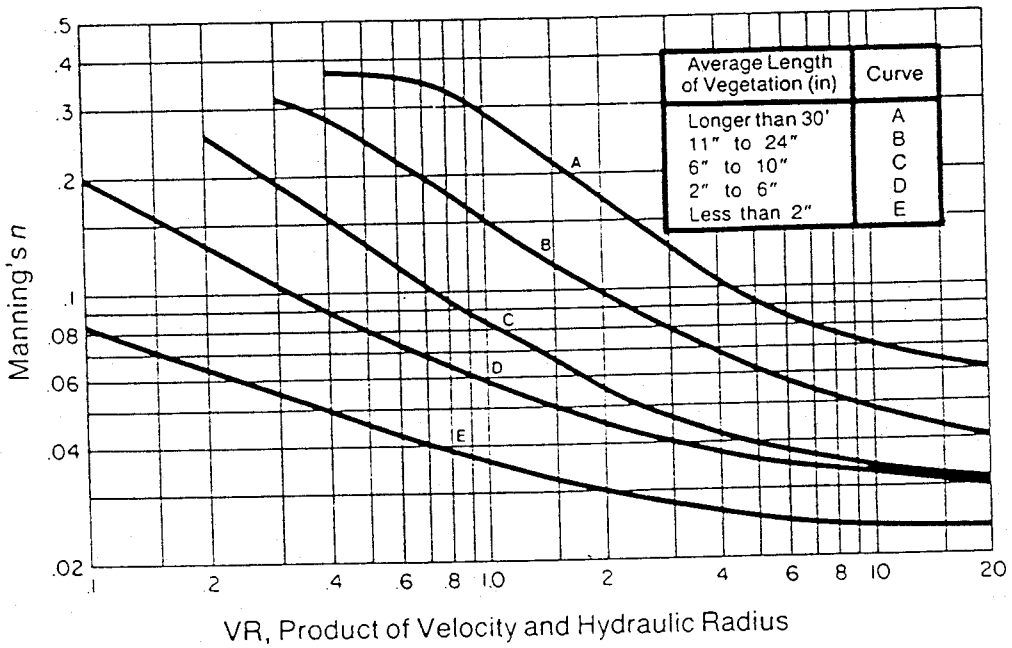


Figure 8.05c Manning's *n* related to velocity, hydraulic radius, and vegetal retardance.

Table 8.05a
Maximum Allowable Design Velocities[1]
for Vegetated Channels

Typical Channel Slope Application	Soil Characteristics[2]	Grass Lining	Permissible Velocity[3] for Established Grass Lining (ft/sec)
0-5%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	5.0
		Tall fescue	4.5
		Bahiagrass	4.5
		Kentucky bluegrass	4.5
		Grass-legume mixture	3.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	6.0
		Tall fescue	5.5
		Bahiagrass	5.5
		Kentucky bluegrass	5.5
		Grass-legume mixture	4.5
5-10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	4.5
		Tall fescue	4.0
		Bahiagrass	4.0
		Kentucky bluegrass	4.0
		Grass-legume mixture	3.0
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	5.5
		Tall fescue	5.0
		Bahiagrass	5.0
		Kentucky bluegrass	5.0
		Grass-legume mixture	3.5
>10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	3.5
		Tall fescue	2.5
		Bahiagrass	2.5
		Kentucky bluegrass	2.5
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	4.5
		Tall fescue	3.5
		Bahiagrass	3.5
		Kentucky bluegrass	3.5

Source: USDA-SCS Modified

NOTE: [1]Permissible Velocity based on 10-yr storm peak runoff
[2]Soil erodibility based on resistance to soil movement from concentrated flowing water.
[3]Before grass is established, permissible velocity is determined by the type of temporary liner used.

Selecting Channel Cross-Section Geometry

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change throughout the length of a channel, subdivide the channel into design reaches, and design each reach to carry the appropriate capacity.

The three most commonly used channel cross-sections are "V"-shaped, parabolic, and trapezoidal. Figure 8.05b gives mathematical formulas for the area, hydraulic radius and top width of each of these shapes.

Table 8.05f
Manning's Roughness Coefficient for Riprap and Gravel

Material	d_{50} (inches)	*n* value for Depth Ranges 0-0.5 ft	0.5-1.0 ft	1.0-2.0 ft	> 2.0 ft
Gravel	1	0.033	0.028	0.026	0.025
	2	0.045	0.034	0.034	0.031
Riprap	6	0.106	0.054	0.044	0.041
	9	0.215	0.068	0.062	0.047
	12	0.797	0.084	0.060	0.053
	15	—	0.104	0.068	0.059
	18	—	0.127	0.076	0.064
	21	—	0.158	0.085	0.070
	24	—	0.199	0.095	0.076

DETERMINING SHEAR STRESS

Shear stress, T, at normal depth is computed for the lining by the following equation:

$$T = yds$$

where:

T = shear stress in lb/ft^2
y = unit weight of water, 62.4 lb/ft^3
d = flow depth in ft
s = channel gradient in ft/ft.

If the permissible shear stress, T_d, given in Table 8.05g is greater than the computed shear stress, the riprap or temporary lining is considered acceptable. If a lining is unacceptable, select a lining with a higher permissible shear stress and repeat the calculations for normal depth and shear stress. In some cases it may be necessary to alter channel dimensions to reduce the shear stress.

Computing tractive force around a channel bend requires special considerations because the change in flow direction imposes higher shear stress on the channel bottom and banks. The maximum shear stress in a bend, T_b, is given by the following equation:

$$T_b = K_b T$$

where:

T_b = bend shear stress in lb/ft^2
K_b = bend factor
T = computed stress for straight channel in lb/ft^2

The value of K_b is related to the radius of curvature of the channel at its center line, R_c, and the bottom width of the channel, B, Figure 8.05e. The length of channel requiring protection downstream from a bend, L_p, is a function of the roughness of the lining material and the hydraulic radius as shown in Figure 8.05f.

Table 8.05g
Permissible Shear Stresses for Riprap and Temporary Liners

Lining Category	Lining Type	Permissible Unit Shear Stress, T_d (lb/ft^2)
Temporary	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	
	Single	0.60
	Double	0.85
	Straw with Net	1.45
	Curled Wood mat	1.55
	Synthetic Mat	2.00
	d_{50} Stone Size (inches)	
Gravel Riprap	1	0.40
	2	0.80
Rock Riprap	6	2.50
	9	3.80
	12	5.00
	15	6.30
	18	7.50
	21	8.80
	24	10.00

Design Procedure-Temporary Liners

The following is a step-by-step procedure for designing a temporary liner for a channel. Because temporary liners have a short period of service, the design Q may be reduced. For liners that are needed for six months or less, the 2-yr frequency storm is recommended.

Step 1. Select a liner material suitable for site conditions and application. Determine roughness coefficient from manufacturer's specifications or Table 8.05e.

Step 2. Calculate the normal flow depth using Manning's equation (Figure 8.05d). Check to see that depth is consistent with that assumed for selection of Manning's *n* in Figure 8.05d.

Step 3. Calculate shear stress at normal depth.

Step 4. Compare computed shear stress with the permissible shear stress for the liner.

Step 5. If computed shear is greater than permissible shear, adjust channel dimensions to reduce shear or select a more resistant lining and repeat steps 1 through 4.

Design of a channel with temporary lining is illustrated in Sample Problem 8.05b.

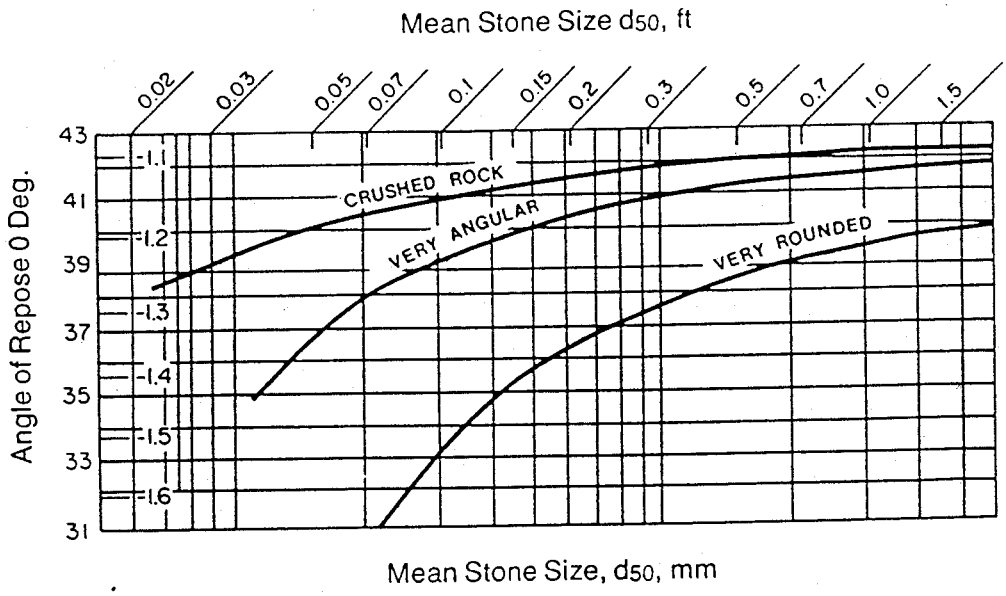


Figure 8.05g Angle of repose for different rock shapes and sizes.

Selection of riprap gradation and thickness. Riprap gradation should have a smooth size distribution curve. The largest stone size in the gradation should not exceed 1.5 times the d_{50} size. The most important criterion is that interstices formed by larger stones be filled with smaller sizes in an interlocking fashion, preventing the formation of open pockets. These gradation requirements apply regardless of the type of filter design used.

In general, riprap constructed with angular stone performs best. Round stones are acceptable as riprap provided they are not placed on side slopes steeper than 3:1. Flat, slab-like stones should be avoided since they are easily dislodged by the flow. An approximate guide to stone shape is that neither the breadth nor the thickness of a single stone be less than one-third its length.

The thickness of a riprap lining should equal 1.5 times the diameter of the largest rock size in the gradation.

Filter design. When rock riprap is used, an appropriate underlying filter material must be selected. The filter material may be either a granular, gravel or sand filter blanket, or a geotextile fabric.

Supplemental Procedure for Riprap Channel With Steep Side Slopes. This procedure should be used when side slopes are steeper than 3:1.

Step 1. From Figure 8.05g, determine the angle of repose for the rock size and shape. NOTE: The side slopes selected for the channel must be stable for the soil conditions.

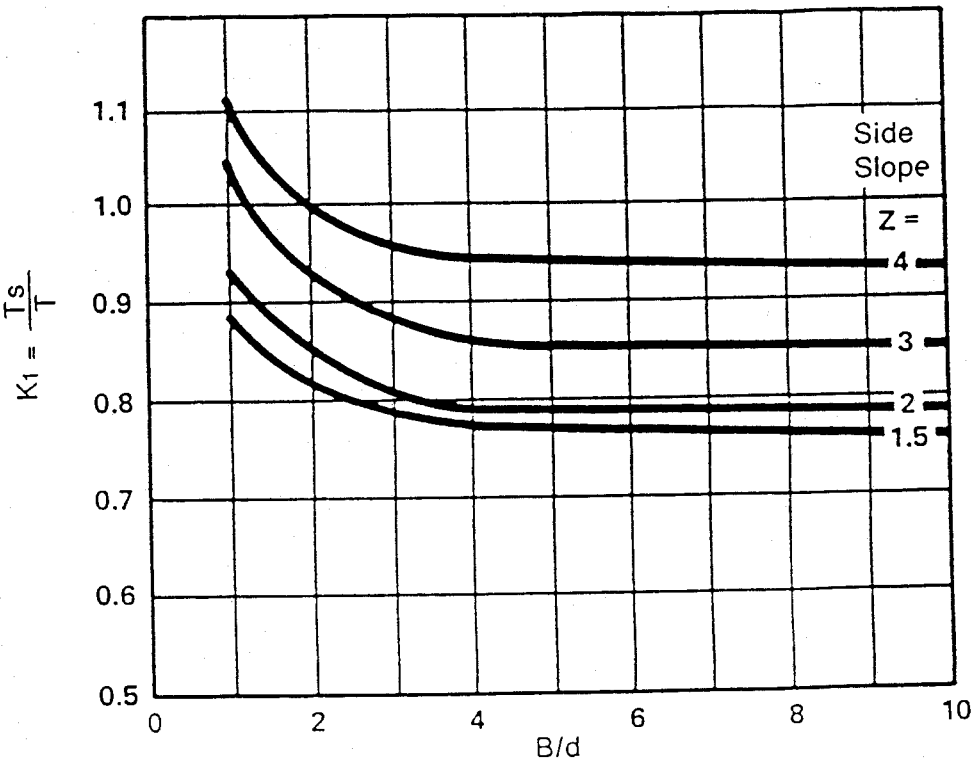


Figure 8.05h Ratio of side shear stress to bottom shear stress , K_1.

Step 2. From Figure 8.05h, determine K_1, the ratio of maximum side shear to maximum bottom shear for a trapezoidal channel, based on bottom width to depth ratio, b/d, and side slope, Z.

Step 3. From Figure 8.05i, determine K_2, the tractive force ratio, based on side slope and the stone angle of repose.

Step 4. The required d_{50} for side slopes is given by the following equation:

$$d_{50\ (sides)} = \frac{K_1}{K_2}\ d_{50\ (bottom)}$$

where:

K_1 = ratio of shear stress on the sides, T_s, and bottom, T, of a trapezoidal channel (Figure 8.05h),

K_2 = tractive force ratio (Figure 8.05i).

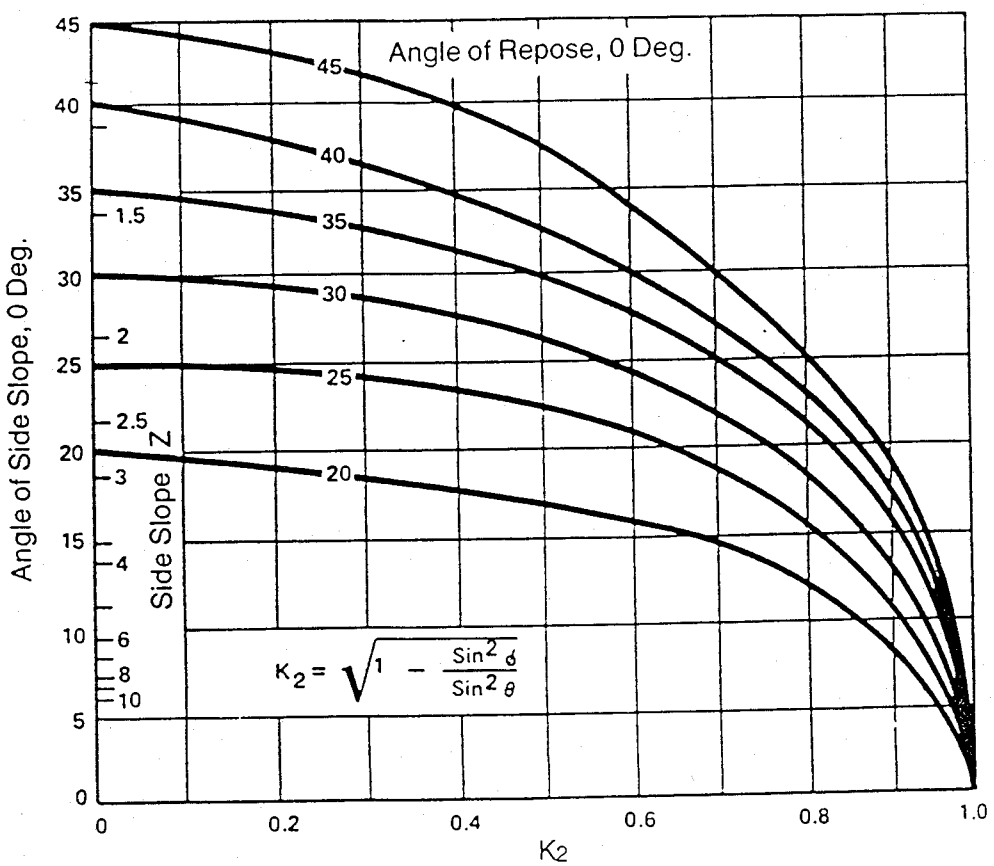


Figure 8.05i Tractive force ratio, K_2.

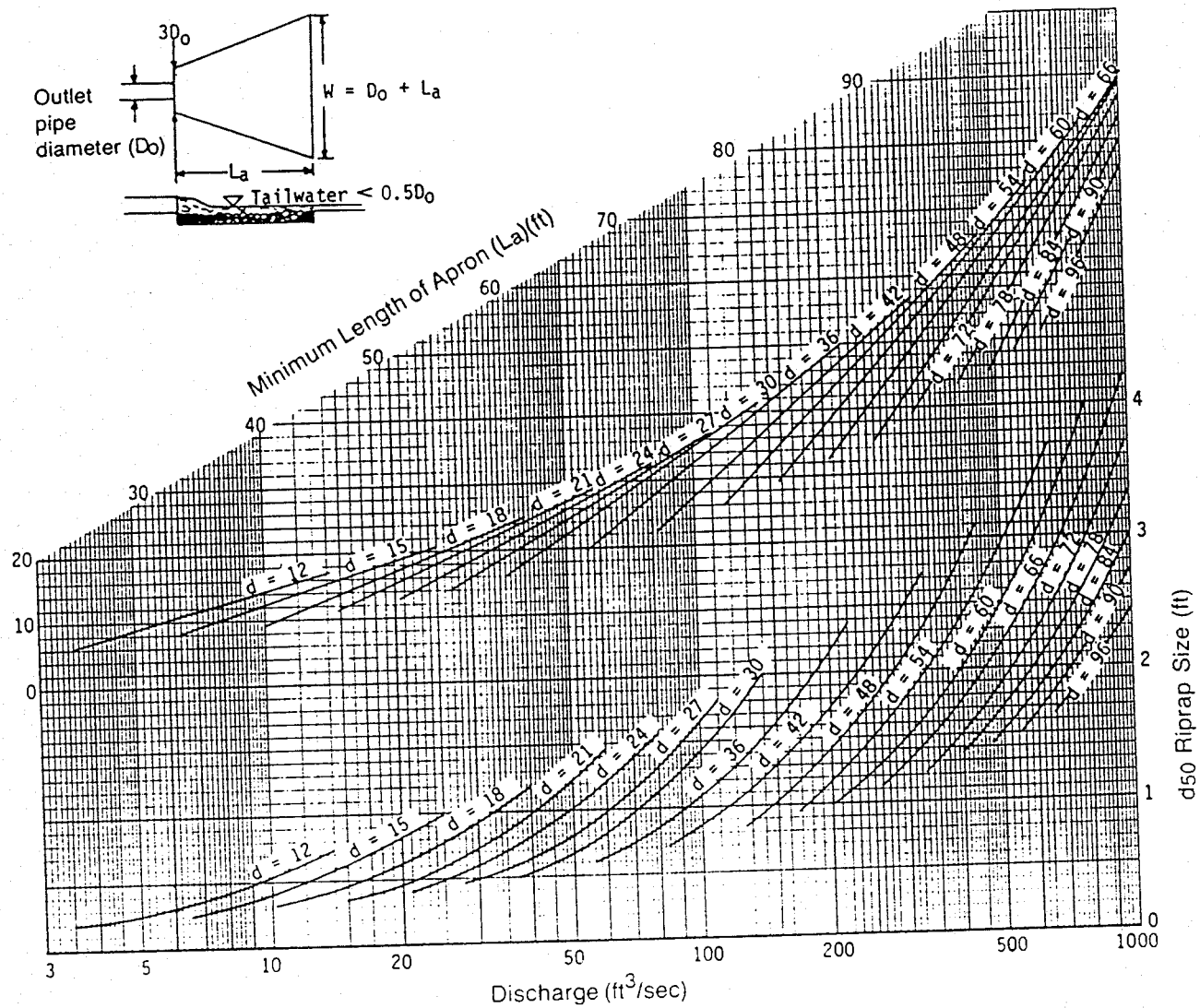
Sample Problem 8.05c demonstrates the tractive force procedure for the design of mild gradient riprap channels.

DESIGN OF RIPRAP LINING-STEEP GRADIENTS

This section outlines the design of riprap channel lining for steep gradients. Achieving channel stability on steep gradients, 10% or more, usually requires some type of channel linings except where the channels can be constructed in durable bedrock.

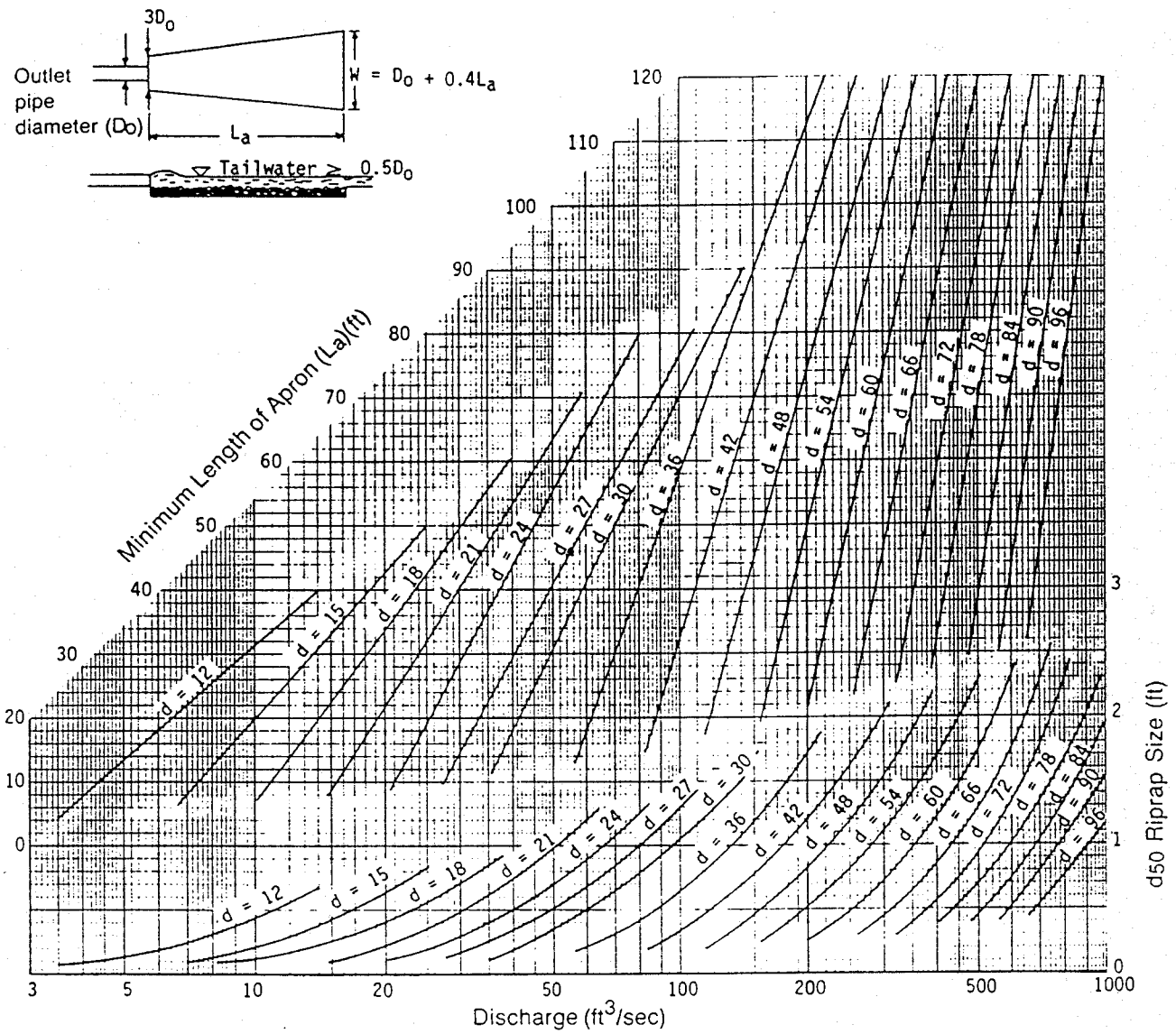
Rigid channel linings may be more cost effective than riprap in steep slope conditions. Riprap stability on a steep slope depends on the average weight of the stones and the lift and drag forces induced by the flow. To resist these forces, steep channels require larger stones than mild slope channels, and the size of riprap linings increases quickly as discharge and channel gradient increase. The decision to select a rigid or flexible lining may be based on other site conditions, such as foundation material and maintenance requirements.

Transition sections protect transition regions of the channel both above and below the steep gradient section. The transition from a steep gradient to a culvert



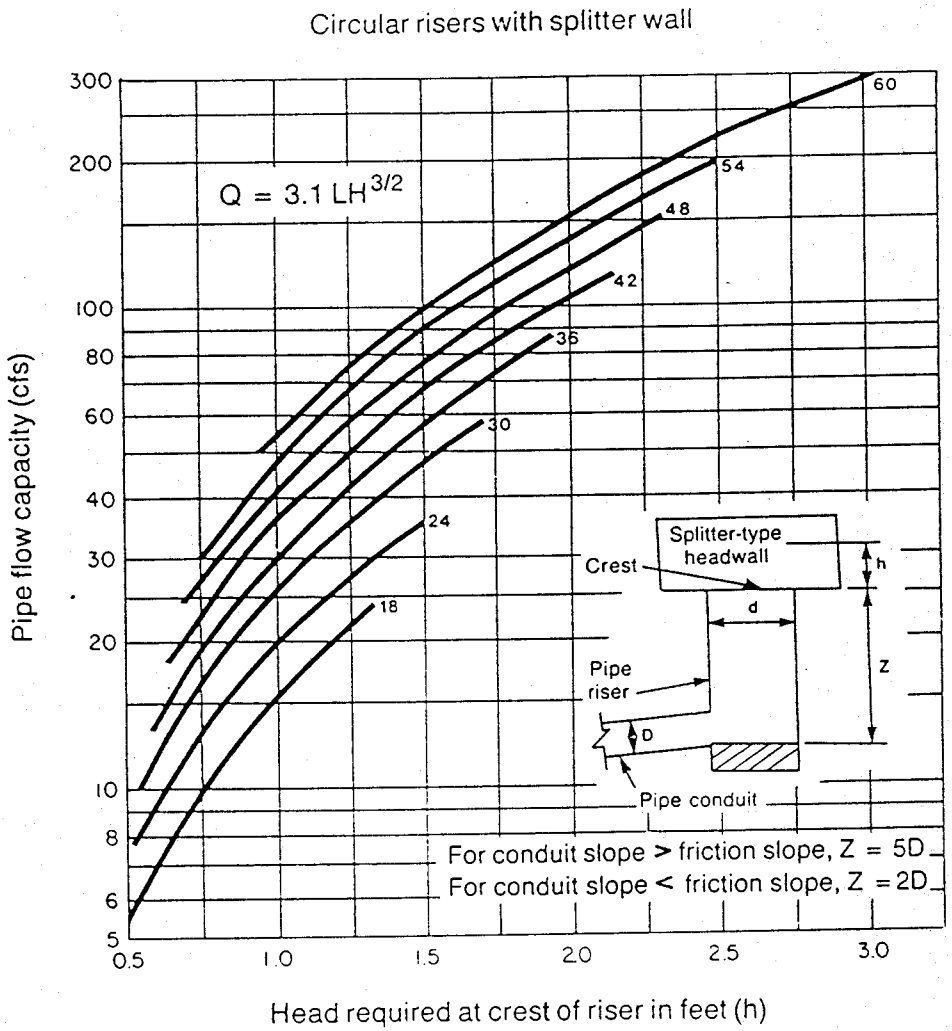
Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).



Curves may not be extrapolated.

Figure 8.06b Design of outlet protection from a round pipe flowing full, maximum tailwater condition ($T_w \geq 0.5$ diameter).



Inlet Proportions	
Pipe Conduit (D) - in	Pipe Riser (D) - in
8-12	18
15	21
18	24
21	30
24 ←	30
30	36
36	48
42	54
48	60

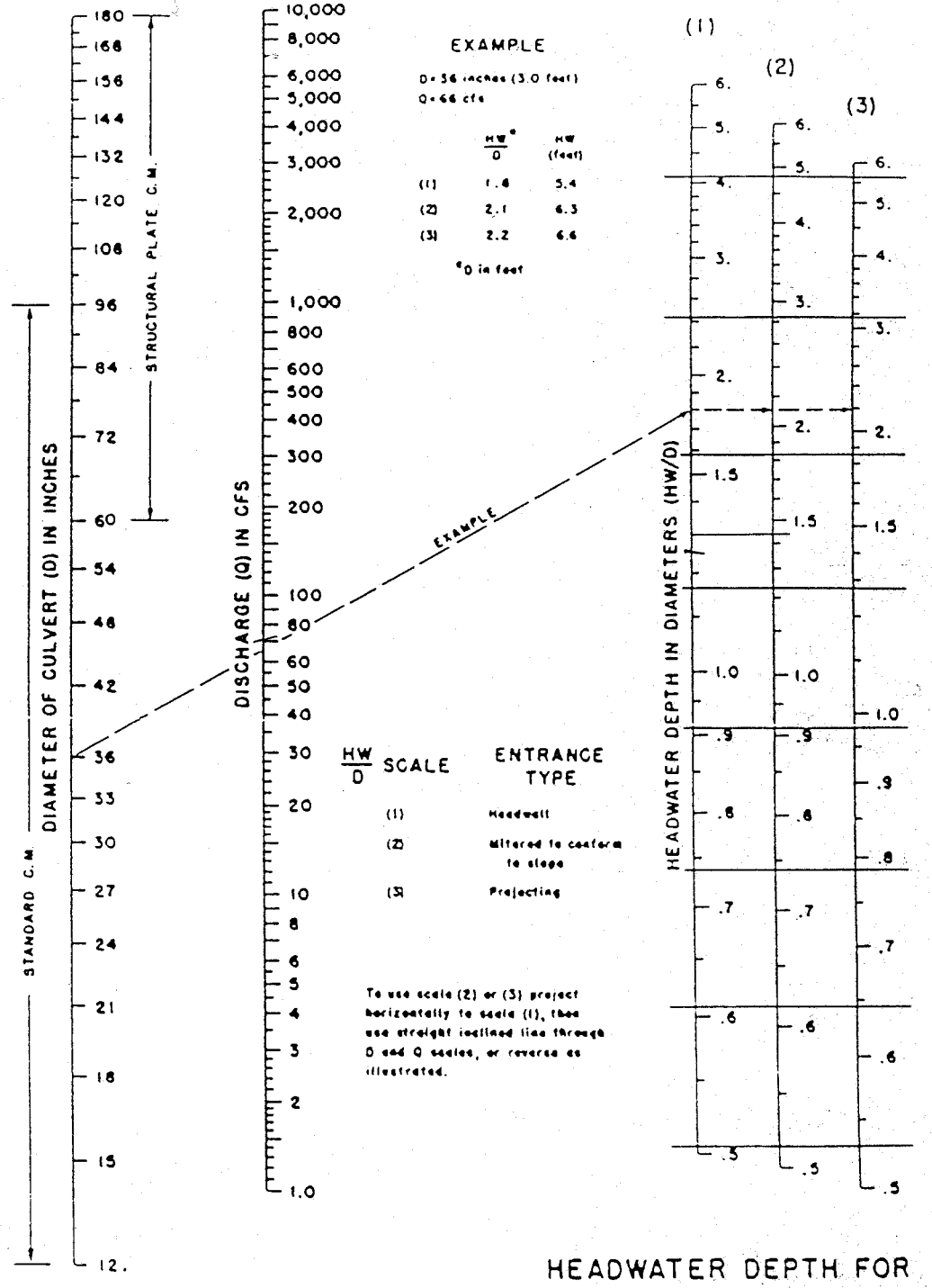
Pipe drop inlet spillway design:

For a given Q and H, refer to Table 8.07a or 8.07b for conduit size. Then determine the riser diameter (d) from the Inlet Proportions Table on this figure. Next, refer to the above curves, using the conduit capacity and riser diameter, and find the head (h) required above the crest of the riser. The height of the riser should not be less than 5D - h, except as noted in the above sketch.

Example - Given: CMP; Q = 20 cfs; H = 14 ft, h max. 1.0 ft; L = 70 ft. From Table 8.07a find conduit size (D) = 18 inches. From Inlet Proportions Table, riser size = 24 inches. Head (h) required for Q = 20 and d = 24 is 1.0 ft.

Figure 8.07b Design chart for riser outlet.

CHART 5



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HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

Exhibit 12