PERMIT APPLICATION REPORT

Halifax County C&D Landfill
Permit 42-04

Prepared for
Halifax County, North Carolina
Solid Waste Department

August 1997

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

Permit Application Report

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Prepared for
Halifax County
Department of Solid Waste Management
P.O. Box 327
Halifax, NC 27839

To the Attention of:
Mr. Richard Garner
Director

GNRA Project No. Halifax-11

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C&D Landfill Site

Halifax County, North Carolina

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A guide to specific NC Solid Waste Management rules addressed in this volume is shown in italics after each entry, and are referenced throughout the text.

1.0 EXECUTIVE SUMMARY

The planned facility is a new Construction and Demolition (C&D) debris landfill to be developed at the existing Halifax County Landfill (Permit #42-04). The planned C&D landfill study area encompasses a ±12-acre tract within the existing permitted facility boundary, located east of the MSW landfill, and a small portion of a 30-acre tract, discussed below. The C&D landfill will be constructed outside a 300 foot buffer, established east (up gradient) from the MSW landfill. The geology and hydrogeology of the study area has been characterized, along with that of relevant portions of the 30-acre tract, and a site design package has been prepared pursuant to applicable North Carolina Solid Waste Management rules 15 NCAC 13B .0503 through .0505.

The County desires to add the 30-acre tract, purchased in 1995, to the permitted facility boundary for the primary purpose of monitoring and buffer for the unlined MSW landfill. Portions of the 30-acre tract will also serve as a soil borrow site. Those portions of the 30-acre tract under consideration for lateral expansion of the C&D facility is based on drainage considerations and anticipated future C&D disposal requirements. No future MSWLF units are anticipated for development within this portion of the property.

Plans are still under consideration for a future lined MSWLF unit, located on a 45-acre study area across a creek from (north of) the unlined MSW landfill, southwest of a lined ash monofill. The current MSW landfill has a targeted closure date of December 31, 1997. The County is pursuing a permit from NC DEHNR - Division of Waste Management, Solid Waste Section, for the new MSWLF unit, although the construction may be postponed indefinitely. The Facility Plan has been modified to show the C&D landfill and the future MSWLF unit, along with the 30-acre tract within the facility boundary.

The planned C&D site meets all applicable location requirements of Rule .0504 (1) through (6). ? The site vicinity is sparsely populated, with virtually no down gradient development. Geological and geotechnical conditions at the planned C&D site are typical of conditions at the ash monofill and lined MSWLF sites, both investigated by G.N. Richardson & Associates in previous years. There are no flood plains, wetlands or endangered species identified within the C&D footprint.

The C&D site was clear cut for timber (ca. 1994). Prior to that, the land was used for agriculture. Soils are relatively deep on the 12-acre site, providing sufficient construction and cover soil. Ground water characteristics at the site are sufficiently well understood to design an effective ground water monitoring network.

The site contains a permanent stream (unnamed tributary) that provides an on-site ground water discharge feature. There are no potable wells located between the planned C&D landfill and the ground water discharge feature. Based on nearby monitoring well records spanning 3 years, ground water levels appear to have attained a maximum seasonal high elevation soon after the investigation was completed earlier this year. Depths to bedrock and/or ground water are such that the current grading plan will meet regulatory vertical separation requirements.

2.0 SITE REPORT - *.0504 (1)*

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

Figure 1A shows the site vicinity and 2-mile radius on the USGS 7.5 minute topographic map (Thelma and Aurelian Springs quadrangles). The facility is located twelve miles south of Roanoke Rapids, one mile north of the intersection of NC 48 and SR 1001 at Aurelian Springs, in the Butterwood township (see inset on Drawing G1). The property is zoned agricultural and/or residential. There is no residential or commercial/industrial development in the site vicinity.

Area land use is primarily undeveloped or agricultural. Scattered houses and businesses exist along NC 48 and the other paved roads in the area. The permitted facility boundary site is bound on the north by SR 1417 and to all other directions by private property. Access to the site is from SR 1417, which connects to SR 1418 to the north and SR 1001 to the south. Both these roads connect to NC 48 and serve as the primary waste transportation routes. All access roads are paved. Current public road transportation routes, shown in Drawing G1, will not be modified.

Public water supply wells in the vicinity are identified on Drawing G1. No surface water intakes or residential subdivisions are known to exist within two miles of the site. The nearest known public water service area is Roanoke Rapids. Municipal water is not available in the vicinity.

Drawing G2 shows the site with a 2000-foot radius on regional mapping (1 inch = 400 feet). A current aerial photograph with the 2000-foot radius is shown on Drawing G3. The photograph has been field verified that no significant new development has occurred within the 2000-foot radius since the photo was taken. On-site easements to the facility boundary include an overhead electric power line (North Carolina Power Company), located along SR 1417 at the north end of the site. No other utilities or easements are known within the site boundary.

Significant ground water users within two miles of the site include two schools: a high school located northeast at a distance of 1.5 miles, and an elementary school located south at a distance of 0.8 miles from the facility boundary. Neither ground water user facility is down gradient of the site, nor are these facilities expected to be influenced by the planned site development.

Potential contaminant sources at the facility include the unlined MSW landfill, located down gradient from the planned C&D landfill. This facility has been investigated and is monitored separately. An old C&D facility exists far down the opposite side of a creek. This unit is not expected to affect ground water at the planned C&D site.

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

The local map and photo show 24 residences within a 2000-foot radius of the site boundary. A potable well survey conducted in conjunction with the transition plan for the old MSW landfill identified 24 potable water wells within 2000 feet of the site boundary, excluding two wells at the nearer school that are outside the 2000-foot radius. None of the area water wells are considered to be down gradient of the landfill.

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

The proposed C&D facility will occupy a shallow swale, which slopes gently toward a perennial stream (unnamed tributary), situated along the north side of a east-west trending ridge. Ground surfaces within the study area vary from El. 322 (feet) along the ridge at the south end of the site, decreasing to El. 260 along the tributary.

The site grading plan will take advantage of the topography to minimize earthwork requirements. The unnamed tributary is the primary water course on the site. The shallow swale serves as a runoff conveyance within the study area. An intermittent spring (wet weather conveyance) has been identified along the north side of the C&D study area. Development of the C&D landfill will not disturb this feature.

Future expansion of the C&D facility will extend south into the 30-acre tract recently purchased by the County. The 30-acre tract will be brought into the permitted facility boundary upon approval of this permit application by the North Carolina DEHNR - Division of Waste Management (NC DWM). No other development plans for the 30-acre site have been made, except for future soil borrow operations.

Other waste disposal facilities within the facility boundary include the old MSW landfill, scheduled to close on December 31, 1997 and an ash monofill operated by Halifax County exclusively for disposal of coal-fired power plant ash from a nearby cogeneration facility. The County's white goods, tires and composting operations now occupy an undeveloped portion of the site, designated as the future lined MSWLF unit.

The County desires to retain the right to develop a future lined MSWLF unit within the permitted facility boundary, in the event that plans to build that facility are eventually realized. The County has an active permit application on file at NC DWM. The County continues to maintain ground water level observation around the site, in pursuit of securing a future construction permit.

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

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

The main drainage feature on the site is an unnamed tributary that roughly bisects the permitted property and drains westward to Brewer's Creek and Bear Swamp. The banks of the unnamed tributary form a narrow flood plain extending no more than 20 feet to either side of the channel within the site boundary. No development is proposed within 50 feet of the stream channel.

An inspection of FIRM mapping [1], reprinted in Appendix B, indicates that no areas of the site

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

exist within the 100 year flood limits. Design grades will be set such that no restriction to the flow of the unnamed tributary will occur and the risk of exposure of the waste due to flooding or scouring will be minimal. There will be minimal disturbance to a wooded area adjacent to the unnamed tributary.

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

Detailed studies of the ash monofill site identified no endangered species habitats in the vicinity of the Halifax County Landfill. The C&D site has been disturbed as recently as 1994, at which time the site was completely timbered. Portions of the site (within 300 feet of the MSW landfill) have been excavated for soil borrow. Refer to Section 2.3.4 below.

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

A Phase 1 Cultural Resource Study was performed in 1991 for the adjacent ash monofill, permitted and constructed in 1992. That study, performed by a reputable archaeologist, identified no significant historical or cultural artifacts within the site boundary. A reprint of the study is presented in Appendix C of this volume.

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

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

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

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

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

On-site soils consist of clayey silt and sandy silt that will serve as suitable cover materials. Test borings indicate that the soils extend to depths in excess of 25 feet over a majority of the study area. There are sufficient soil quantities to meet the anticipated cover soil requirements.

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

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

The site will be managed such that explosive gas concentrations will not exceed regulatory thresholds in on-site structures and at the property line. This will be accomplished through waste segregation. The inert waste stream is not anticipated to produce methane in sufficient quantities to cause an explosion concern. No explosive gas control devices are anticipated to be required.

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

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

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

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

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

The site drawings demonstrate that the bottom elevation of the waste will be a minimum of four feet above the seasonal high water table, as determined by the site study. Ground water records are available for a portion of the site for more than a 3 year period. The site will be managed to prevent the likelihood of ground water impact. Due to the inert nature of the C&D wastes, a liner and leachate collection system will not be required.

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

Open burning of waste will not be allowed. The Operations Plan for the facility will reflect this.

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

A horizontal buffer of 300 feet will be observed between the C&D facility and the old MSW landfill. A minimum 200-foot buffer will be observed along the east property line. There are no private dwellings or water wells within 500 feet of the planned facility. A 50-foot buffer will be observed along the perennial stream (unnamed tributary) and the intermittent spring to the north.

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

A sedimentation and erosion control plan will be implemented and proper maintenance of control structures will be observed to meet this requirement.

3.0 GEOLOGY AND HYDROGEOLOGY - *.0504 (1) (c)*

3.1 Soil Test Boring Investigation - *.0504 (1) (c) (i)*

A test boring investigation of the planned C&D site was performed. Test borings BP-1 through 6 were installed in December 1995. Test borings BP-7 through 14, extending to depths of 6 to 50 feet, were installed in April-May 1997. Test boring data are summarized on Table 1A. Drawing S1 shows the locations of the test borings and ground water observation points.

All but three of the BP-series borings were converted to standpipe piezometers for long-term ground water level observation. Three earlier piezometers, GY-1 through 3, and two ground water monitoring wells, MW-11 and MW-15, provide supplemental data. There are 16 ground water observation points within and near the proposed C&D facility footprint.

3.1.1 Soil Classification - *.0504 (1) (c) (i) (A-C)*

The soil test borings were sampled with standard penetration test techniques (ASTM D-1586). Soil samples were visually classified by an experienced soils technician, and laboratory testing was performed on representative samples to confirm the field classifications. The results of laboratory testing are presented on Table 2. Test boring records are presented in Appendix D.

The soils within the upper 10 feet of the surface are generally classified as low to medium plasticity clayey and/or sandy silt (ML) and high plasticity silt (MH) with occasional silty sand (SM). The borings generally did not encounter bedrock or partially weathered rock. The deeper soils are more granular and exhibit a relic rock-like texture, generally classified as coarse silty sand (SM). Test boring BP-1 encountered partially weathered rock and auger refusal on bedrock.

3.1.2 Geologic Considerations - *.0504 (1) (c) (i) (D)*

No unusual geologic features or conditions, including seismic hazards or unstable areas, have been identified on the site. Rock outcrops are present along the unnamed tributary to the north of the C&D site, but none were observed within the planned footprint. The soils appear similar in all respects to those observed at the ash monofill site and the lined MSWLF site.

3.1.3 Undisturbed Samples - *.0504 (1) (c) (i) (E)*

Shelby tube samples were procured from within the facility boundary during the site study for the lined MSWLF unit. The samples were subjected to laboratory triaxial permeability testing, summarized on Table 2. Permeability values were in the range of 10^{-5} to 10^{-6} cm/sec for these samples. Visual observation and laboratory classification indicates that these samples are representative of the soils within the planned C&D site. Table 2 presents results of density, moisture and porosity for these samples. Laboratory data is presented in Appendix E.

3.1.4 Remolded Samples - *.0504 (1) (c) (i) (F)*

Representative bulk samples were procured from the upper 20 feet the surface within the C&D study area. Remolded samples were subjected to laboratory triaxial permeability tests, summarized on Table 2. Remolded permeability values were in the range of 10^{-7} to 10^{-8} cm/sec. The bulk samples are considered to be representative of the shallower soils with in the site. Table 2 presents results of density, moisture and porosity for these samples. Laboratory test data is presented in Appendix E.

3.1.5 Site Stratigraphy - *.0504 (1) (c) (i) (G)*

Hydrogeologic profiles are presented on Drawing X1. The site stratigraphy is based more on the in-situ weathering pattern than actual depositional units. The upper soils are stiff, reddish-orange clayey silt and silty clay, extending to depths of 10 to 15 feet below the surface. These soils are moist and often exhibit mottling. Occasional dark brown iron and/or manganese staining along joint surfaces, noted in the boring logs, gives evidence of water movement through the soils.

The near-surface soils are underlain by pink-white and gray sandy silt that exhibits a relic texture derived from the parent bedrock (saprolite), resembling the nearby granite outcrops. These soils grade with depth to a deeper coarse silty sand, often containing angular quartz or feldspar gravel and fresh mica, and eventually transition into weathered rock and bedrock.

Based on the borings, standard penetration test (SPT) values vary spatially due to density variations and the degree of saturation. Only one boring, BP-1, encountered partially weathered rock, defined as residual soils that can be penetrated by a hollow stem auger, driven by a rotary drilling rig, but which also exhibit standard penetration resistance values in excess of 100 blows per foot. This boring encountered auger refusal and was dry, thus a piezometer was not installed.

The site stratigraphy is divided into two hydrogeologic units, Unit 1 and 2, consistent with criteria used for the lined MSWLF site study. Unit 1, has two subunits, 1a and 1b, defined on the basis of standard penetration test values, used here as an indication of the degree of weathering. Unit 1a is defined by SPT values less than 100 blows per foot (bpf), while Unit 1b represents soils that exhibit SPT values above 100 bpf. Unit 2, identified in the earlier site studies as bedrock and weathered rock that cannot be penetrated by a hollow stem auger, was not encountered at the C&D site. All of the piezometers were completed within Unit 1a soils.

3.1.6 Water Table Information - *.0504 (1) (c) (i) (H)*

Short-term water level observations (taken at time of boring completion and following 24 hours) are tabulated on Table 1A. Seven-day water level readings were not acquired, but water levels were observed after 15 days and monthly thereafter. Long-term ground water level observation data is presented on Table 1C.

3.2 Test Boring Locations - *.0504 (1) (c) (ii)*

The test borings and relevant site features are shown on Drawing S1. Vertical and horizontal control is tied into the site grid, referencing permanent bench marks located just east of the old MSW landfill. Bench mark data is provided on Drawing S1.

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

5-1-97 per sheet S1A

Ground water potentiometric surfaces, based on observed seasonal high ground water elevations, are shown on Drawing S1A. The potentiometric contours reflect estimates of hydraulic head, the likely highest elevations below which saturated soils are expected to be found, and may not reflect actual ground water depths at a given location. The potentiometric surface reflects a subdued expression of the surface topography, which is typical of the Piedmont, and indicates a generally northwest ground water flow pattern, toward the perennial stream (unnamed tributary).

3.4 Geological and Hydrogeological Evaluation - *.0504 (1) (c) (iv)*

3.4.1 Local and Regional Geology

A review of historical literature [2] and available geologic mapping [3] indicates that the proposed landfill site is situated on the eastern edge of the Eastern Piedmont Physiographic Province, just west of the Coastal Plain overlap. Western Halifax County is underlain by an assemblage of felsic to intermediate crystalline igneous and metamorphic rocks of early to late Paleozoic age.

The rocks of the eastern Piedmont exhibit a northeast strike and dip gently eastward, resulting from regional metamorphism and folding that produced a broad plunging anticline. The area was simultaneously intruded by a number of felsic (granite) plutons. The rock formation underlying the subject site is a granitic pluton, identified as the Butterwood Creek intrusive.

A few miles east of the site, the crystalline rocks of the Piedmont plunge beneath unconsolidated fluvial and deep-marine deposits of the Coastal Plain. During late Tertiary time, portions of the eastern Piedmont were over washed by deltaic streams and shallow seas. This resulted in a thin veneer of clayey sands and rounded quartz gravel, still visible along the uplands at the site. The deeper soils are chiefly in-situ weathering products of granitic origin.

Primary lineaments observed in area topographic mapping (Drawings G1 and G2) are defined by the northeast-southwest orientation of Bear Swamp and the main ridge occupied by SR 1417. This northwest-southeast orientation aligns with the regional strike of mapped geologic formations. Secondary topographic lineaments noted throughout the region include subparallel ridges and north-south oriented drainage features. These secondary features align with prominent topographic features within the study area and are believed to reflect regional jointing

Granite outcrops were observed along the creek bottom north of the study area, south of the ash monofill site. The granite exhibits a coarse porphyritic texture, with one- to two-inch diameter potassic feldspar crystals embedded in a fine matrix of feldspar, quartz, mica and accessory minerals. The outcrops exhibit surficial exfoliation (near horizontal convex fracturing) and differential weathering along widely spaced, steeply dipping joint sets, resulting in rounded surface exposures. The joint surfaces are generally too weathered to obtain reliable strike and dip measurements. There were no rock outcrops observed in the planned C&D landfill footprint.

3.4.2 Ground Water Flow Characteristics

The upper-most aquifer, Unit 1, is characterized as a closed-loop, partially confined, porous flow medium, with a relatively short separation between the recharge and discharge zones. A conceptual ground water flow model, shown on Drawing X1, consists of the following:

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

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

- recharge occurs over most of the site from the non-saturated surface soils
- partially confined flow occurs within a saturated layer of porous saprolite, existing between the lower permeability near surface soil and underlying bedrock
- some downward recharge occurs into the deeper, widely spaced bedrock fractures
- discharge occurs along the perennial stream existing at the north side of the site.

These conditions are considered typical of piedmont terranes. Based on test boring data, Unit 1 varies from 25 to 40 feet in thickness, measured between the upper point of saturation (water table) and the estimated depth of competent bedrock. There are no obvious confining layers, except for partial confinement caused by the non-saturated near surface soils. Observed seasonal high water levels (Table 3) vary from depths of 1 foot below the surface within the low lying drainage features to 45 feet (or more) within the higher elevations of the study area.

The deeper bedrock aquifer(s), Unit 2, typically occur as discreet fractures in the less weathered bedrock, differentiated from the upper most aquifer based on flow characteristics. The discreet fractures offer more restricted flow paths and provide partial to complete confinement, based on the earlier site work. Unit 2 was not penetrated by test borings at the C&D site.

3.4.3 Ground Water Gradients and Velocities

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

$$V = KI/n:$$

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

Saturated hydraulic conductivity values for the upper-most aquifer vary from 0.30 to 28 feet/day (1.0×10^{-4} to 8.0×10^{-2} cm/sec). Horizontal ground water gradients vary from 0.023 at BP-3 to 0.112 at BP-7 (units are ft/ft). Corresponding ground water velocities vary from 0.033 ft/day at BP-3 to 12.8 ft/day at BP-7. Slug tests (Appendix F) are short-term, non-steady state tests that measure permeability within a limited zone of influence about each piezometer. The velocity calculations are sensitive to variable hydraulic gradients and empirical porosity values[4].

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

Laboratory porosity values are based on the *total* percentage of pore space (voids) within a soil, where *effective* porosity reflects the degree of interconnectivity of the pore space. Laboratory porosity values can be adversely affected by sample disturbance, where the published empirical values are based on numerous field tests and reflect more probable in-situ conditions. The ground water velocities shown on Table 4 serve as a guide for planned modifications to the facility ground water monitoring plan (Section 4.6).

3.4.4 Summary of Hydrogeological Evaluation

The planned C&D landfill will be situated over a portion of the recharge area, effecting a minor reduction in ground water recharge within the facility boundary. The area in which ground water recharge will be reduced is small compared to the drainage basin feeding the permanent stream (unnamed tributary). The base flow reduction at the stream will be minimal. No ground water receptors (water wells) are located between the planned C&D landfill and the nearest ground water discharge feature. No ground water users are down gradient of the facility.

Based on the investigation of the C&D study area and previous studies for the ash monofill, the lined MSWLF unit and the old MSW disposal site, geologic and hydrogeologic conditions are consistent throughout the 200± acre permitted site boundary and the 30-acre tract. Based on this characterization, study area appears to be well suited to development of a new C&D landfill. The Ground Water Monitoring Plan will provide effective monitoring of the upper-most aquifer.

4.0 FACILITY PLAN REPORT - *.0504 (1) (d) through (h)*

4.1 Conceptual Design Plan - *.0504 (1) (d)*

The ±4.5-acre (waste footprint) C&D landfill will be developed with five-year operational cells. Soil dikes and diversion berms will be utilized to manage storm water and prevent run on to the inert wastes. Site development will require average cuts and fills of 10 feet. The final waste thickness will be 60 feet. Drawings S2 and FC1 set show planned base grades and final contours, respectively. Planned final side slope ratios are 4H:1V.

4.2 Local Government Approval - *.0504 (1) (e)*

The County makes this site permit application in their own behalf. A resolution by the County Commissioners has not been formalized. However, in consideration of the December 31, 1997 closure of the existing landfill, this application has been initiated without this documentation in the interest of time. Local government approvals will be submitted when available.

4.3 Service Area - *.0504 (1) (g) (I)*

The planned C&D landfill will serve all of Halifax County and its municipalities. Wastes will be accepted at the landfill and at designated, manned convenience centers.

4.4 Waste Stream Characterization - *.0504 (1) (g) (ii)*

The planned C&D landfill will accept inert construction and demolition wastes, including, but not limited to, concrete, untreated and unpainted lumber, brick/block, asphalt, non-recyclable metal (e.g. rebar in concrete), roofing materials and occasional brush or stumps. Recyclable inert materials will be separated for beneficial use. Painted materials will be accepted.

A current estimate of annual waste loading rate [5] includes approximately 8,500 tons of inert C&D debris and 1,500 tons of land clearing/inert debris (LCID). Most of the LCID is ground on the site and incorporated into a mulching operation. A provision for disposal of LCID wastes in the C&D landfill is made for contingency operations. The County also reports an annual 100 tons of animal carcasses annually. These wastes will be placed in trenches outside the C&D footprint.

The C&D landfill will not accept any household garbage, putrescible wastes, liquid or hazardous wastes as defined by applicable state federal regulations. Waste water treatment sludge will not be accepted, except as a potential cover soil amendment. Asbestos laden debris will be accepted, providing that it is packaged according to 40 CFR 61 and applicable state regulations.

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

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

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

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

The planned C&D landfill will be provided with two monitoring wells, one up gradient and one down gradient. The facility plan (Drawing G4) shows tentative locations for the new wells. The Ground Water Sampling and Analysis Plan (Appendix G) is modified accordingly.

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[5] Halifax County Solid Waste Management Plan, July 1996 - July 2006, prepared for NC DEHNR - Division of Waste Management, Solid Waste Section, July 1997

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

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

A boundary survey prepared by a North Carolina registered land surveyor is presented in Appendix A. The site is wholly owned by Halifax County.

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

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

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

Future site use after closure is undecided. The C&D landfill will be closed in accordance with the permit and applicable regulations. No future site development is anticipated at this time.

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

The planned C&D landfill is expected to provide about 190,000 cubic yards of solid waste disposal space. The anticipated annual loading of 8,500 tons will require about 9,900 cubic yards per year, based on an estimated 0.86 tons per cubic yard for C&D wastes. The planned C&D landfill will to provide approximately 20 years of capacity, with future expansion potential, if needed.

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

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

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

Earthwork calculations are presented in Appendix K. Based on these calculations, there will be approximately 43,000 cubic yards of cut and 19,000 yards of fill within the C&D footprint.

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

A seeding and mulching schedule is provided in the project technical specifications presented in Appendix H. All berms and exterior slopes shall be seeded after construction and placement of final cover.

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

An erosion and sedimentation control plan is presented in Appendix K. This plan will be implemented (subject to approval by NC DEHNR - Division of Land Quality) to prevent excess soil loss and lessen the possibility for impacting surface water quality.

Tables

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

Elevation Data				Geotechnical Data					Piezometer Construction Data				
Boring Number	Boring Date	Ground Elev.	PVC Pipe Elev.	Boring Depth, ft.	PWR Depth, ft.	PWR Elev.	Refusal Depth, ft.	Refusal Elev.	Top of Piez. Screen Depth, ft.	Top of Piez. Screen Elev.	Bot. of Piez. Screen Depth, ft.	Bot. of Piez. Screen Elev.	Stickup ft.
BP-3	12/06/95	313.7	315.39	50	--	--	--	--	38	275.7	48	265.7	1.69
BP-4	12/06/95	310.8	313.16	48	--	--	--	--	38	272.8	48	262.8	2.36
BP-6	12/05/95	315.0	317.28	25	--	--	--	--	15	300.0	25	290.0	2.28
BP-7	04/29/97	301.1	303.91	20	--	--	--	--	15	286.1	20	281.1	2.81
BP-8	04/29/97	299.8	303.07	30	--	--	--	--	24	276.3	28.5	271.3	3.27
BP-9	04/28/97	302.1	303.48	36	--	--	--	--	26	276.1	36	266.1	1.38
BP-10	04/30/97	284.4	286.40	15	--	--	--	--	10	274.4	15	269.4	2.00
BP-11	05/01/97	280.0	284.83	6	--	--	--	--	1	279.0	6	274.0	4.83
BP-12	04/30/97	294.4	295.97	26	--	--	--	--	21	273.4	26	268.4	1.57
BP-13	04/30/97	286.1	288.50	20	--	--	--	--	15	271.1	20	266.1	2.40
BP-14	05/01/97	269.7	274.03	6	--	--	--	--	1	268.7	6	263.7	4.33
GY-1		291.2	292.51	30	--	--	--	--					1.31
GY-2		297.9	299.99	20	--	--	--	--					2.09
GY-3		304.2	304.20	50	--	--	--	--					0.00
MW-11			265.96		--	--	--	--					
MW-15	09/21/94	307.1	309.09	20	--	--	--	--	35	272.6	49	258.1	1.99

Ground Water Observations				
Boring Number	Time of Boring Depth, ft.	Time of Boring Elev.	24-hour readings Depth, ft.	24-hour readings Elev.
BP-3	45.51	268.19	45.22	268.48
BP-4	38.3	272.50	36.25	274.55
BP-6	16.64	298.36	15.94	299.06
BP-7	1	300.10	3.26	297.84
BP-8	21.7	278.10	14.43	285.37
BP-9	18.4	283.70	18.88	283.22
BP-10	4.8	279.60	5.86	278.54
BP-11	0.5	279.50	2.05	277.95
BP-12	21.3	273.10	6.97	287.43
BP-13	15.8	270.30	7.32	278.78
BP-14	2.5	267.20	2.6	267.10
GY-1				
GY-2				
GY-3				
MW-11				
MW-15	41.5	265.60	42.15	264.95

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

2. No data exists for GY series brings, performed by others ca. 1994

3. Boring record not located for MW-11, performed by others ca. 1994

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

Table 1B
Summary of Hydrogeological Properties
Halifax County Landfill

Hydrological Unit	Well No.	Lithological Unit	Aquifer Thickness	Effective Porosity	Total Porosity	Hydraulic Conductivity	Grain Size Distribution			
							% Gravel	% Sand	% Silt	% Clay
1a	BP-3	Saprolite Zone	22.00	0.20	40.3	0.29	0	59	40*	NM
	BP-4	Saprolite Zone	40.00	0.20	NM	2.21	NM	NM	NM	NM
	BP-6	Saprolite Zone	40.00	0.20	43.2	10.80	0	20	35	45
	BP-7	Saprolite Zone	40.00	0.20	NM	22.84	0	39	39	22
	BP-8	Saprolite Zone	40.00	0.20	45.90	3.20	0	37	10	53
	BP-9	Saprolite Zone	40.00	0.20	NM	3.45	0	48	34	18
	BP-10	Saprolite Zone	40.00	0.20	0.46	27.92	NM	NM	NM	NM
	BP-12	Saprolite Zone	22.00	0.20	NM	4.74	0	18	65	17
	BP-13	Saprolite Zone	40.00	0.20	NM	9.46	0	20	62	18
	GY-3	Saprolite Zone	22.00	0.20	NM	0.32	NM	NM	NM	NM

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

Hydraulic Conductivities calculated from slug tests (see Appendix B)

NM = Not Measured

Total porosity and grain size distribution determined in laboratory tests.

Aquifer thickness calculated from high water table measurements

Hydraulic Conductivity in ft/day

Table 1C
Long-Term Ground Water Level Observations

Boring Number	Boring Date	Ground Elev.	PVC Pipe Elev.	05/15/97 Depth, ft.	Elev.	06/30/97 Depth, ft.	Elev.	07/17/97 Depth, ft.	Elev.
BP-3	12/06/95	313.7	315.39	43.39	272	43.91	271.48	44.27	271.12
BP-4	12/06/95	310.8	313.16	36.12	277.04	37.77	275.39	38.45	274.71
BP-6	12/05/95	315.0	317.28	14.54	302.74	19.02	298.26	20.88	296.4
BP-7	04/29/97	301.1	303.91	5.62	298.29	9.30	294.61	10.64	293.27
BP-8	04/29/97	299.8	303.07	14.31	288.76	17.58	285.49	18.82	284.25
BP-9	04/28/97	302.1	303.48	19.16	284.32	21.55	281.93	22.56	280.92
BP-10	04/30/97	284.4	286.40	8.23	278.17	9.82	276.58	10.37	276.03
BP-11	05/01/97	280.0	284.83	6.82	278.01	9.21	275.62	dry	
BP-12	04/30/97	294.4	295.97	10.40	285.57	15.71	280.26	18.20	277.77
BP-13	04/30/97	286.1	288.50	9.91	278.59	13.56	274.94	15.24	273.26
BP-14	05/01/97	269.7	274.03	7.12	266.91	8.17	265.86	9.06	264.97
GY-1	**	291.2	292.51	dry		dry		dry	
GY-2	**	297.9	299.99	dry		dry		dry	
GY-3	**	304.2	304.20	36.44	267.76	37.03	267.17	lost	
MW-11			265.96					5.07	260.89
MW-15	09/21/94	307.1	309.09	40.23	268.86	40.93	268.16	41.17	267.92

** Test Boring Data not available, borings performed ca. 1994

Table 2
Geotechnical Laboratory Data

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

Sample Number	Sample Depth, ft.	Sample Type	Remolded Moisture-Density Data: Max. Dry Density, pcf	Optimum Moisture, %	Natural Moisture, %	Total** Porosity, %	Hydraulic Conductivity Data: Rem. Dry Density, pcf	Remolded Moisture, %	Ksat @ 5 psi cm/sec
BP-3	3.0 - 5.0	Bulk	107.5	19.0	13.8	40.3	102.5	22.0	3.97E-08
BP-6	15.0 - 20.0	Bulk	102.6	21.5	34.2	43.2	97.6	24.5	1.45E-07
BP-8	1.0-10.0	Bulk	98.1	24.0	25.1	45.9	92.9	24.4	2.96E-07

The following Undisturbed Samples were collected during Nov-Dec 1995 for MSW permiting report and considered representative:

Sample Number	Sample Depth, ft.	Sample Type	In-Situ Moisture-Density and Hydraulic Conductivity Data: Dry Density, pcf	Wet Density, pcf	Natural Moisture, %	Total Porosity,%	Ksat @ 5 psi cm/sec**
B-4	1.0 - 3.0	Tube	110.6	129.8	17.3	35.6	4.66E-06
B-8	5.0 - 7.0	Tube	99.5	123.2	23.8	42.0	1.62E-05

Note to Above:

Moisture Contents are Dry Unit Weight Based

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

** Total Porosity values are backcalculated from Void Ratios

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

Samples tested by Geotechnologies, Inc.

Table 3
Ground Water Hydrograph

	01/24/96	02/26/96	03/20/96	04/23/96	05/22/96	06/25/96	07/31/96	08/27/96	10/02/96	10/29/96	11/27/96	12/31/96	01/31/97	02/25/97	03/28/97	05/15/97	06/30/97	07/17/97
MW-15		265.51	266.53	266.46	266.95	267.06	267.32	267.47	267.13	267.53	267.39	268.19	268.52	268.48	268.79	268.86	268.16	267.92
GY-2	278.36	278.35	278.35	278.34	278.32	--	278.32	278.33	278.32	278.27	278.25	278.24	278.28	--	--	--	--	--
GY-3	265.07	265.10	265.52	265.81	266.10	266.18	266.33	266.40	266.40	266.61	266.48	267.00	267.29	267.35	267.68	267.76	267.17	--
BP-3	268.44	269.28	269.94	270.14	270.48	270.41	270.51	270.55	270.50	270.89	270.79	271.10	272.02	271.93	272.26	272.00	271.48	271.12
BP-4	273.72	274.93	275.26	275.67	275.88	275.21	274.55	274.68	275.18	275.87	275.64	276.66	277.05	277.23	277.19	277.04	275.39	274.71
BP-6	300.98	303.97	303.48	303.67	302.89	298.93	298.80	298.92	298.86	302.03	301.34	301.50	299.79	304.80	304.21	302.72	298.26	296.40
BP-7																298.29	294.61	293.27
BP-8																288.76	285.49	284.25
BP-9																284.32	281.93	280.92
BP-10																278.17	276.58	276.03
BP-11																278.01	275.62	--
BP-12																285.75	280.26	277.77
BP-13																278.59	274.94	273.26
BP-14																266.91	265.86	264.97

Summary of Highest Water Elevations Observed Since January 1996

Boring	H.W.E.	Date	Comment
MW-15	268.86	05/01/97	Well has been in service since Sept. 1994
GY-2	278.36	01/24/96	Recurred 1/31/97, went dry the next month
GY-3	267.76	05/01/97	
BP-3	272.26	03/28/97	
BP-4	277.23	02/25/97	
BP-6	304.21	03/28/97	
BP-7	298.29	05/01/97	24-hour stabilized reading
BP-8	288.76	05/01/97	
BP-9	284.60	04/29/97	24-hour stabilized reading
BP-10	280.54	05/01/97	24-hour stabilized reading
BP-11	278.01	05/02/97	24-hour stabilized reading
BP-12	289.00	05/01/97	24-hour stabilized reading
BP-13	281.18	05/01/97	24-hour stabilized reading
BP-14	267.10	05/02/97	24-hour stabilized reading

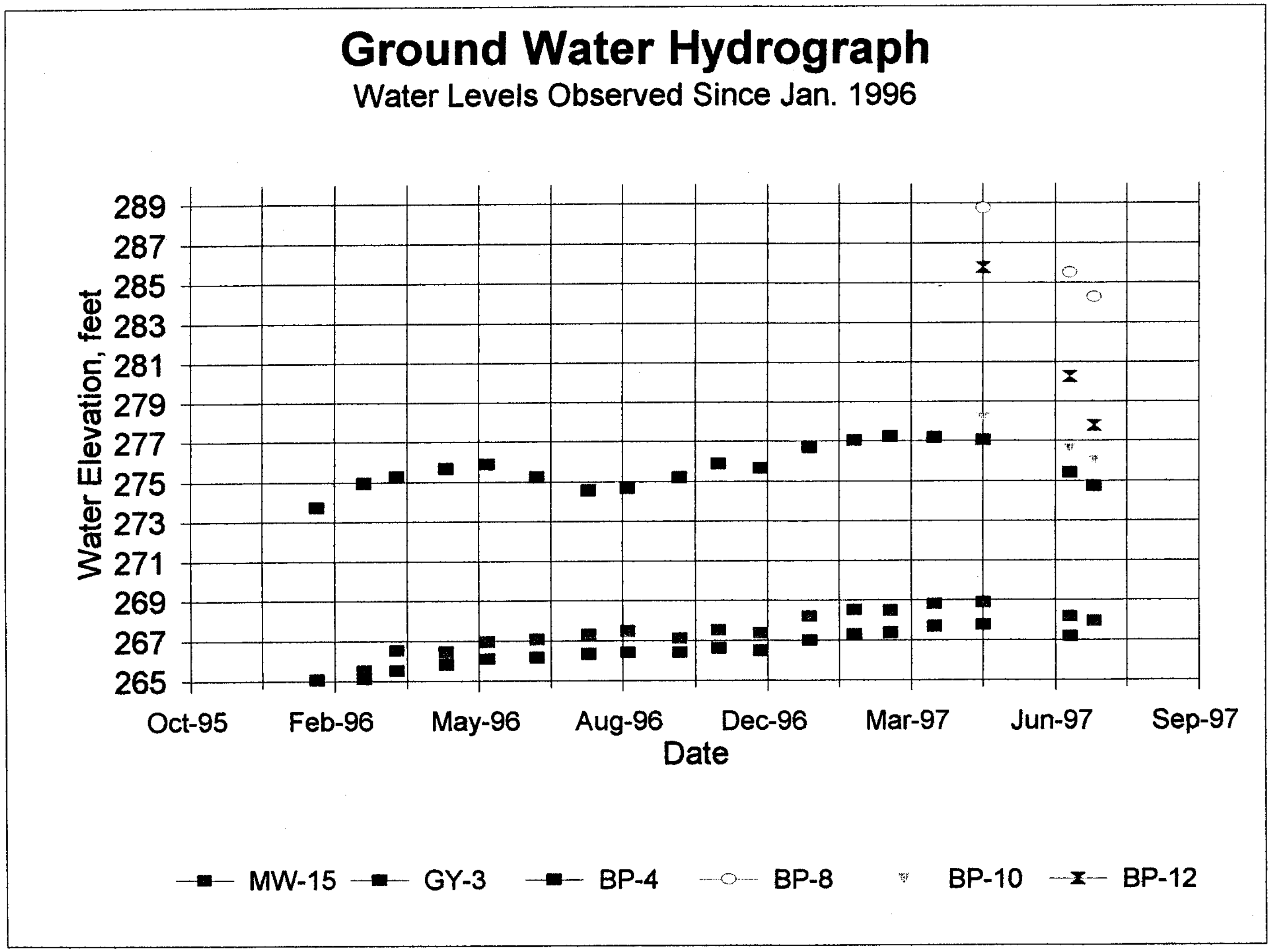

Ground Water Hydrograph
Water Levels Observed Since Jan. 1996
Water Elevation, feet
289
287
285
283
281
279
277
275
273
271
269
267
265
Oct-95
Feb-96
May-96
Aug-96
Dec-96
Mar-97
Jun-97
Sep-97
Date
MW-15
GY-3
BP-4
BP-8
BP-10
BP-12

Table 4
Horizontal Ground Water Gradient and Velocity Calculations
Halifax County Landfill

Well No.	Hydraulic Conductivity (K)	Hydraulic Gradient (I)	Effective Porosity (n)	Ground Water Velocity (V)
BP-3	0.29	0.023	0.2	0.03
BP-4	2.21	0.040	0.2	0.44
BP-6	10.80	0.070	0.2	3.78
BP-7	22.84	0.112	0.2	12.79
BP-8	3.20	0.050	0.2	0.80
BP-9	3.45	0.030	0.2	0.52
BP-10	27.92	0.060	0.2	8.38
BP-12	4.74	0.050	0.2	1.19
BP-13	9.46	0.093	0.2	4.40

Notes: Ground Water Velocity Calculated from Equation:
$V=KI/n$

Hydraulic Conductivity in ft/day
Hydraulic Gradient in ft/ft
Effective Porosity in ft/ft
Ground Water Velocity in ft/day

Effective Porosity values from published literature.
Hydraulic Conductivity values from aquifer slug testing
Hydraulic Gradient values calculated from hydraulic gradient map

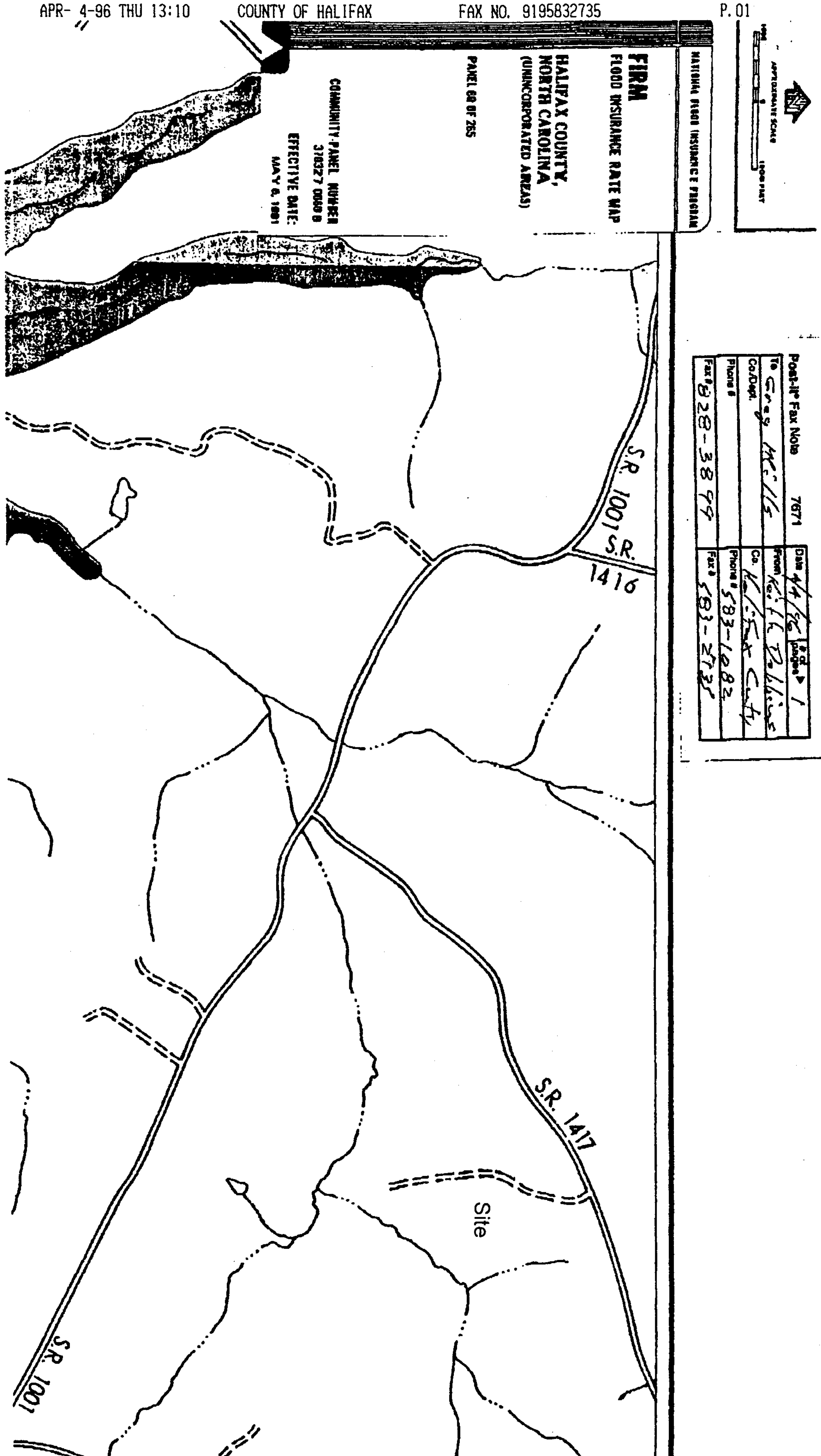
Figures

Refer to the Plan Set that accompanies this report.

Half-size review prints are located in the back of this binder.

Full-size (24" x 36") prints are available from GNRA by calling (919) 828-0577.

Appendix B



Post-it® Fax Note 7671

Date 4/4/96	# of pages ▶ 1
To Greg McGills	From Keith Rollins
Co./Dept.	Co. Halifax Cnty
Phone #	Phone # 583-1682
Fax # 828-3899	Fax # 583-2735

Appendix C

North Carolina Department of Cultural Resources

James G. Martin, Governor
Patric Dorsey, Secretary

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

January 31, 1991

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

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

Dear Mr. Barnard:

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

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

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

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

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

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

Dr. Philip K. McKnelly
Director

December 11, 1990

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

Dear Mr. Barnard:

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

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

Sincerely,

Harry E. LeGrand, Jr.

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

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

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

Sincerely,

David Brook

David Brook
Deputy State Historic Preservation Officer

DB:slw

Enclosures

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

by:

David M. Van Horn, Ph.D.

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

(714) 244-1783
FAX 244-0084

March 9, 1991

TABLE OF CONTENTS

MANAGEMENT SUMMARY

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

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

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

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

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

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

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

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

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

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

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

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

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

I. INTRODUCTION

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

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

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

II. PHYSICAL ENVIRONMENT

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

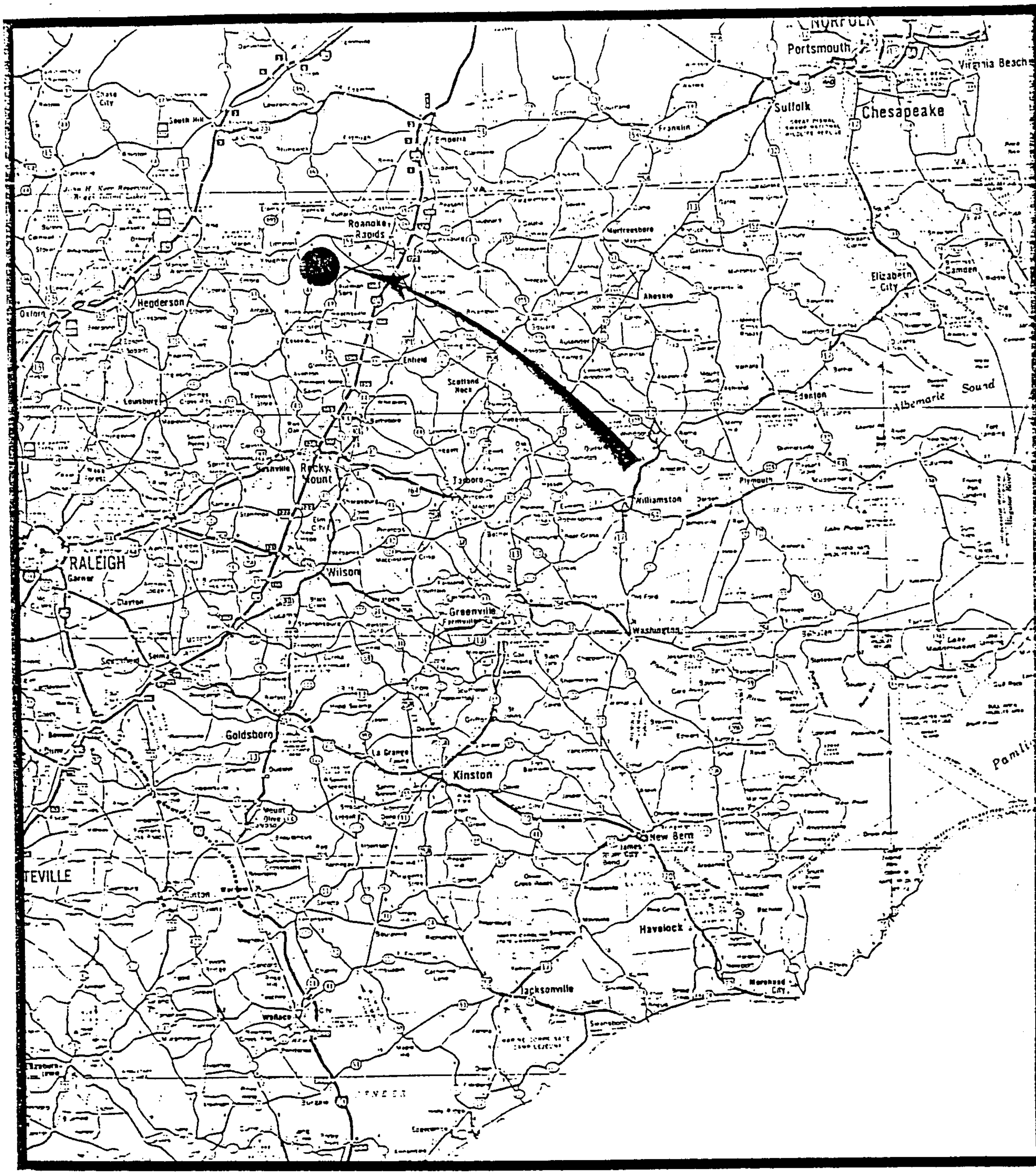


Figure 1. General location of study area shown on map of a portion of eastern North Carolina.

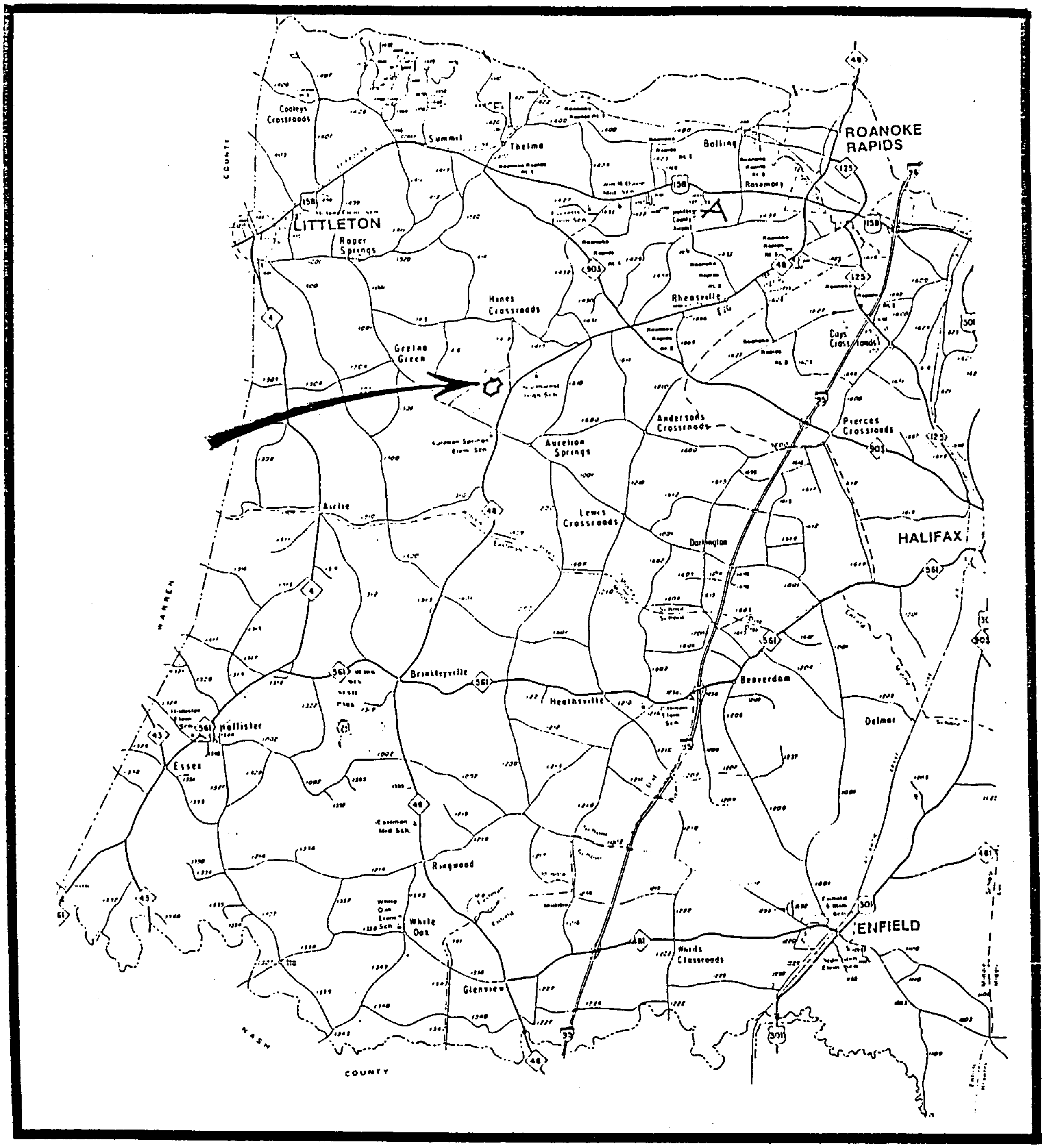


Figure 2. Location of study area shown on a map of Halifax County.

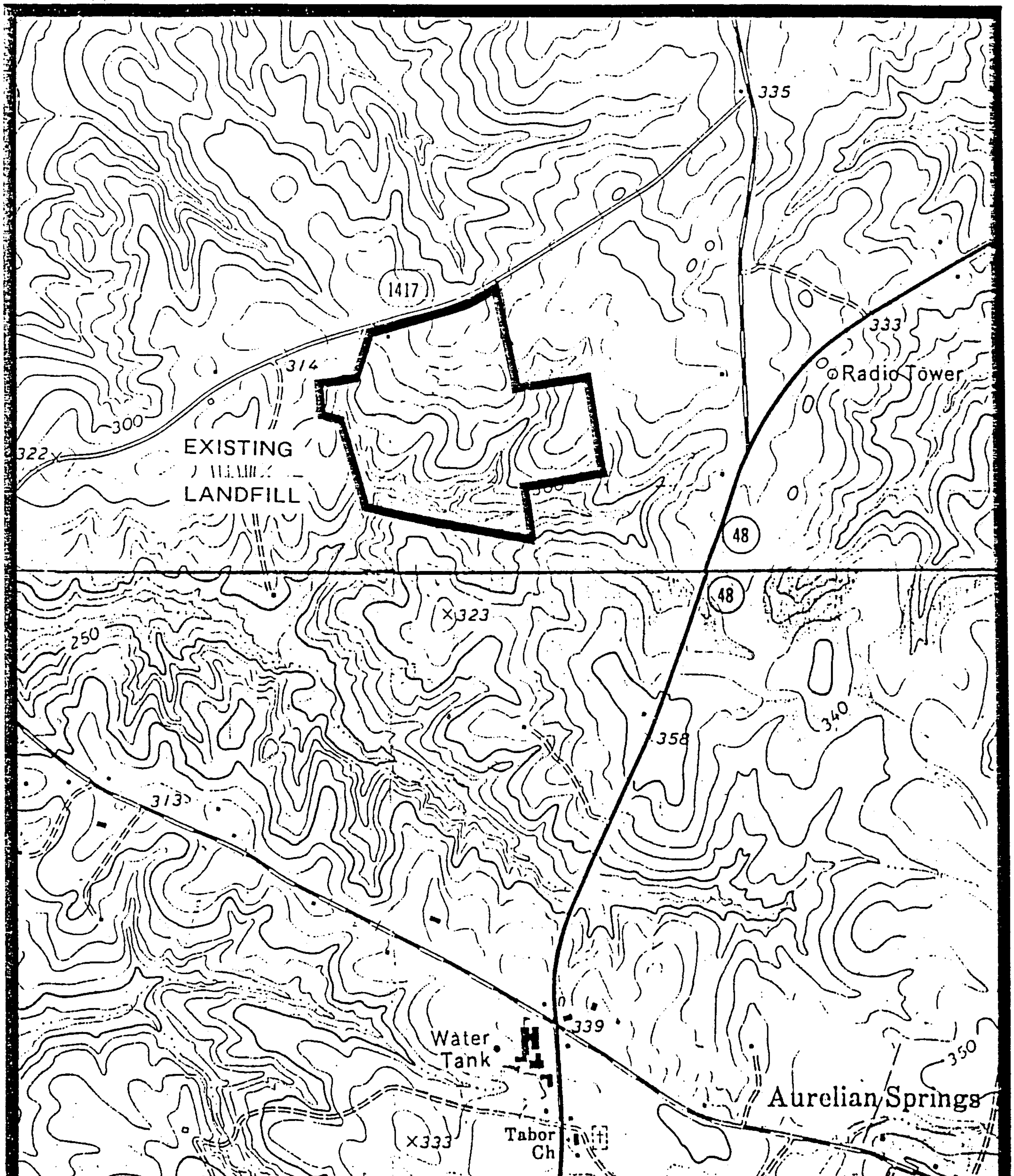


Figure 3. Study area plotted on a portion of the USGS 7.5' Thelma Topographic Quadrangle. The topograpy below the central horizontal line is a portion of the Aurelian Springs Quadrangle.

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

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

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

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

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

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

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

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

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

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

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

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

III. ARCHAEOLOGICAL & HISTORICAL BACKGROUND

A. ARCHAEOLOGICAL BACKGROUND

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. The Ethnographic Period: The Tuscarora War

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

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

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

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

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

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

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

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

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

4. Modern Indians: The Haliwa Tribe

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

B. HISTORICAL BACKGROUND

1. Halifax County

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

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

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

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

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

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

2. Notes on Aurelian Springs

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

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

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

3. Comments on Anticipated Cultural Resources Based upon Background Research

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

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

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

IV. METHODS

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

1. Systematic Walk-Over Inspection

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

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

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

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

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

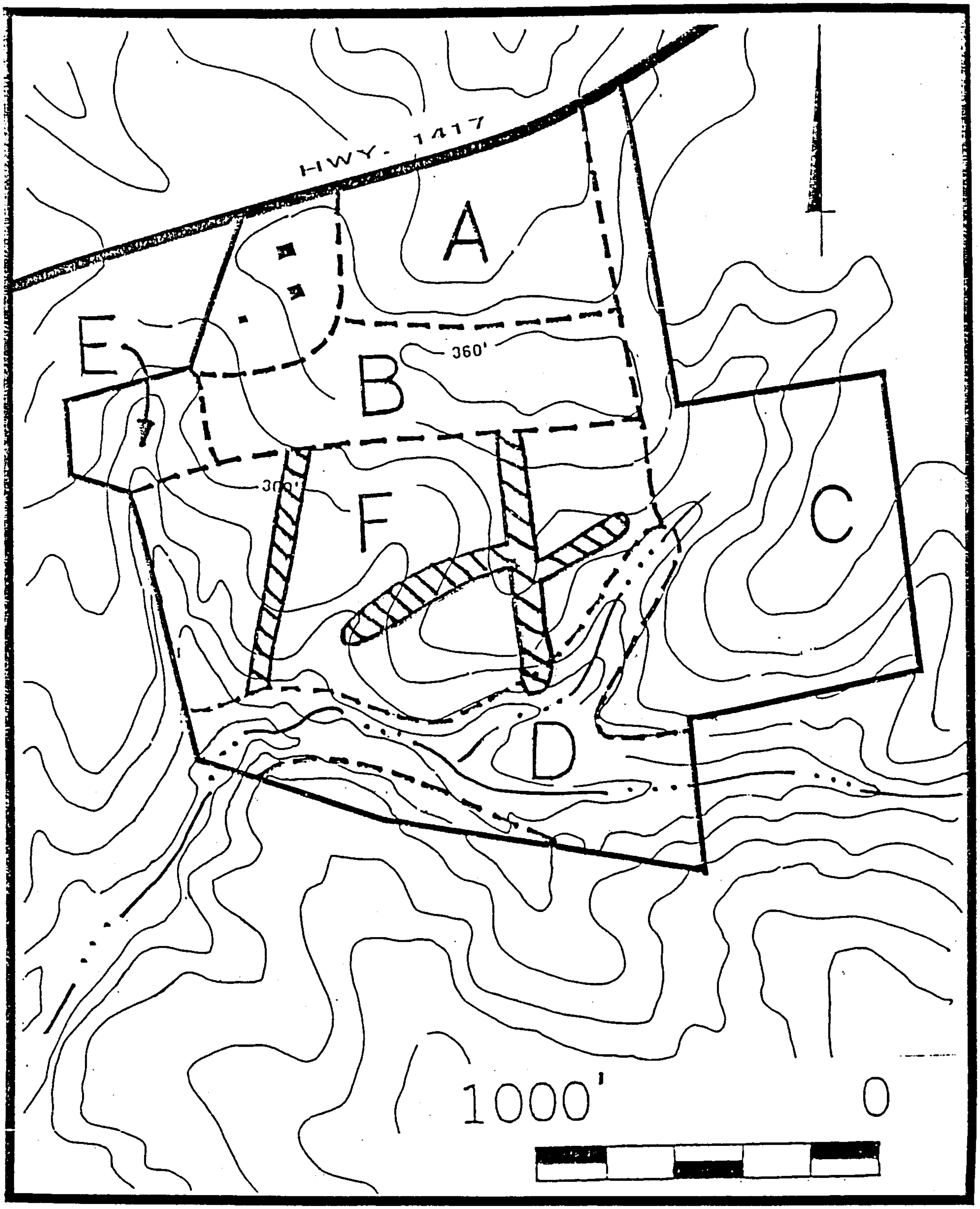


Figure 9. Study area divided into zones A through F. The hatched areas represent bulldoze cuts through wooded Area F. The farmhouse, service building, and privy are at upper left.

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

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

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

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

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

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

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

2. <u>Shovel-Testing Program</u>

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

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

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

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

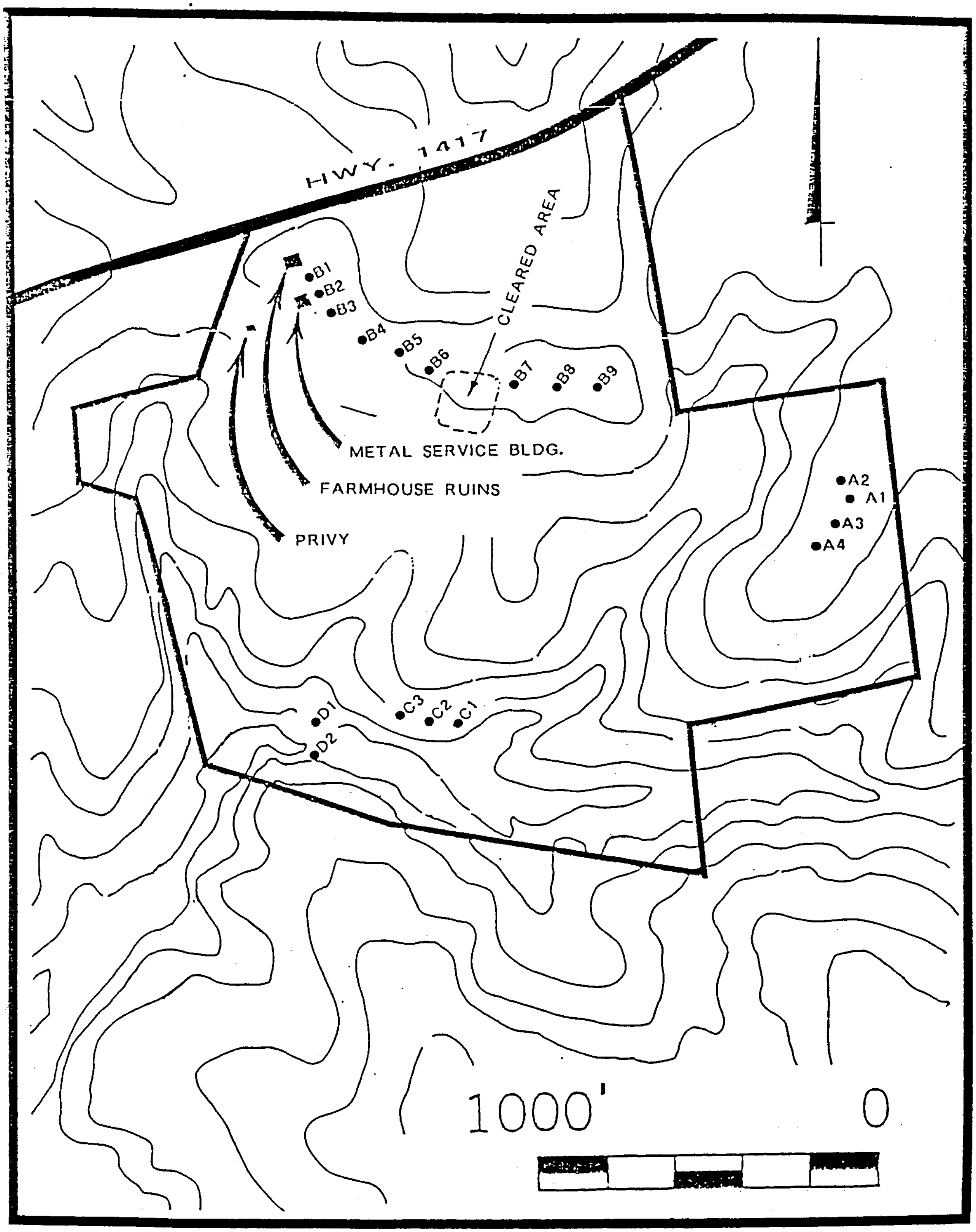


Figure 10. Shovel-Test pit locations and identifications of farm structures.

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

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

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

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

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

V. RESULTS

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

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

TABLE 1

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

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

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

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

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

VI. SIGNIFICANCE EVALUATIONS

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

VII. RECOMMENDATIONS

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

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Appendix D

FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-1

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

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

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION	DEPTH	LITHOLOGY	WELL INSTALLATION
0.0	3 5 7	Ss	S1			18"		SANDY CLAY: Orange brown sandy clay and topsoil; took a jar sample from 0 to 1.5 feet.	0.0		
3.0	8 16 15	Ss	S2			18"		CLAYEY SANDY SILT: Yellow-orange clayey sandy silt; abundant feldspar; trace mica.	3.0		
8.0	5 6 9	Ss	S3			18"					
12.0								SILTY SAND: Yellow tan fine silty sand; powdery; felsic; trace mica.	12.0		
13.0	5 6 7	Ss	S4			18"					
18.0	4 5 6	Ss	S5			18"					
23.0	5 10 9	Ss	S6			12"		SILTY SAND: Slightly clayey silty sand; micaceous; coarse sand; gravel at 25'.	23.0		
28.0	10 50/.4	Ss	S7			8"					
29.0								SILTY SAND: Relict granite; very felsic; iron stained; quartz sand and mica; auger refusal at 36'.	29.0		
33.0	50/.3	Ss	S8			3"					
36.0									36.0		

FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-2

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

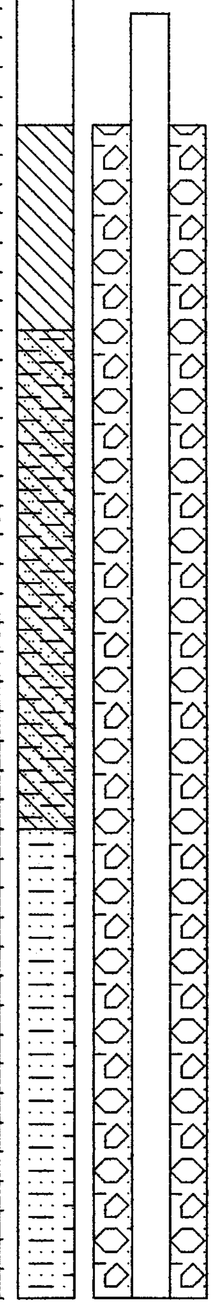
TOP OF CASING ELEVATION: -
TOTAL DEPTH: 40.0 FT
GROUND SURFACE ELEVATION: -
SHEET: 1 OF: 2

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
0.0	2, 4, 6	Ss	S1			12"		CLAY: Orange brown clay with a 3" layer of topsoil above it; took a jar sample from 0 to 1.5 feet.
3.5	7, 8, 9	Ss	S2	D		16"		SANDY CLAYEY SILT: Orange brown sandy clayey silt; slightly plastic.
8.5	5, 8, 11	Ss	S3	D		14"		
12.0								SANDY SILT: Pink to white to tan sandy silt; relict granite structure visible; sample contains feldspar, mica and quartz; wet at 28.5'.
13.5	4, 5, 8	Ss	S4	M		16"		
18.5	5, 11, 11	Ss	S5	M		18"		

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

LITHOLOGY / WELL INSTALLATION



FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-2

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

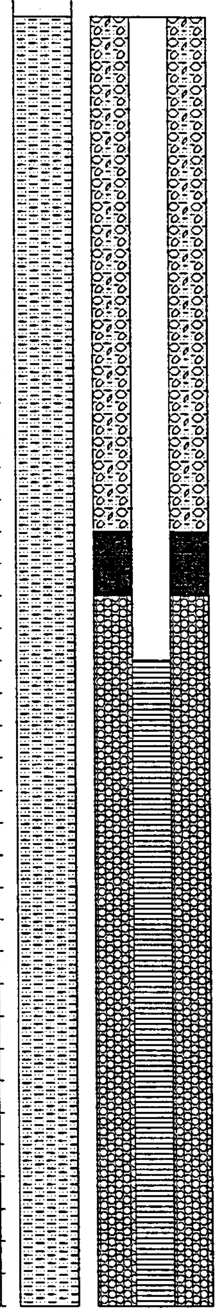
TOP OF CASING ELEVATION: -
TOTAL DEPTH: 40.0 FT
GROUND SURFACE ELEVATION: -
SHEET: 2 OF: 2

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

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

DEPTH: 20.0 21.0 22.0 23.0 24.0 25.0 26.0 27.0 28.0 29.0 30.0 31.0 32.0 33.0 34.0 35.0 36.0 37.0 38.0 39.0 40.0

LITHOLOGY / WELL INSTALLATION



FIELD BOREHOLE LOG

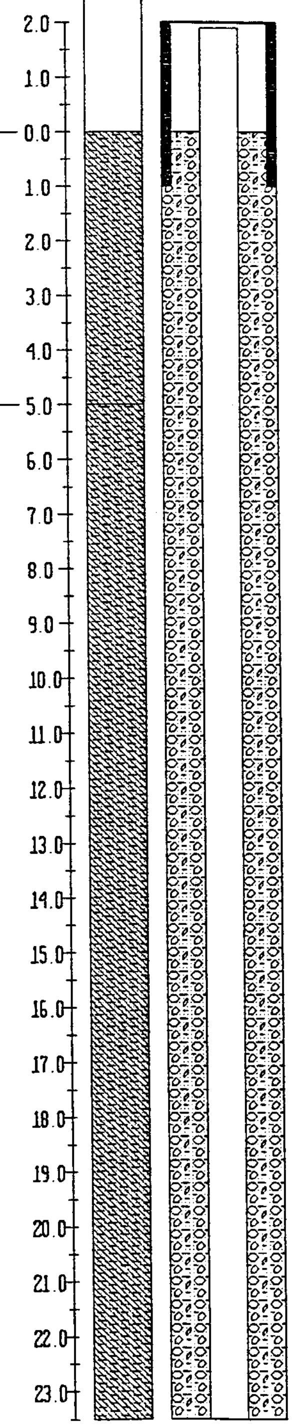
BOREHOLE NUMBER: BP-3

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

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

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

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



FIELD BOREHOLE LOG

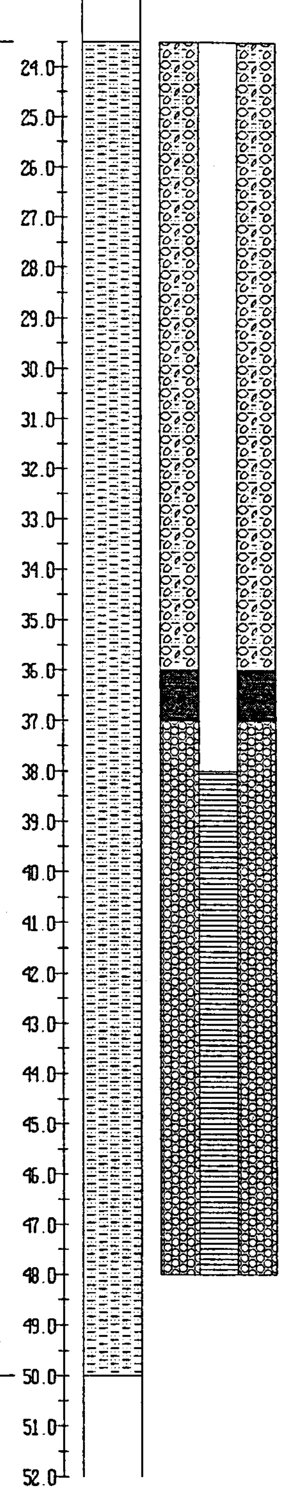
BOREHOLE NUMBER
BP-3

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

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

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
24.0	6 12 13	Ss	S6					SANDY SILT: White-orange relict granite with abundant feldspar; more k-spar and coarse quartz sand at 33.5 ft.
28.0–29.0	10 16 18	Ss	S7					
33.0–34.0	7 12 16	Ss	S8			12"		
38.0–39.0	9 13 17	Ss	S9			8"		
43.0–44.0	7 12 17	Ss	S10			10"		
48.0–49.0	10 17 21	Ss	S11					
50.0								Boring Terminated at 50 feet.



FIELD BOREHOLE LOG

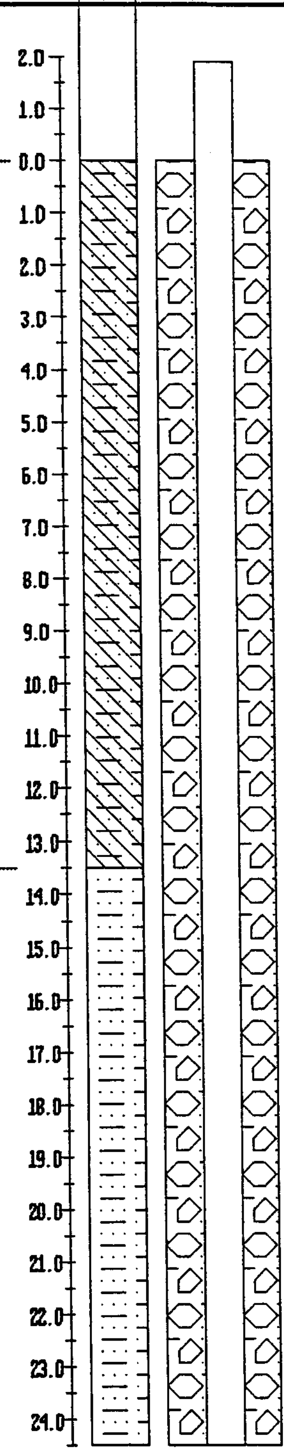
BOREHOLE NUMBER: BP-4

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

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

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

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



FIELD BOREHOLE LOG

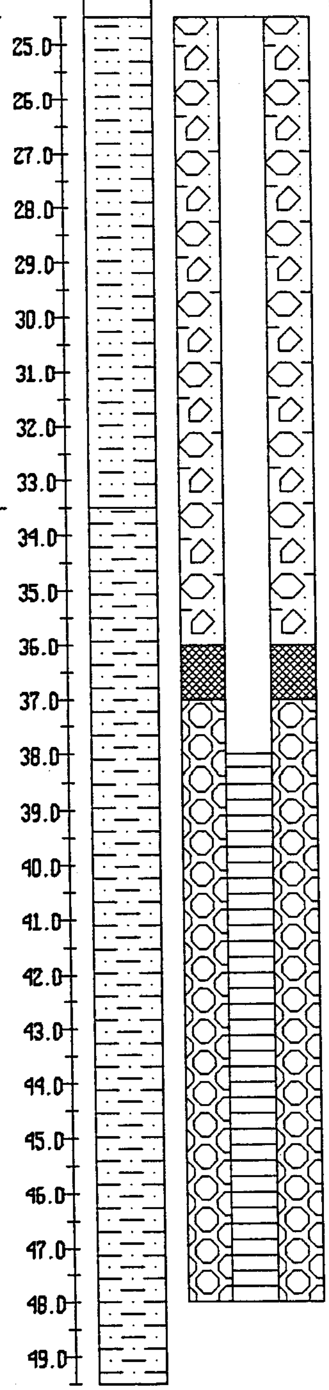
BOREHOLE NUMBER: BP-4

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

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

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
25.0–28.0	13							SANDY SILT: Relict Granite; moist, pink to gray micaceous sandy silt with quartz and abundant feldspar.
28.0–33.0	11 10 14	Ss	S7	M		14"		
33.0–38.0	3 4 6	Ss	S8	M				SILT: Thin 1/8" layers of gray and tan with an interface of orange - iron staining and black Mn staining in a vertical direction; relict granite texture more pronounced at bottom of boring.
38.0–43.0	6 11 14	Ss	S9	W				
43.0–48.0	13 16 25	Ss	S10	W				
48.0–49.0	10 16 16	Ss	S11	W				



FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-5

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

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

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

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

FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-5

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

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

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
19.0	5 8 11	Ss	S5	M		14"		SANDY SILT: Relict Granite; moist to wet, pink to gray with weathered iron and Mn staining.
23.0–24.0	5 7 11	Ss	S6	M		16"		
28.0–29.0	6 9 12	Ss	S7	W		12"		
33.0–34.0	5 9 15	Ss	S8	W		12"		
38.0–39.0	7 11 15	Ss	S9	W		10"		
40.0								Boring Terminated at 40.0 feet.

Depth scale: 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0, 26.0, 27.0, 28.0, 29.0, 30.0, 31.0, 32.0, 33.0, 34.0, 35.0, 36.0, 37.0, 38.0, 39.0, 40.0, 41.0

LITHOLOGY | WELL INSTALLATION

FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-6

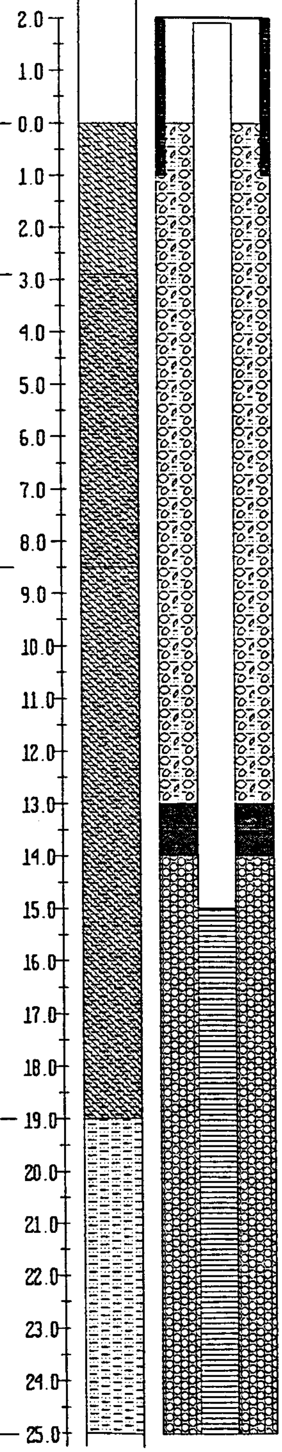
PROJECT NUMBER: HALIFAX-5
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, 45 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: G. MILLS
DATE BEGUN: 12/5/95 DATE COMPLETED: 12/5/95

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

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
0.0	4 5 7	Ss	S1					SANDY SILTY CLAY: 6" of topsoil underlain by sandy silty clay; took a jar sample from 0 to 1.5 feet.
3.0	6 7 9	Ss	S2	D				SANDY CLAYEY SILT: Red-brown fine sandy clayey silt; took a jar sample from 3.5 to 5 feet.
8.0	8 5 10	Ss	S3	D				SANDY CLAYEY SILT: Red-brown fine sandy clayey silt; relict rock structure is evident at 8.5 feet; color becomes pink, texture is sandier at 13.5 feet; bulk sample taken between 13.5 and 19 feet.
13.0	3 4 6	Ss	S4	D				
18.0	3 6 9	Ss	S5	W				
19.0								SANDY SILT: Tan, slightly clayey sandy silt; wet at 19'; very wet at 23.5'.
23.0	3 6 9	Ss	S6	VW				
25.0								

DEPTH | LITHOLOGY | WELL INSTALLATION



FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-7

PROJECT NUMBER: HALIFAX-8
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, RAIN 50 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: P. MAY
DATE BEGUN: 4/29/97 DATE COMPLETED: 4/29/97

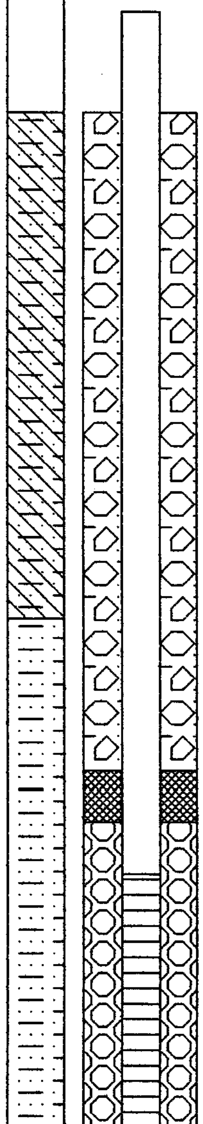
TOP OF CASING ELEVATION: NA
TOTAL DEPTH: 20.0 FT
GROUND SURFACE ELEVATION: NA
SHEET: 1 OF: 1

STATIC WATER LEVEL (BLS)		
WD=While Drilling AB=After Boring		
Depth(ft)	1.0	3.26
Time	5:00 pm	2:00 pm
Date:	4/29/97	4/30/97

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

DEPTH: 2.0, 1.0, 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0

LITHOLOGY | WELL INSTALLATION



FIELD BOREHOLE LOG

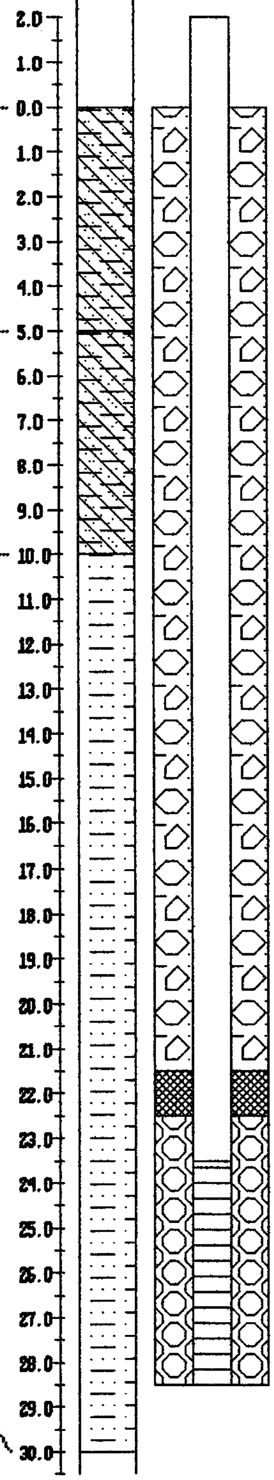
BOREHOLE NUMBER: BP-8

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

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

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
0.0–1.0	2 6 10	Ss	S1	D		16"		SILTY SANDY CLAY: 6" of topsoil underlain by firm red-brown dry silty sandy clay; bulk sample 1-10'; MH-CL.
3.0–4.5	10 12 18	Ss	S2	D		18"		
5.0								SANDY CLAYEY SILT: Tan fine dry sandy clayey silt; ML.
8.0–9.5	10 13 19	Ss	S3	D		14"		
10.0								SANDY SILT: Red-purple moist fine sandy silt; trace clay; micoceous; MH;
13.0–14.5	4 7 11	Ss	S4	M		16"		
17.0								water at 18 feet; bands of white feldspar at 19-20 feet; manganese striations starting at 18-20 feet.
18.0–19.5	6 7 12	Ss	S5	M		18"		
23.0–24.5	5 8 13	Ss	S6	VM		16"		
28.0–29.5	5 8 14	Ss	S7	VM		14"		
30.0								Boring terminated at 30.0 feet.



FIELD BOREHOLE LOG

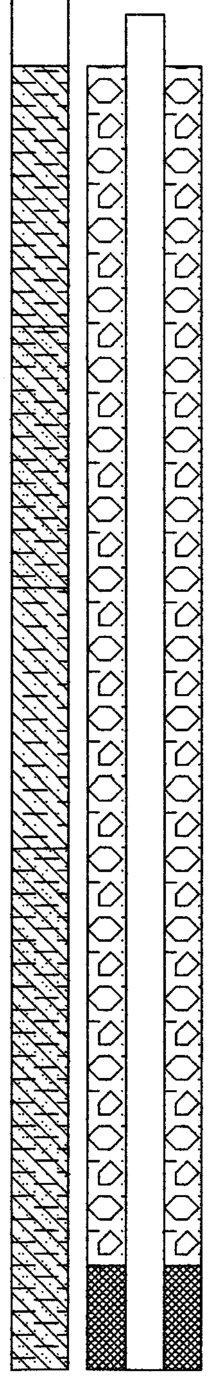
BOREHOLE NUMBER: BP-9

PROJECT NUMBER: **HALIFAX-8**
PROJECT NAME: **HALIFAX COUNTY**
LOCATION: **HALIFAX, NORTH CAROLINA**
DRILLING COMPANY: **BORE AND CORE**
RIG TYPE & NUMBER: **CME 450**
DRILLING METHOD: **HOLLOW STEM AUGER**
WEATHER: **CLOUDY, RAIN 60 DEGREES**
FIELD PARTY: **L. FOSKEY**
GEOLOGIST: **P. MAY**
DATE BEGUN: **4/28/97** DATE COMPLETED: **4/28/97**

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

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

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



FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-9

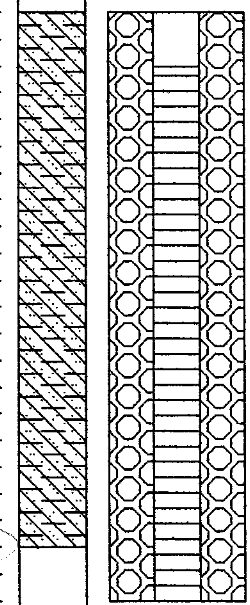
PROJECT NUMBER: HALIFAX-8
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: BORE AND CORE
RIG TYPE & NUMBER: CME 450
DRILLING METHOD: HOLLOW STEM AUGER
WEATHER: CLOUDY, RAIN 60 DEGREES
FIELD PARTY: L. FOSKEY
GEOLOGIST: P. MAY
DATE BEGUN: 4/28/97 DATE COMPLETED: 4/28/97

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

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

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

LITHOLOGY / WELL INSTALLATION



FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-10

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

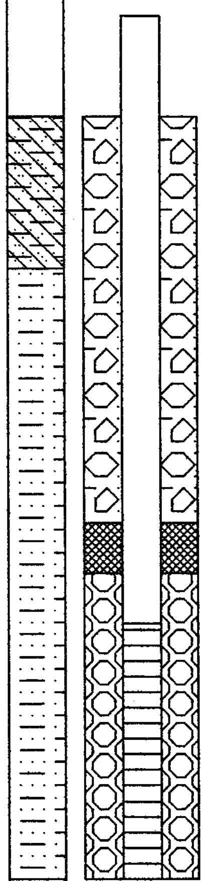
TOP OF CASING ELEVATION: **NA**
TOTAL DEPTH: **15.0 FT**
GROUND SURFACE ELEVATION: **NA**
SHEET: **1** OF: **1**

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

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
0.0–3.0	4 5 6	Ss	S1	D		14"		SANDY CLAYEY SILT: 6" of topsoil underlain by tan dry C sandy clayey silt; some quartz; ML.
3.0–15.0	3 4 5	Ss	S2	D		16"		SANDY SILT: Tan-grey moist F-M sandy silt; iron banding; MH;
8.0	2 3 4	Ss	S3	M		18"		less sand at 8-10'; some manganese in vertical bands; mottled with white & gray granite; water at 10';
13.0	3 3 5	Ss	S4	W		10"		turns brown-grey at 13'; more sand and mica; white feldspar striations.
15.0								Boring terminated at 15.0'.

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

LITHOLOGY / WELL INSTALLATION



FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-11

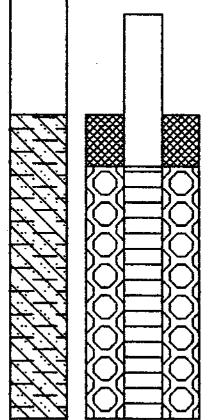
PROJECT NUMBER: **HALIFAX-8**
PROJECT NAME: **HALIFAX COUNTY**
LOCATION: **HALIFAX, NORTH CAROLINA**
DRILLING COMPANY: **GNRA**
RIG TYPE & NUMBER: **NA**
DRILLING METHOD: **HAND AUGER**
WEATHER: **SUNNY 70 DEGREES**
FIELD PARTY: **P. MAY**
GEOLOGIST: **P. MAY**
DATE BEGUN: **5/1/97** DATE COMPLETED: **5/1/97**

TOP OF CASING ELEVATION: **NA**
TOTAL DEPTH: **6.0 FT**
GROUND SURFACE ELEVATION: **NA**
SHEET: **1** OF: **1**

STATIC WATER LEVEL (BLS)		
WD=While Drilling AB=After Boring		
Depth(Ft)	0.5	2.05
Time	10:30 am	1:00 pm
Date:	5/1/97	5/1/97

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION	DEPTH
2.0									2.0
1.0									1.0
0.0								SANDY CLAYEY SILT: 2" of topsoil underlain by tan wet F-M sandy clayey silt; some quartz; some white-gray striations (granite); quartz at 4-5'; ML.	0.0
1.0									1.0
2.0									2.0
3.0									3.0
4.0									4.0
5.0									5.0
6.0								Boring terminated at 6.0'.	6.0
7.0									7.0
8.0									8.0
9.0									9.0
10.0									10.0
11.0									11.0
12.0									12.0
13.0									13.0
14.0									14.0
15.0									15.0
16.0									16.0
17.0									17.0
18.0									18.0
19.0									19.0
20.0									20.0
21.0									21.0
22.0									22.0
23.0									23.0
24.0									24.0
25.0									25.0

LITHOLOGY | WELL INSTALLATION



FIELD BOREHOLE LOG

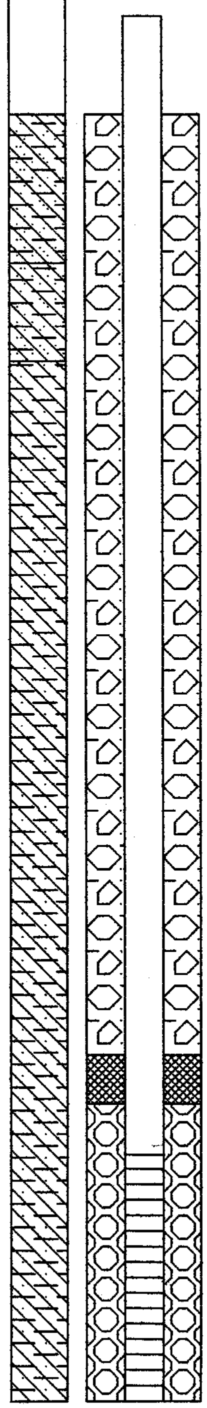
BOREHOLE NUMBER: BP-12

PROJECT NUMBER: **HALIFAX-8**
PROJECT NAME: **HALIFAX COUNTY**
LOCATION: **HALIFAX, NORTH CAROLINA**
DRILLING COMPANY: **BORE AND CORE**
RIG TYPE & NUMBER: **CME 450**
DRILLING METHOD: **HOLLOW STEM AUGER**
WEATHER: **PARTLY SUNNY, 70 DEGREES**
FIELD PARTY: **L. FOSKEY**
GEOLOGIST: **P. MAY**
DATE BEGUN: **4/30/97** DATE COMPLETED: **4/30/97**

TOP OF CASING ELEVATION: **NA**
TOTAL DEPTH: **25.0 FT**
GROUND SURFACE ELEVATION: **NA**
SHEET: **1** OF: **1**

STATIC WATER LEVEL (BLS)		
WD=While Drilling AB=After Boring		
Depth(ft)	21.3	6.97
Time	9:00 Am	2:00 pm
Date:	4/30/97	5/1/97

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION	DEPTH
0.0	3 7 13	Ss	S1	D		14"		SILTY SANDY CLAY: 6" of topsoil underlain by tan dry F silty sandy clay; MH-CL.	0.0
3.0	8 10 13	Ss	S2	D		16"		SANDY CLAYEY SILT: Tan dry F sandy clayey silt; ML.	3.0
5.0								CLAYEY SILT: Dark purple dry clayey silt; fractures of white feldspar;	5.0
8.0	5 5 7	Ss	S3	D		16"		MH-CL;	8.0
11.0								turns red with tan bands; grey/white granite striations;	11.0
13.0	5 5 5	Ss	S4	M		18"		water at 15.0';	13.0
16.0								tan colored; manganese striations; moist;	16.0
18.0	3 5 7	Ss	S5	M		16"		some relict rock texture.	18.0
23.0	4 4 6	Ss	S6	M		16"			23.0
25.0								Boring terminated at 26.0'.	25.0



LITHOLOGY / WELL INSTALLATION

FIELD BOREHOLE LOG

BOREHOLE NUMBER: BP-13

PROJECT NUMBER: **HALIFAX-8**
PROJECT NAME: **HALIFAX COUNTY**
LOCATION: **HALIFAX, NORTH CAROLINA**
DRILLING COMPANY: **BORE AND CORE**
RIG TYPE & NUMBER: **CME 450**
DRILLING METHOD: **HOLLOW STEM AUGER**
WEATHER: **PARTLY SUNNY, 70 DEGREES**
FIELD PARTY: **L. FOSKEY**
GEOLOGIST: **P. MAY**
DATE BEGUN: **4/30/97** DATE COMPLETED: **4/30/97**

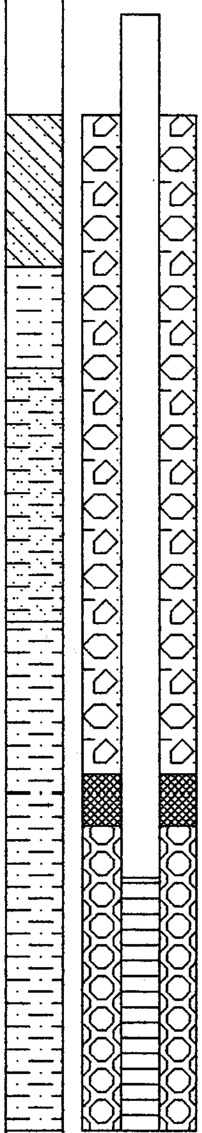
TOP OF CASING ELEVATION: **NA**
TOTAL DEPTH: **20.0 FT**
GROUND SURFACE ELEVATION: **NA**
SHEET: **1** OF: **1**

STATIC WATER LEVEL (BLS)		
WD=While Drilling AB=After Boring		
Depth(ft)	15.8	7.32
Time	12:00 pm	1:30 pm
Date:	4/30/97	5/1/97

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION
0.0–3.0	3 5 6	Ss	S1	D		12"		SANDY CLAY: 6" of topsoil underlain by brown dry F sandy clay; slightly micaceous, some manganese bands at 1.0'; SC.
3.0–6.0	5 6 7	Ss	S2	D		12"		SANDY SILT: Brown dry F sandy micaceous silt;white feldspar bands; brown clay from 3-3.5'; ML-SM.
6.0–10.0	8 12 12	Ss	S3	M		16"		SILTY SAND: Tan slightly moist F silty sand; some white feldspar; shifts from silty clay to silty sand from 8-8.5'; SM.
10.0–20.0	6 7 12	Ss	S4	M		16"		SILT: Tan slightly moist silt; manganese striations; MH-ML.
	6 8 10	Ss	S5	M		18"		
20.0								Boring terminated at 20.0'.

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

DEPTH | LITHOLOGY | WELL INSTALLATION



FIELD BOREHOLE LOG

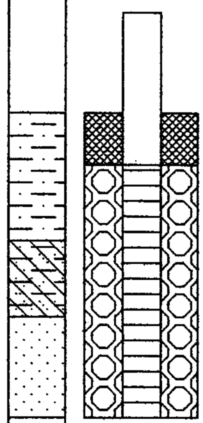
BOREHOLE NUMBER: BP-14

PROJECT NUMBER: HALIFAX-B
PROJECT NAME: HALIFAX COUNTY
LOCATION: HALIFAX, NORTH CAROLINA
DRILLING COMPANY: GNRA
RIG TYPE & NUMBER: NA
DRILLING METHOD: HAND AUGER
WEATHER: SUNNY, 70 DEGREES
FIELD PARTY: P. MAY
GEOLOGIST: P. MAY
DATE BEGUN: 5/1/97 DATE COMPLETED: 5/1/97

TOP OF CASING ELEVATION: NA
TOTAL DEPTH: 6.0 FT
GROUND SURFACE ELEVATION: NA
SHEET: 1 OF: 1

STATIC WATER LEVEL (BLS)		
WD=While Drilling AB=After Boring		
Depth(Ft)	2.5	2.50
Time	11:00 am	1:30 pm
Date:	5/1/97	5/1/97

DEPTH	BLOW COUNTS	SAMPLING METHOD	SAMPLE NUMBER	MOISTURE	CONSISTANCY	SAMPLE RECOVERY	DRILL METHOD	LITHOLOGY DESCRIPTION	DEPTH	LITHOLOGY	WELL INSTALLATION
2.0									2.0		
1.0									1.0		
0.0								SILT: 6" of topsoil underlain by dark brown slightly moist silt; MH-ML.	0.0		
1.0									1.0		
2.0									2.0		
3.0								SANDY CLAYEY SILT: Tan-grey moist F-M sandy clayey silt; ML.	3.0		
4.0								SAND: Grey wet F-M sand; tan bands; SW.	4.0		
5.0									5.0		
6.0								Boring terminated at 6.0'.	6.0		
7.0									7.0		
8.0									8.0		
9.0									9.0		
10.0									10.0		
11.0									11.0		
12.0									12.0		
13.0									13.0		
14.0									14.0		
15.0									15.0		
16.0									16.0		
17.0									17.0		
18.0									18.0		
19.0									19.0		
20.0									20.0		
21.0									21.0		
22.0									22.0		
23.0									23.0		
24.0									24.0		
25.0									25.0		



Civil & Environmental Consultants, Inc.
Cincinnati, OH (513) 469-0200 • (800) 759-5614
Pittsburgh, PA (412) 921-4302 • (800) 365-2324

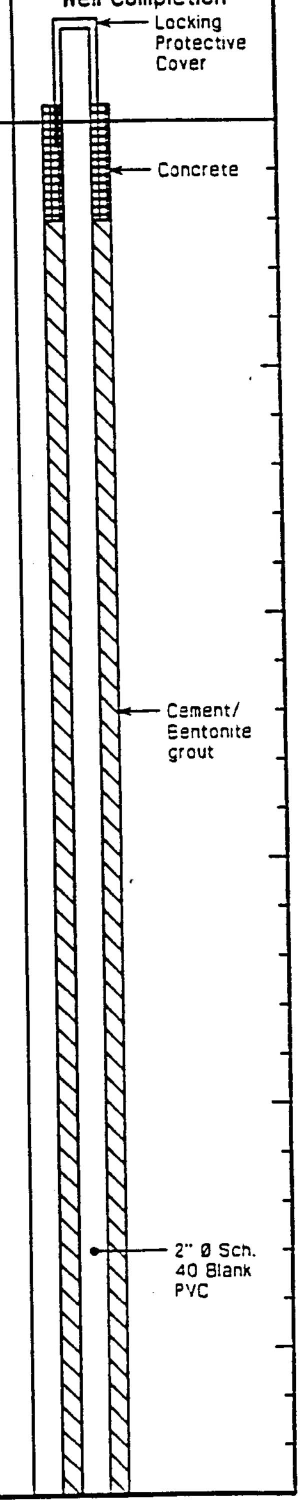
Hazen & Sawyer
Halifax County Landfill
Halifax, NC

JOB NO.: 94521
LOG OF MW-15

LOGGED BY: J. Barnard	**GROUND SURFACE ELEVATION:** 307.1 FT. MSL
DRILLER: Parratt-Wolff	**TOP OF CASING ELEVATION:** 309.10 FT. MSL
DATE DRILLED: 9/21/94	**INITIAL WATER LEVEL:** 41.5 ' BGS **DATE:** 9/21/94
DRILL METHOD: 4 1/4" ID Hollow Stem Auger	**STATIC WATER LEVEL:** 42.15 ' BGS **DATE:** 9/28/94

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

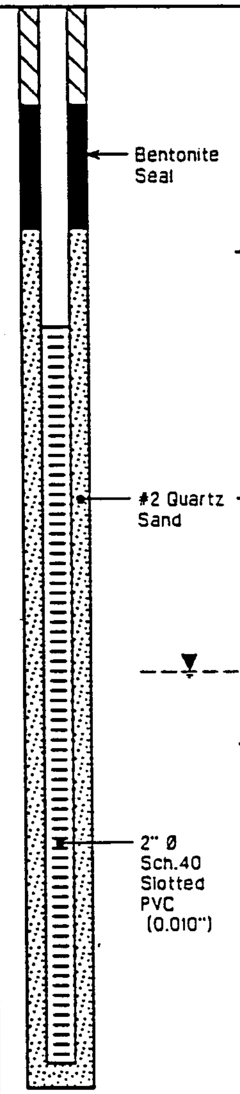
Well Completion



Civil & Environmental Consultants, Inc.	Hazen & Sawyer	JOB NO.: 94521
Cincinnati, OH (513) 469-0200 ● (800) 759-5614 — Pittsburgh, PA (412) 921-4302 ● (800) 365-2324	Halifax County Landfill	LOG OF MW-15
	Halifax, NC	Sheet 2 of 2

HNu (ppm)	Recovery (in.)	Blow Counts	Elevation MSL	Depth (ft.)	Graphic Log	Materials Description
	22	14 18 19 24	275	33		Same, dry.
	13	14 16 18 19	270	38		Pink, orangish-tan, and white, silty fine to coarse SAND, high % of pink feldspar crystals, sl. moist.
	21	9 10 7 8	285	43		Same, with increasing clay content, moist.
			260	48		
						Bottom of boring at 50.0' BGS.
			255	53		
			250	58		

Well Completion



Appendix E

MAY 23 1997

GeoTechnologies, Inc., P.A.

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

5/20/97

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

Attention: Project Manager

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

Very truly yours,

GeoTechnologies, Inc.

R. Sherwood Core, CET
Construction Services Manager

Edward B. Hearn, P.E.
President

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

c:

GeoTechnologies, Inc.

PERMEABILITY TEST

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

Soil Description: TAN SANDY SILT

SAMPLE DATA

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

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

TEST DATA

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

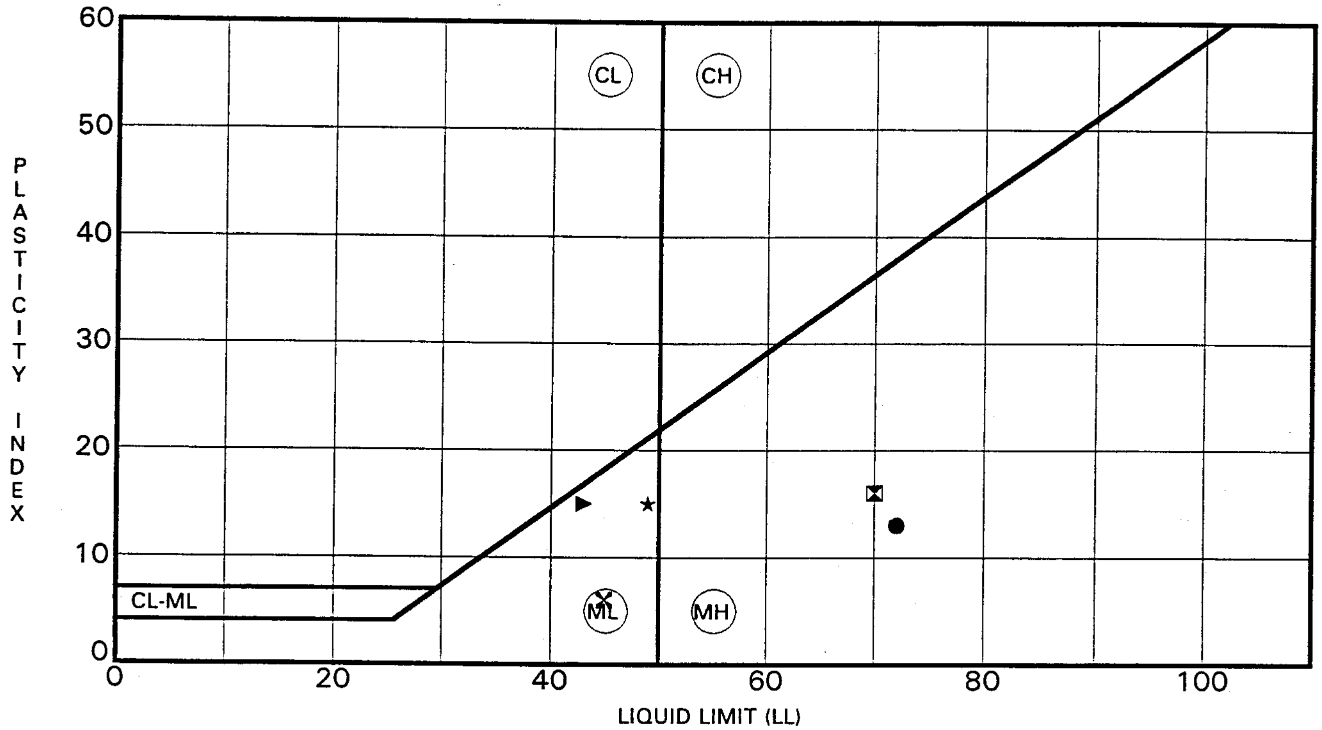
t1	t2	ho1	hi1	h1	ho2	hi2	h2
0	**2400**	94	0.7	**93.3**	93.6	1.2	**92.4**
0	**3120**	93.6	1.2	**92.4**	93	1.6	**91.4**
0	**2580**	93	1.6	**91.4**	92.5	2.1	**90.4**
0	**4320**	92.5	2.1	**90.4**	91.8	2.7	**89.1**

ASTM D 5084

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

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

Average **k =** **2.96E-07** cm/sec



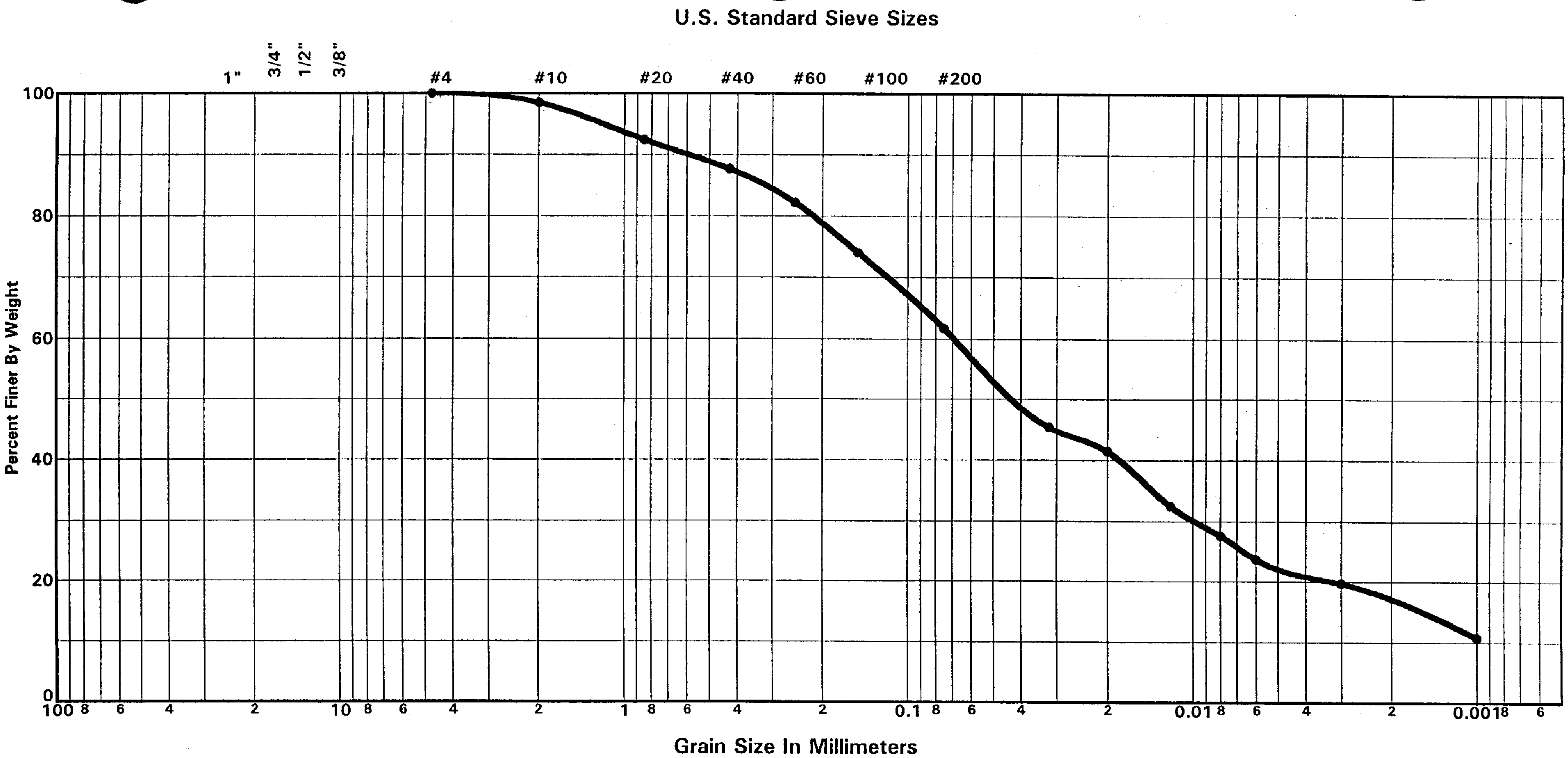
	Specimen Identification	LL	PL	PI	Fines	Classification
●	BP-12	72	59	13		Orange Brown Clayey SILT (MH)
⧗	BP-13	70	54	16		Light Green Yellow Sandy SILT (MH)
▶	BP-7	43	28	15		Light Brown Fine Sandy Slightly Clayey SILT (ML)
★	BP-8	49	34	15		Orange Brown Slightly Clayey SILT (ML)
✕	BP-9	45	39	6		Tan Brown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

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

JOB NO. 1-95-0084 CA
DATE 5/19/97

ATTERBERG LIMITS' RESULTS

GeoTechnologies, Inc.
Raleigh, North Carolina



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

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

Project:

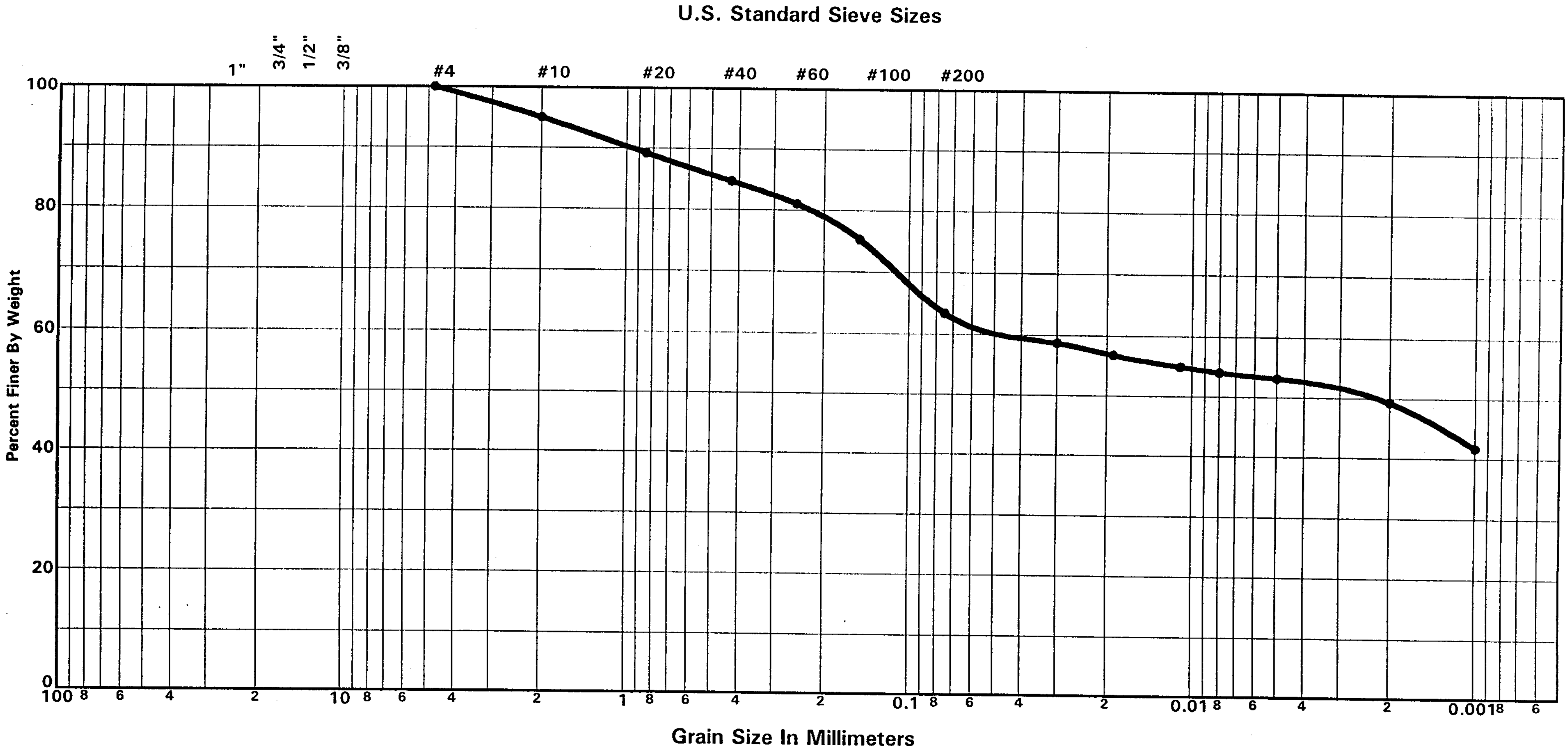
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

Job No.: 1-95-0084 CA

Date: 5/19/97

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:

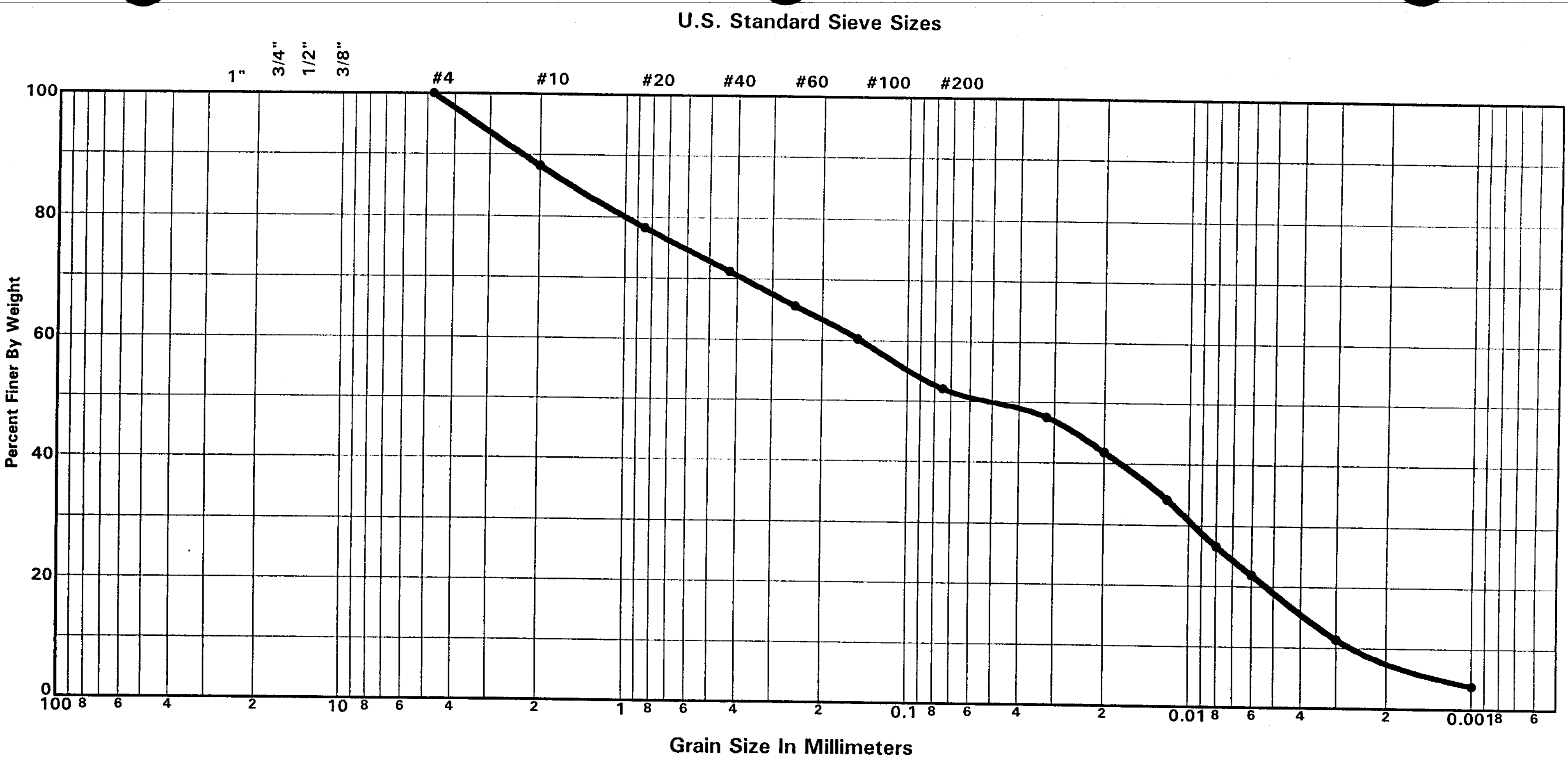
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

Job No.: 1-95-0084 CA

Date: 5/19/97

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:

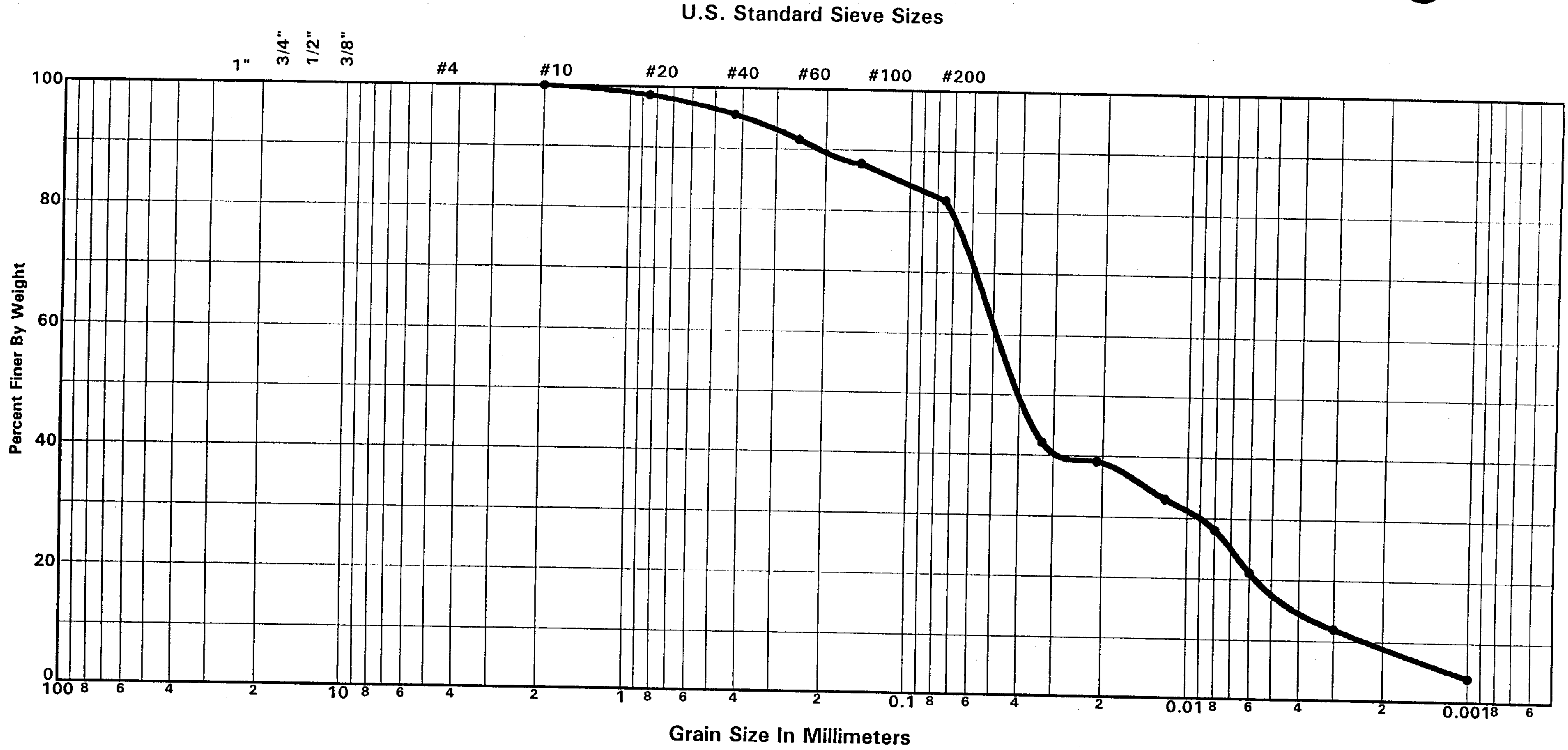
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

Job No.: 1-95-0084 CA

Date: 5/19/97

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:

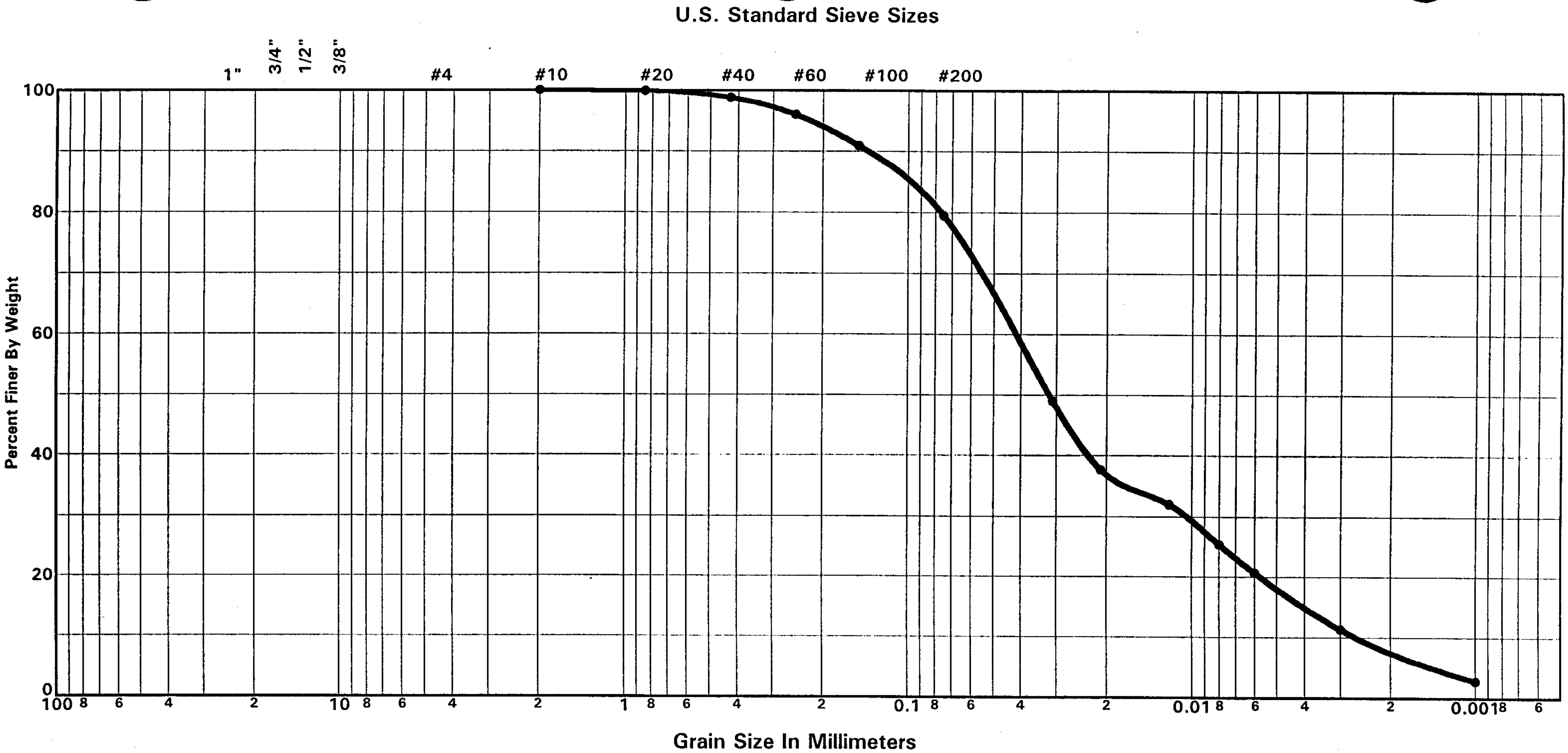
G.N. Richardson & Associates Lab Services
Raleigh, North Carolina

Job No.: 1-95-0084 CA

Date: 5/19/97

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:

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

Job No.: 1-95-0084 CA

Date: 5/19/97

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

GeoTechnologies, Inc.

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

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

Job Location: Raleigh, North Carolina

Boring No:

Sample No: BP-8

Depth:

TEST RESULTS

Method of Test: ASTM D 698

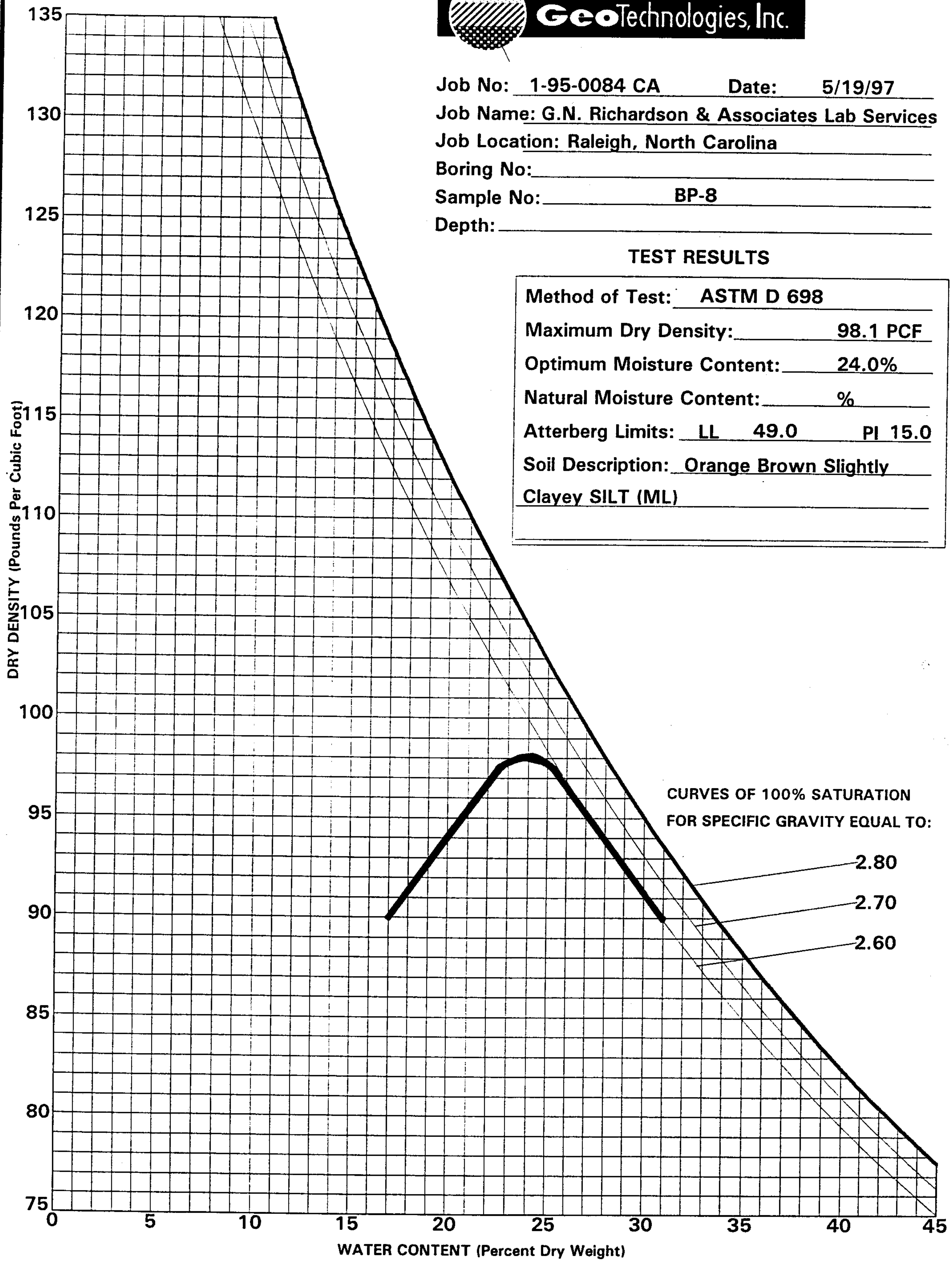
Maximum Dry Density: 98.1 PCF

Optimum Moisture Content: 24.0%

Natural Moisture Content: %

Atterberg Limits: LL 49.0 PI 15.0

Soil Description: Orange Brown Slightly Clayey SILT (ML)



MOISTURE-DENSITY RELATIONSHIP

GeoTechnologies, Inc.

Raleigh, North Carolina

ologies, Inc.

MOISTURE CONTENT DATA SHEET

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

Date:

	Sample I.D.	[illegible]	[illegible]	[illegible] + Tare	[illegible] + Tare	[illegible]	[illegible]	[illegible] Content =f/g
1	BP-7	TRI	100.71	326.97	266.23	60.74	165.52	36.7
2	BP-12	I-6	106.53	260.53	196.05	64.48	89.52	72.0
3	BP-9	URG	100.83	332.78	276.84	55.94	176.01	31.8
4	BP-13	PET	100.58	263.80	204.04	59.76	103.46	57.8
5	BP-8	SAR	97.86	369.74	315.20	54.54	217.34	25.1
6								
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GeoTechnologies, Inc.

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

January 3, 1996

RECEIVED
JAN 10 1996

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

Attention: Mr. Gregg Richardson

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

Gentlemen:

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

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

Very truly yours,

GeoTechnologies, Inc.

R. Sherwood Core, CET
Construction Services Manager

Edward B. Hearn, P.E.
President

RSC/fgo
Attachments

GeoTechnologies, Inc.

PERMEABILITY TEST

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

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

Soil Description: ORANGE BROWN SILTY SAND

SAMPLE DATA

type
remolded ( )
undisturbed (X)

standard proctor

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

	inches	cm.	
Length	**2.861**	**7.267**	
Diameter	**2.852**	**7.244**	
Area	**6.388**	**41.214**	
Volume	**18.277**	**299.504**	
Wet Mass	**1.323**	**600.16**	grams
Dry Mass	**1.0845**	**491.9**	grams

Moisture Content	**22**	%
Wet Density	**125.1**	lbs./cu.ft.
Dry Density	**102.5**	lbs./cu.ft.
Initial Saturation	**89.7**	%
Final Saturation	**100.0**	%
Initial Void Ratio	**0.7**	
Porosity	**40.3**	%
Specific Gravity	**2.75**	apparent

TEST DATA

hi = inflow burette
ho = outflow burette
t = time

L = 7.27 cm. length of sample
A = 41.214 sq.cm. area of sample
a = 0.852 sq.cm. area of burettes
h1 = head loss across specimen at t1
h2 = head loss across specimen at t2

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

ASTM D 5084

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

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

Average k= 3.97E-08 cm/sec

GeoTechnologies, Inc.

PERMEABILITY TEST

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

Soil Description: RED ORANGE SANDY SILT

SAMPLE DATA

type
remolded ( )
undisturbed (X)

standard proctor

Max. Dry Density	102.6	lbs/cu.ft.
Moisture Content	21.5	%
Compaction	95.1	%

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

TEST DATA

hi = inflow burette
ho = outflow burette
t = time

L = 7.46 cm. length of sample
A = 41.534 sq.cm. area of sample
a = 0.852 sq.cm. area of burettes
h1 = head loss across specimen at t1
h2 = head loss across specimen at t2

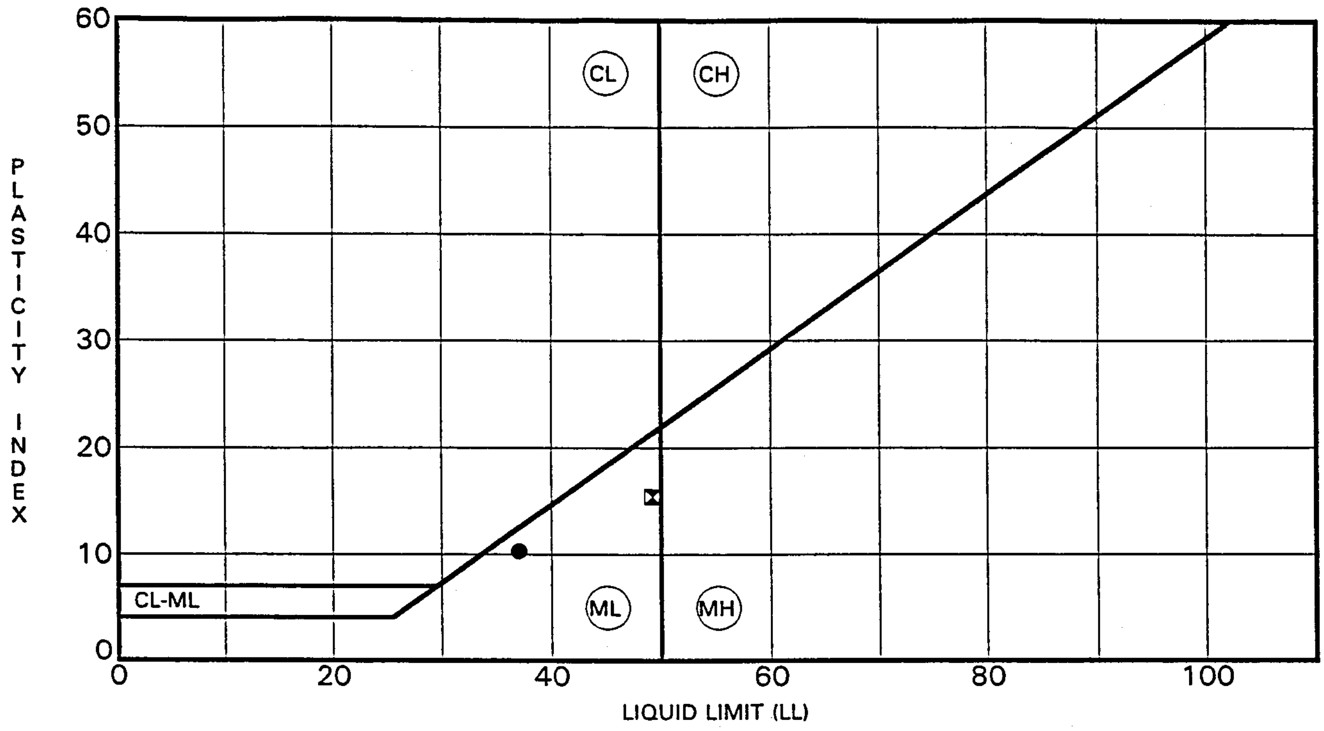
t1	t2	ho1	hi1	h1	ho2	hi2	h2
0	**5700**	93.9	0.9	**93**	93.4	1.4	**92**
0	**3900**	93.4	1.4	**92**	93.1	1.8	**91.3**
0	**4500**	93.1	1.8	**91.3**	92.7	2.1	**90.6**
	74400	92.7	2.1	**90.6**	86.5	8.5	**78**

ASTM D 5084

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

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

Average k= 1.45E-07 cm/sec



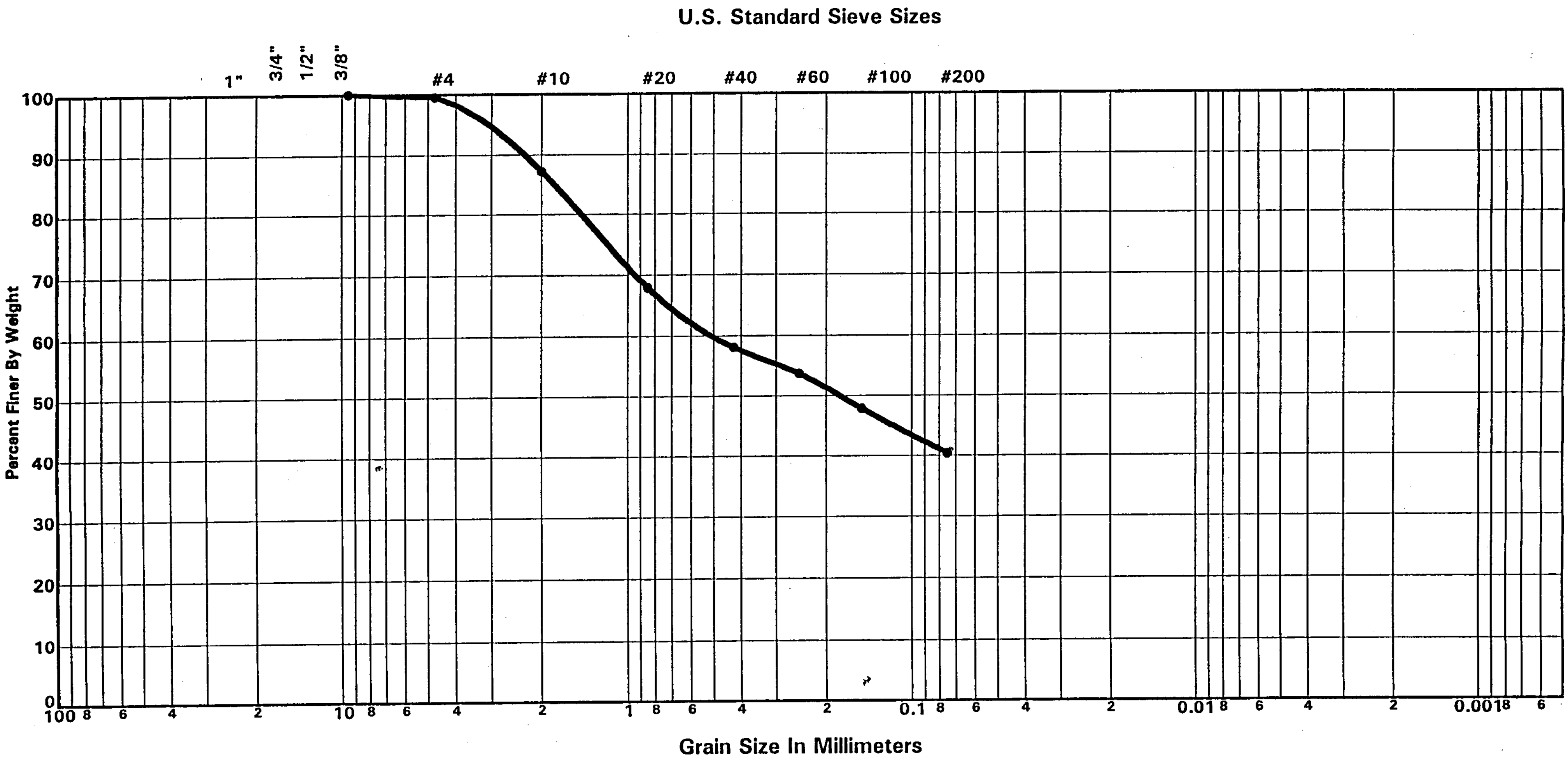
	Specimen Identification			LL	PL	PI	Fines	Classification
●	BP	#3	3.0-5.0'	37	27	10	40.4	Brown-Orange Silty SAND (SM)
⊠	BP	#6	15.0'	49	34	15	52.8	Red Orange Sandy SILT (ML)

PROJECT Halifax-6 - Halifax, North Carolina

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

ATTERBERG LIMITS' RESULTS

Geotechnologies, Inc.
Raleigh, North Carolina



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

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

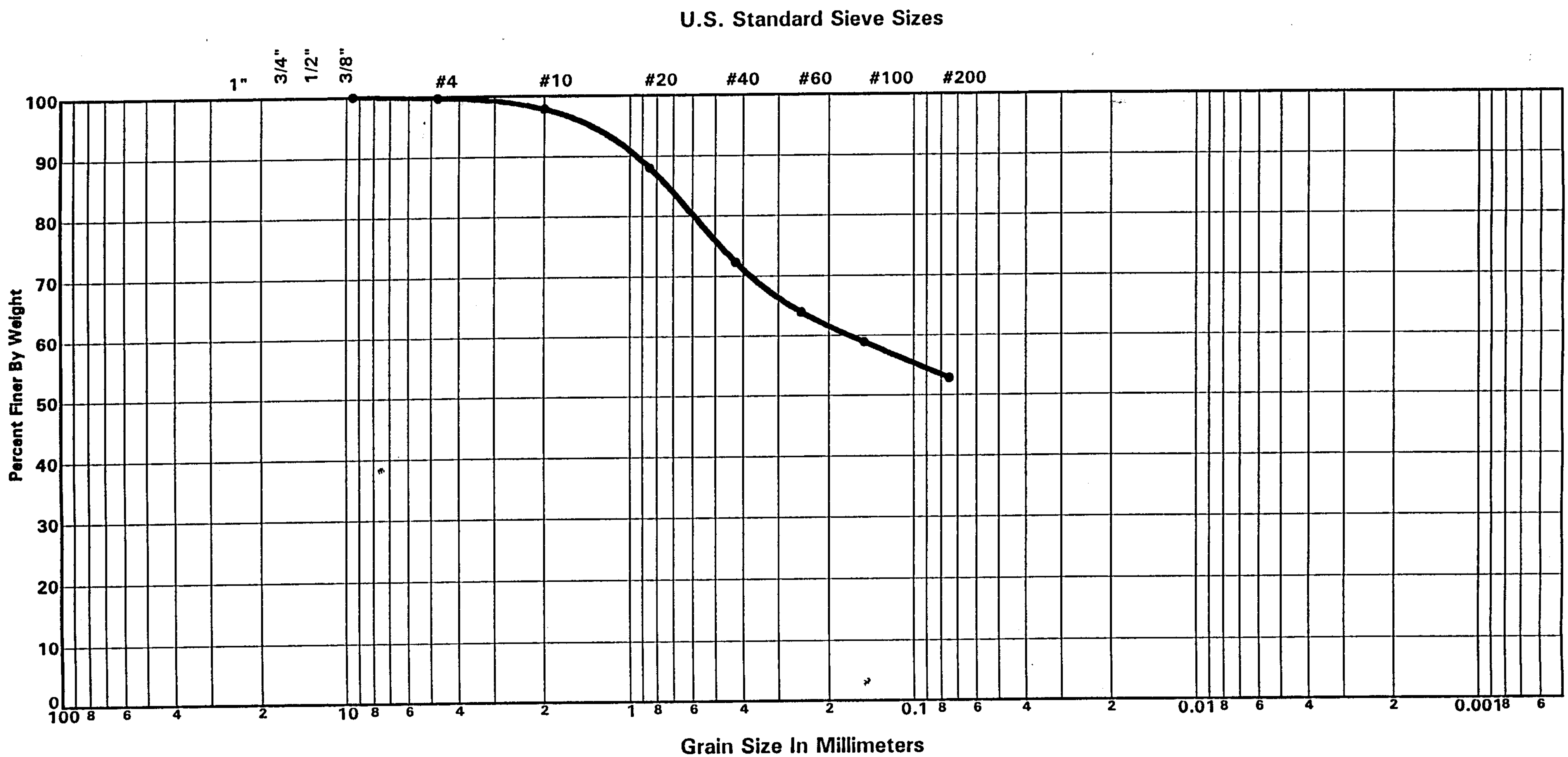
Project:
Halifax-6
Halifax, North Carolina

Job No.: 1-95-1181-CA

Date: 1/2/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:
Halifax-6
Halifax, North Carolina

Job No.: 1-95-1181-CA

Date: 1/2/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

GeoTechnologies, Inc.

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

Job Name: Halifax-6

Job Location: Halifax, North Carolina

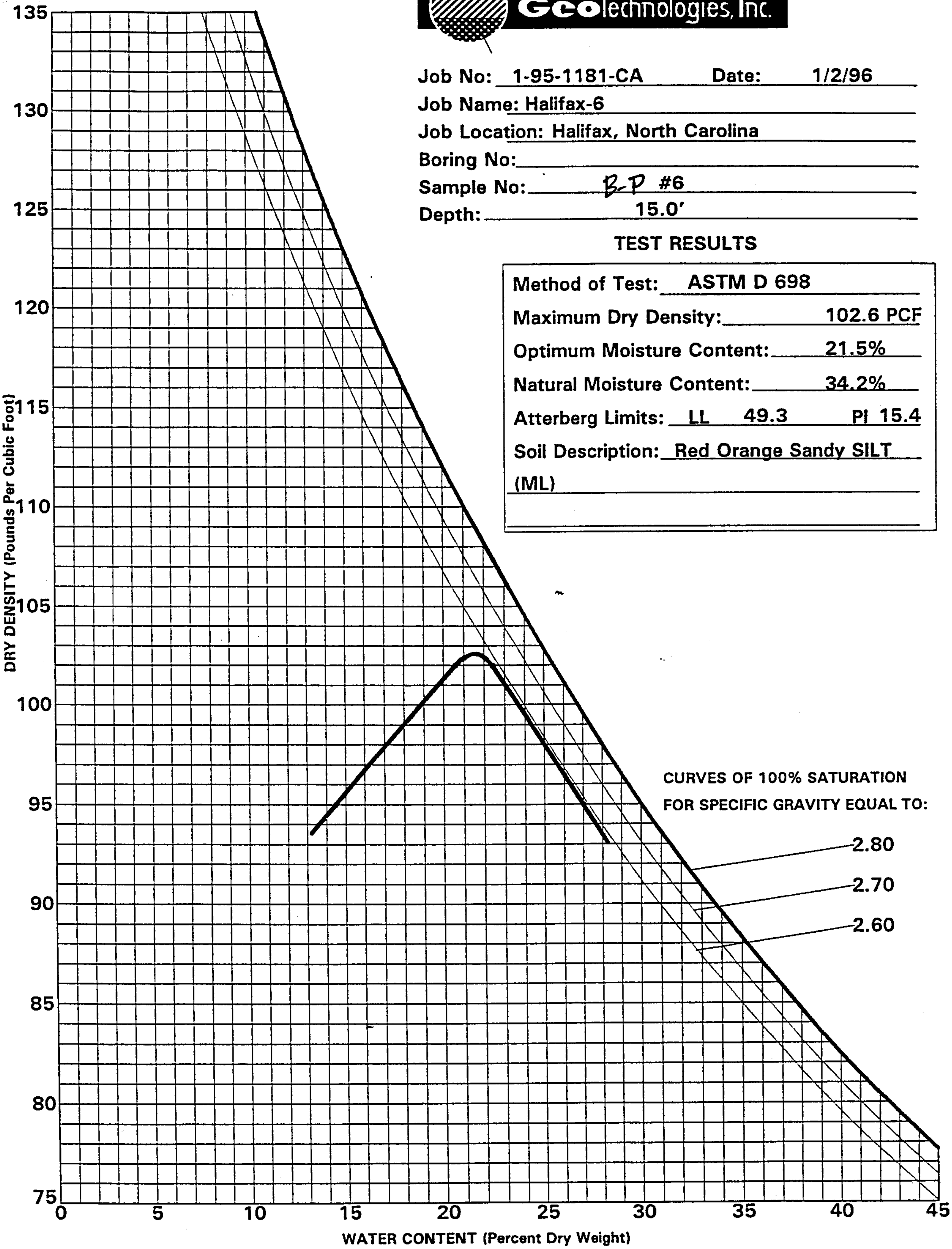
Boring No:

Sample No: B-P #6

Depth: 15.0'

TEST RESULTS

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



MOISTURE-DENSITY RELATIONSHIP

Geotechnologies, Inc.

Raleigh, North Carolina

GeoTechnologies, Inc.

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

Job Name: Halifax-6

Job Location: Halifax, North Carolina

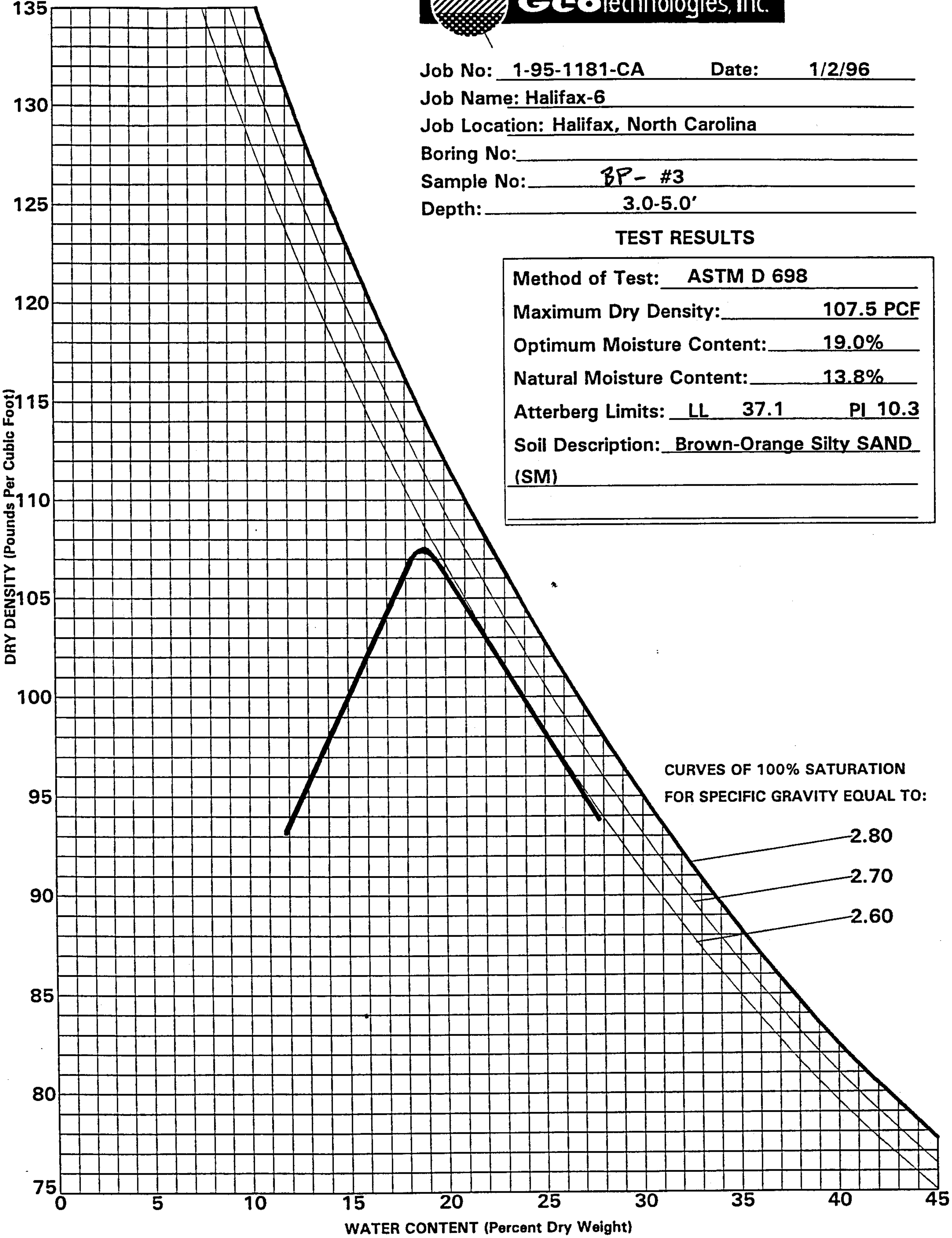
Boring No:

Sample No: BP- #3

Depth: 3.0-5.0'

TEST RESULTS

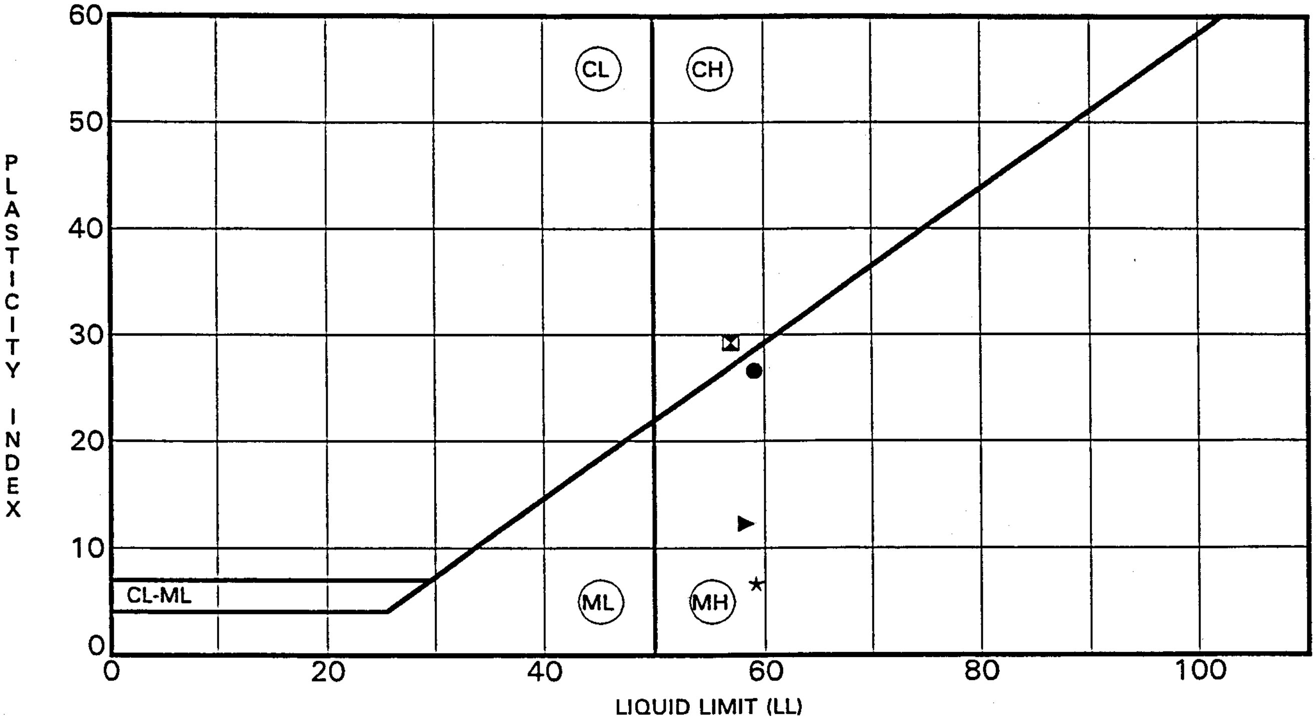
Method of Test:	ASTM D 698
Maximum Dry Density:	107.5 PCF
Optimum Moisture Content:	19.0%
Natural Moisture Content:	13.8%
Atterberg Limits:	LL 37.1 PI 10.3
Soil Description:	Brown-Orange Silty SAND (SM)



MOISTURE-DENSITY RELATIONSHIP

Geotechnologies, Inc.

Raleigh, North Carolina



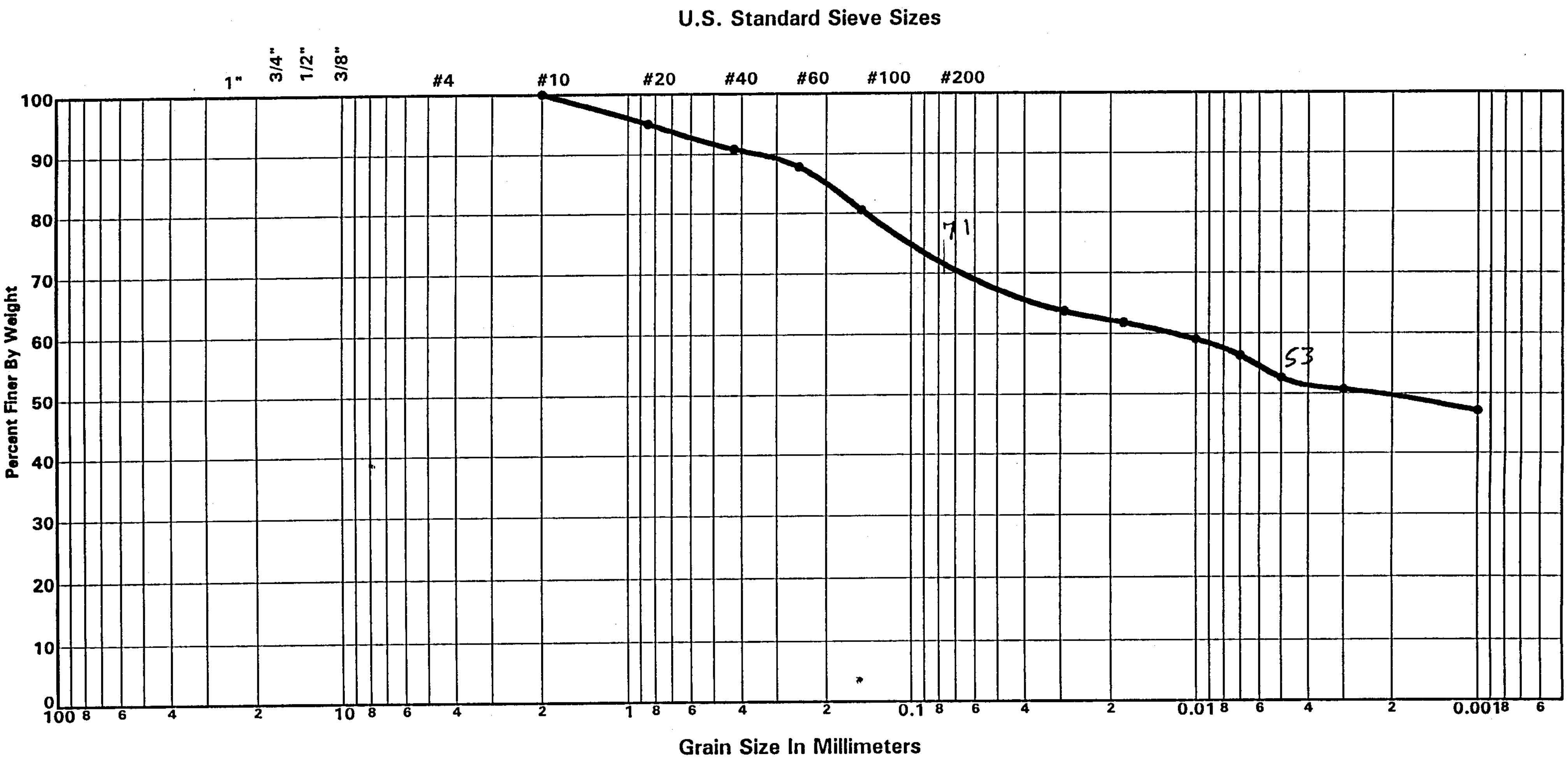
	Specimen Identification		LL	PL	PI	Fines	Classification
●	BP #1 - 1	0-1.5'	59	33	27		Tan Slightly Sandy CLAY (MH)
⧗	BP #2 - 1	0-1.5'	57	28	29		Tan-Orange Slightly Sandy CLAY (CH)
▶	BP #6-1	0-1.5'	58	46	12		Brown Orange Slightly Fine Sandy SILT (MH)
★	BP #6-2	3.5-5.0'	59	53	7		Brown Micaceous Slightly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

PROJECT Halifax-6 - Halifax, North Carolina

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

ATTERBERG LIMITS' RESULTS

Geotechnologies, Inc.
Raleigh, North Carolina



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

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

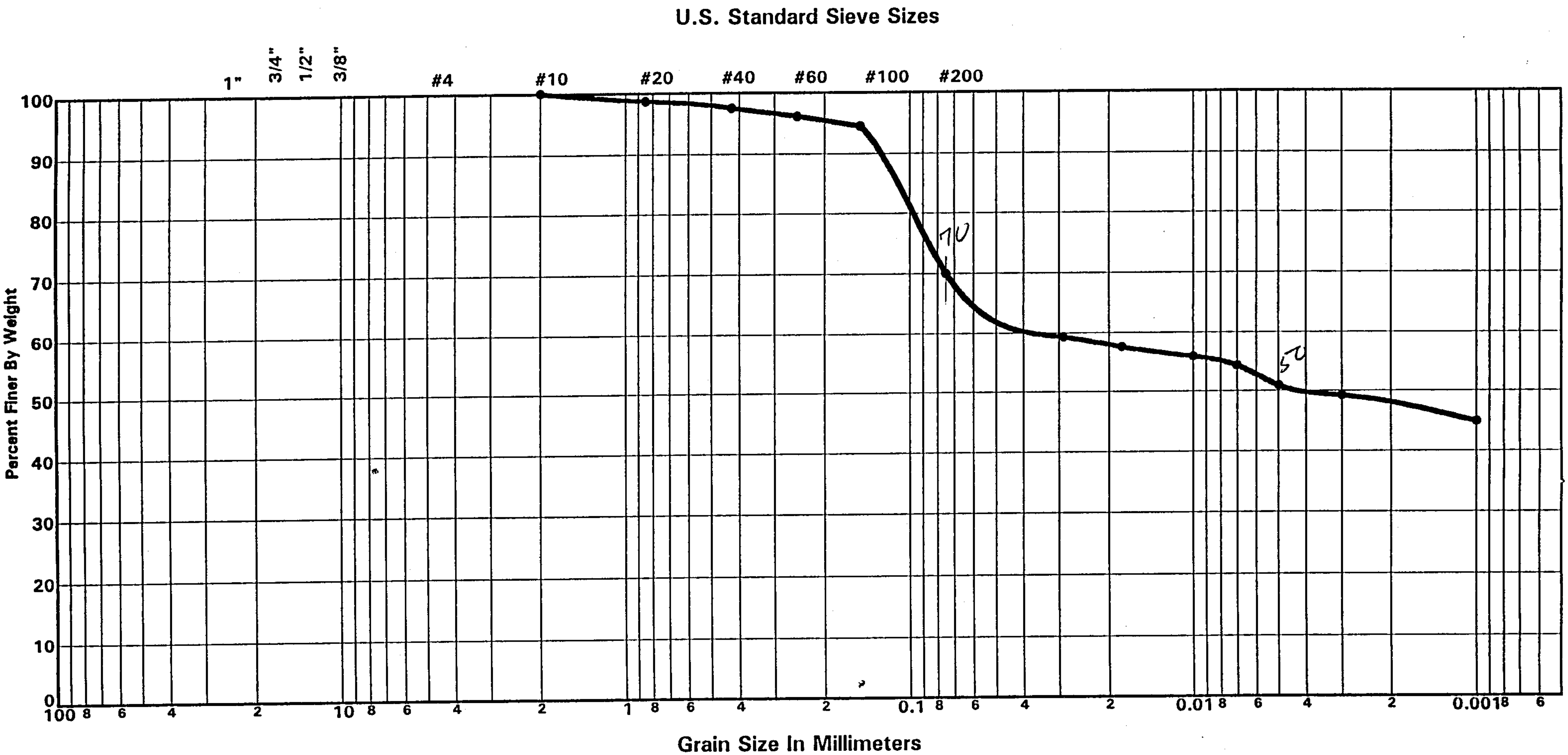
Project:
Halifax-6
Halifax, North Carolina

Job No.: 1-95-1181-CA

Date: 1/4/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

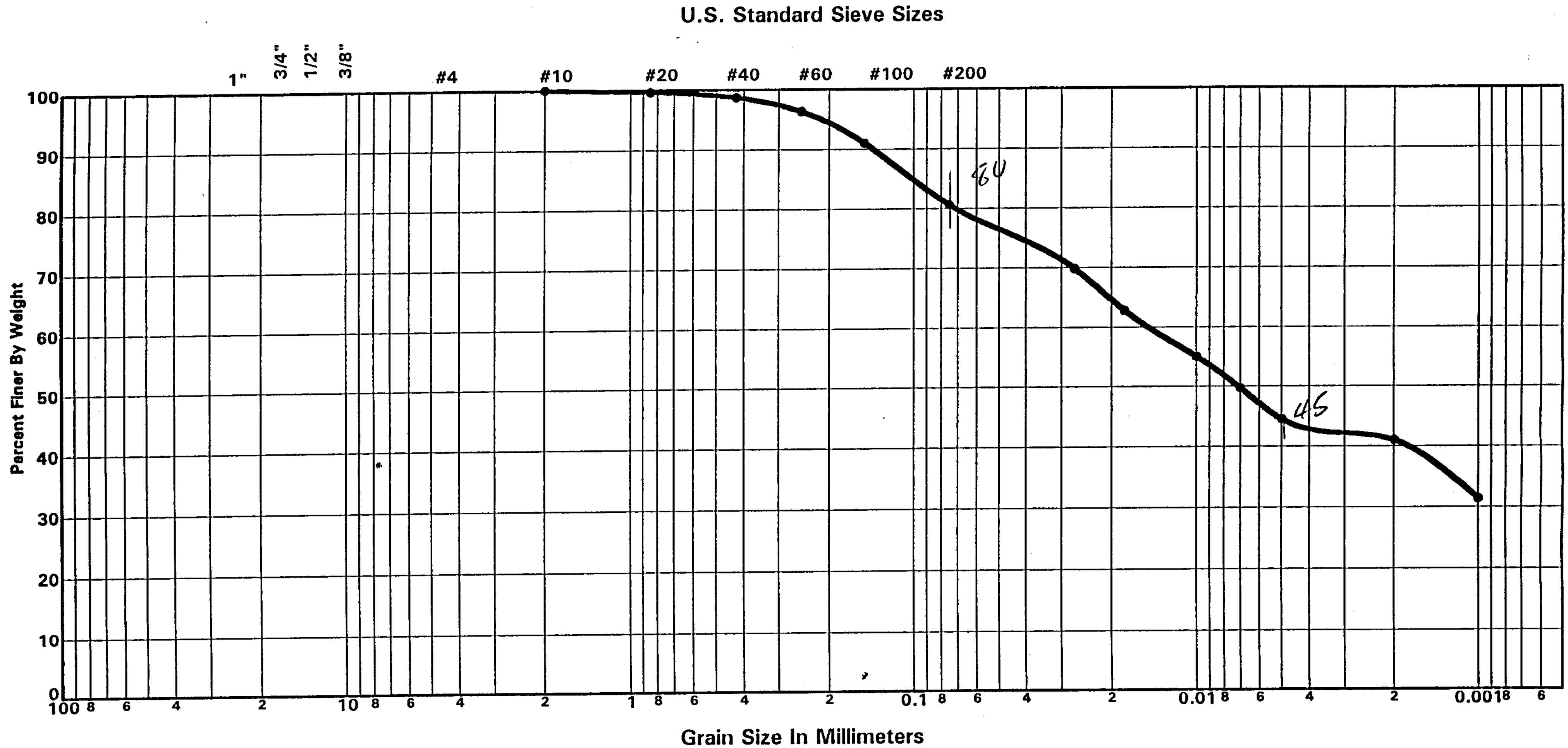
Project:
Halifax-6
Halifax, North Carolina

Job No.: 1-95-1181-CA

Date: 1/2/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

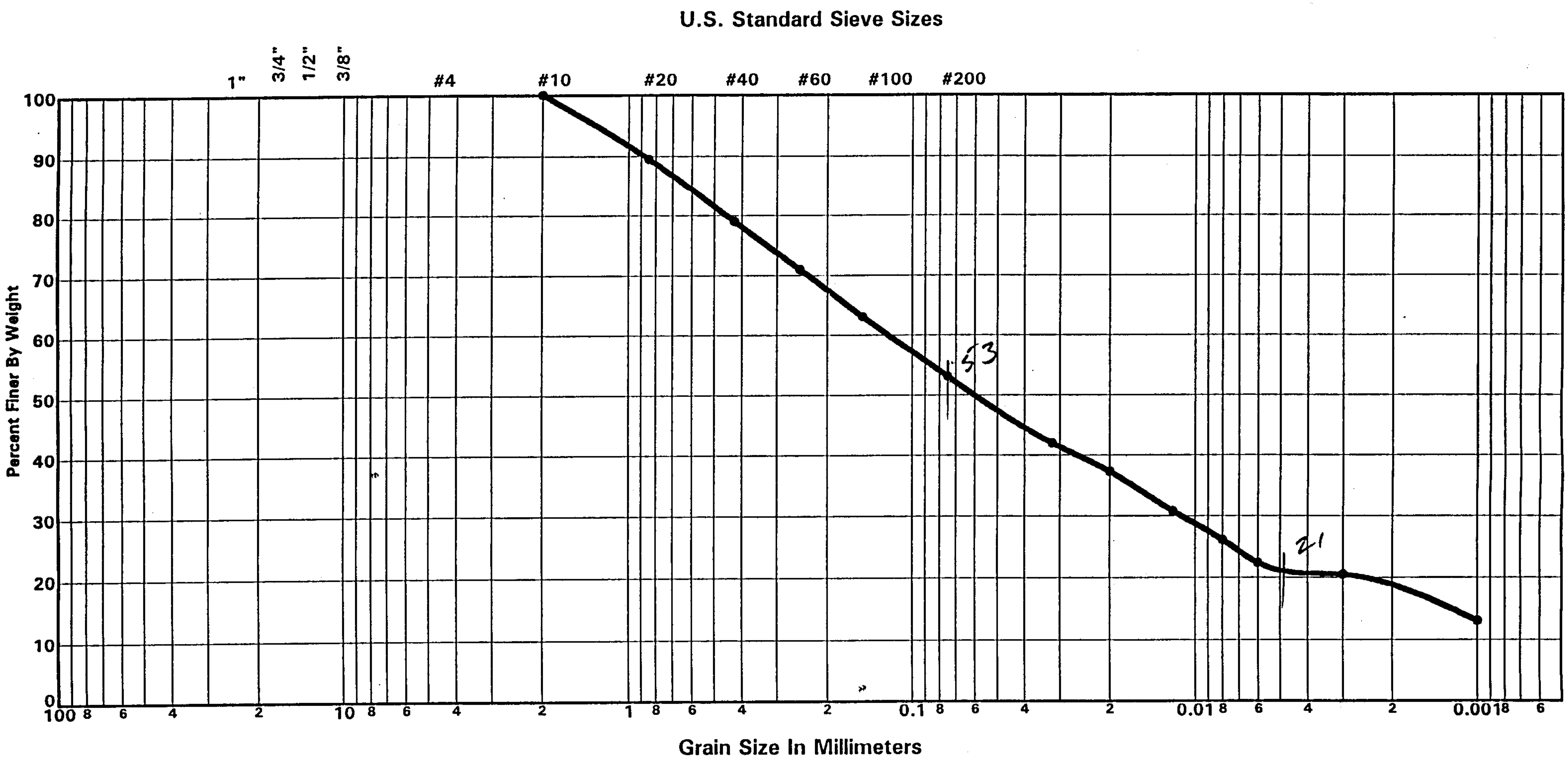
Project:
Halifax-6
Halifax, North Carolina

Job No.: 1-95-1181-CA

Date: 1/2/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:
Halifax-6
Halifax, North Carolina

Job No.: 1-95-1181-CA

Date: 1/2/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

GeoTechnologies, Inc.

PERMEABILITY TEST

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

Soil Description: RED ORANGE CLAYEY SILT

SAMPLE DATA

type		standard proctor		
remolded	( )	Max. Dry Density		lbs/cu.ft.
undisturbed	(X)	Moisture Content		%
		Compaction	#DIV/0!	%

	inches	cm.			
				Moisture Content	**17.3** %
Length	**6.007**	**15.258**		Wet Density	**129.8** lbs./cu.ft.
Diameter	**2.896**	**7.356**		Dry Density	**110.6** lbs./cu.ft.
Area	**6.587**	**42.497**		Initial Saturation	**86.2** %
Volume	**39.568**	**648.404**		Final Saturation	**100.0** %
Wet Mass	**2.971**	**1347.69**	grams	Initial Void Ratio	**0.6**
Dry Mass	**2.5329**	**1148.9**	grams	Porosity	**35.6**
				Specific Gravity	**2.75** apparent

TEST DATA

	L =	15.26 cm.	length of sample
hi = inflow burette	A =	42.497 sq.cm.	area of sample
ho = outflow burette	a =	0.852 sq.cm.	area of burettes
t = time	h1 =	head loss across specimen at t1	
	h2 =	head loss across specimen at t2	

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

ASTM D 5084

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

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

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

GeoTechnologies, Inc.

PERMEABILITY TEST

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

Soil Description: RED ORANGE CLAYEY SILT

SAMPLE DATA

type
remolded ( )
undisturbed (X)

standard proctor

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

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

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

TEST DATA

hi = inflow burette
ho = outflow burette
t = time

L =	15.11	cm.	length of sample
A =	41.708	sq.cm.	area of sample
a =	0.852	sq.cm.	area of burettes

h1 = head loss across specimen at t1
h2 = head loss across specimen at t2

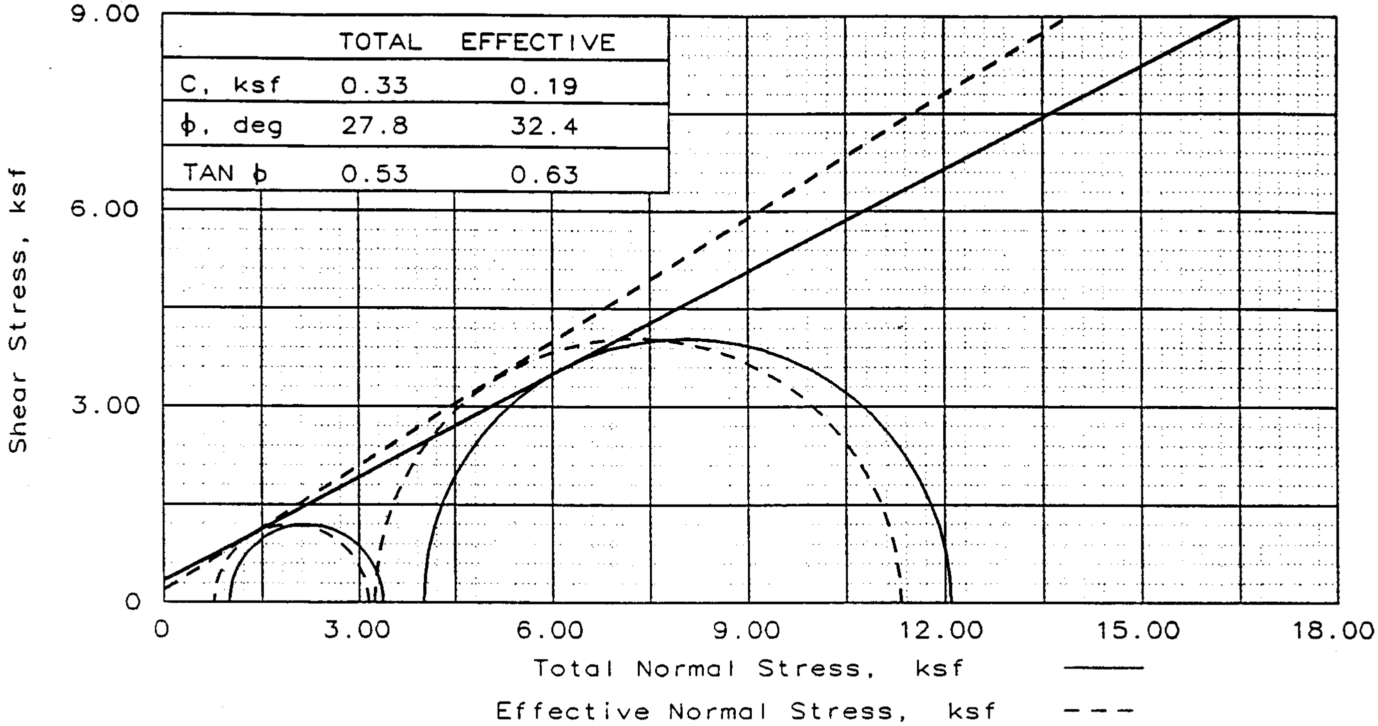
t1	t2	ho1	hi1	h1	ho2	hi2	h2
0	1800	94.5	0.5	94	87.1	7.6	79.5
0	1440	87.1	7.6	79.5	81.5	13.2	68.3
0	2700	81.5	13.2	68.3	71.9	23	48.9
0	2700	94.5	0.8	93.7	83.7	11.5	72.2

ASTM D 5084

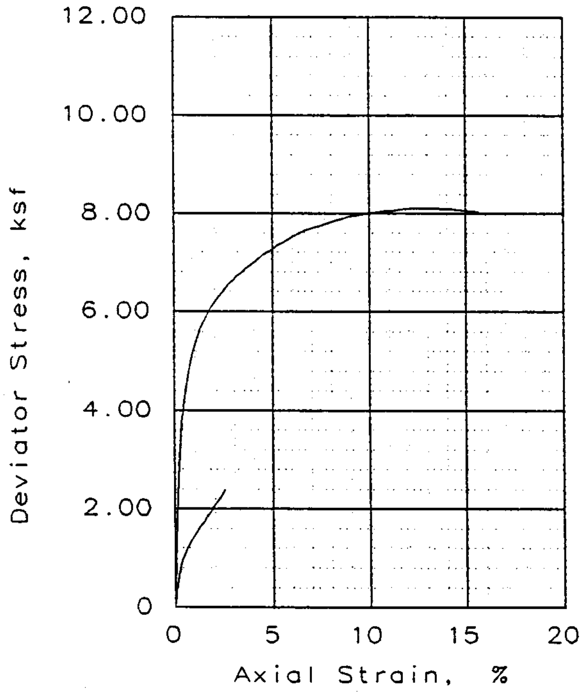
k = ((aaL/(At(a+a)))*ln(h1/h2)

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

Average k = 1.62E-05 cm/sec



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



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

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

FIG. NO.

CLIENT: RICHARDSON AND ASSOCIATES

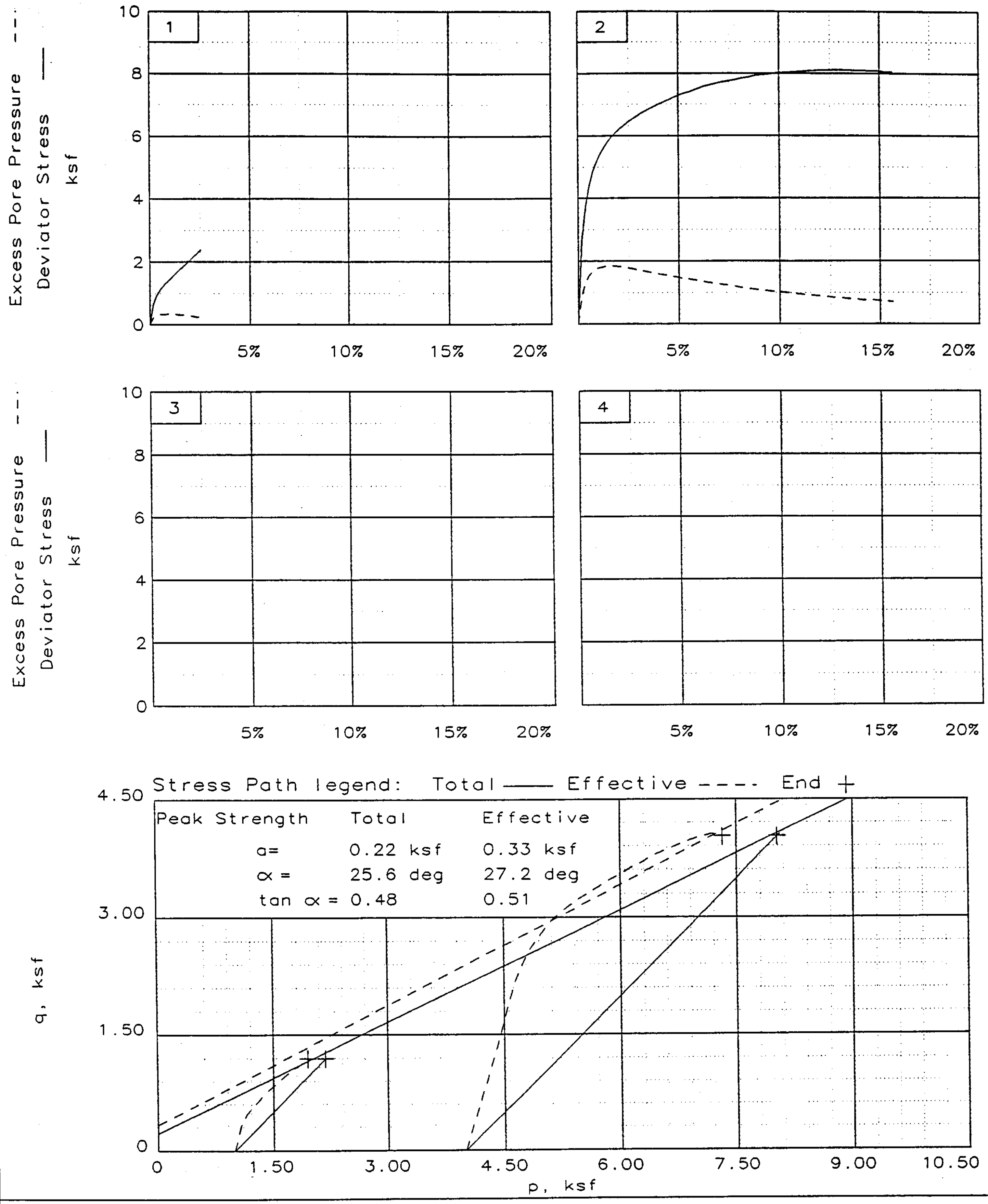
PROJECT: HALIFAX - 5

SAMPLE LOCATION: B - 4

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

TRIAXIAL SHEAR TEST REPORT

GEOTECHNOLOGIES, INC., P.A.

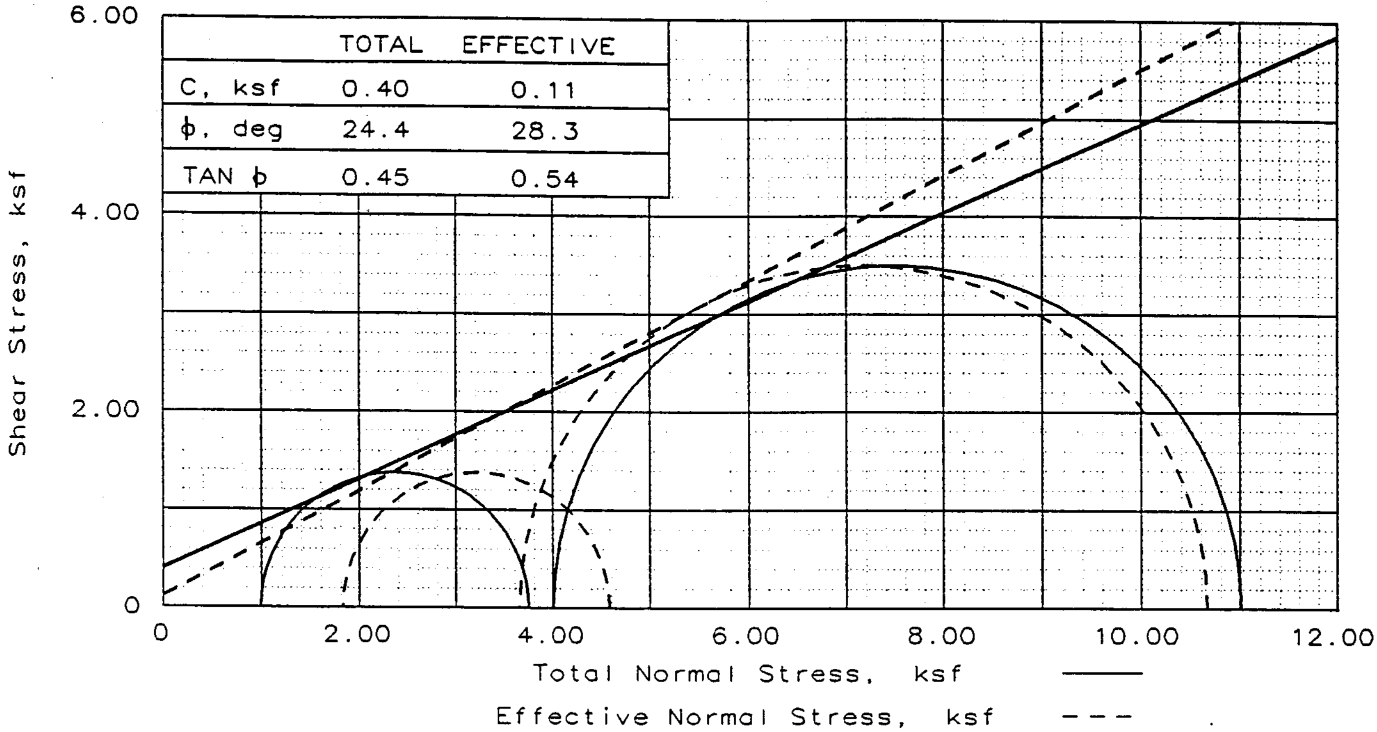


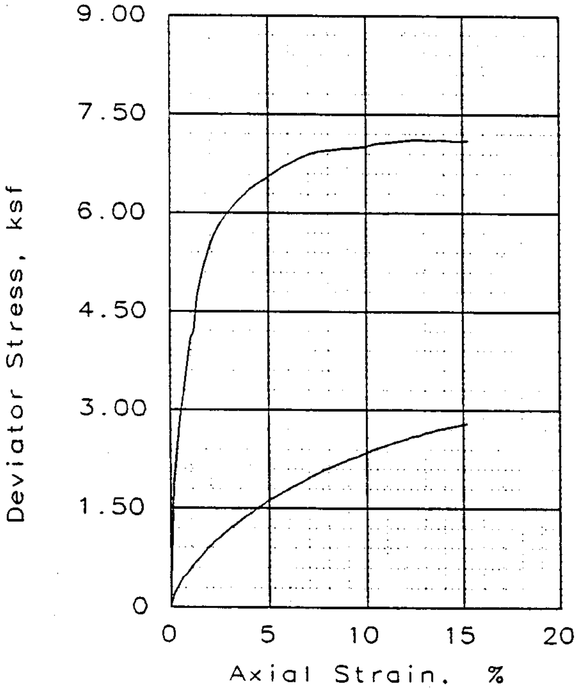
Client: RICHARDSON AND ASSOCIATES

Project: HALIFAX - 5

Location: B - 4

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





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

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

FIG. NO.

CLIENT: G.N. RICHARDSON & ASSOC

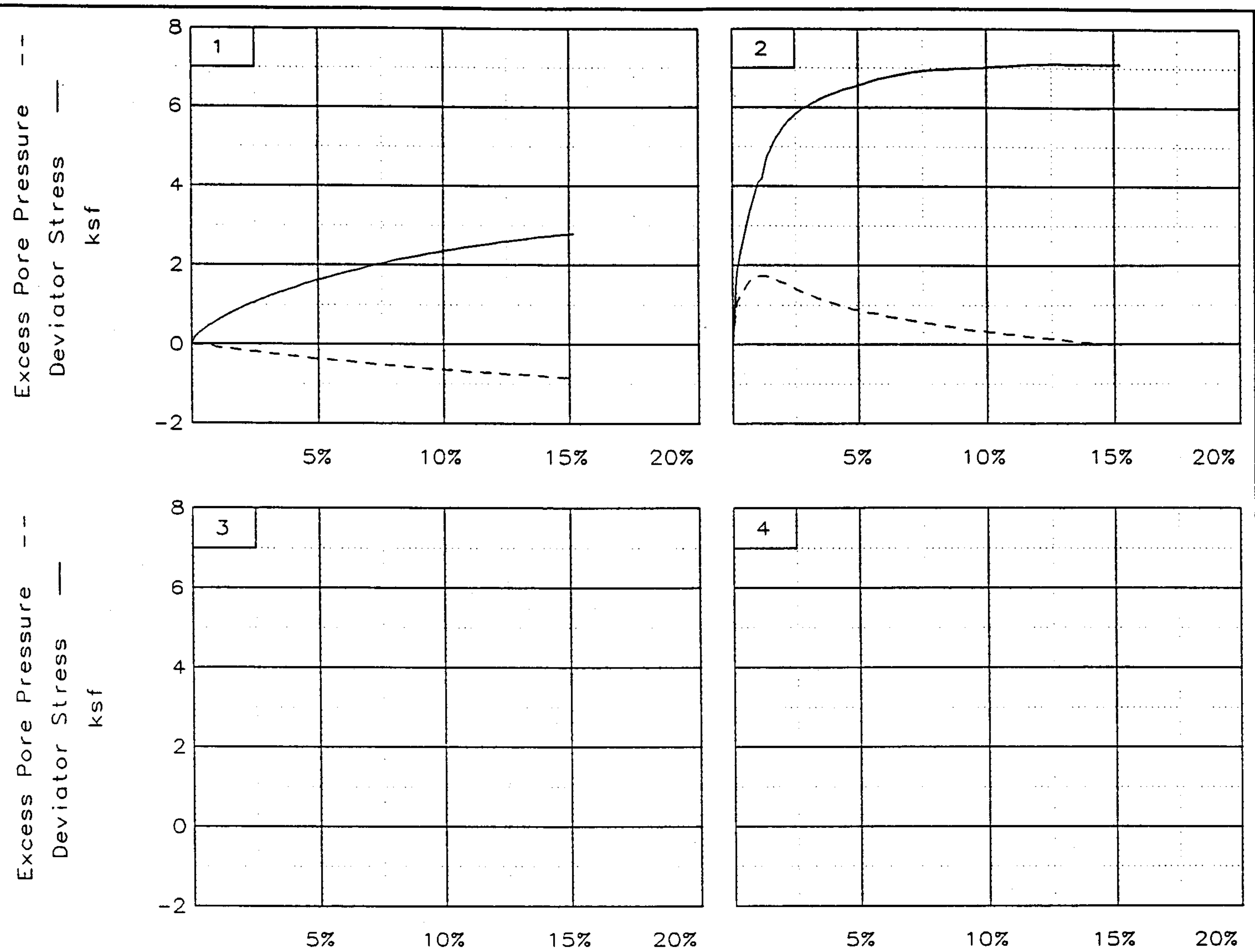
PROJECT: HALIFAX 5

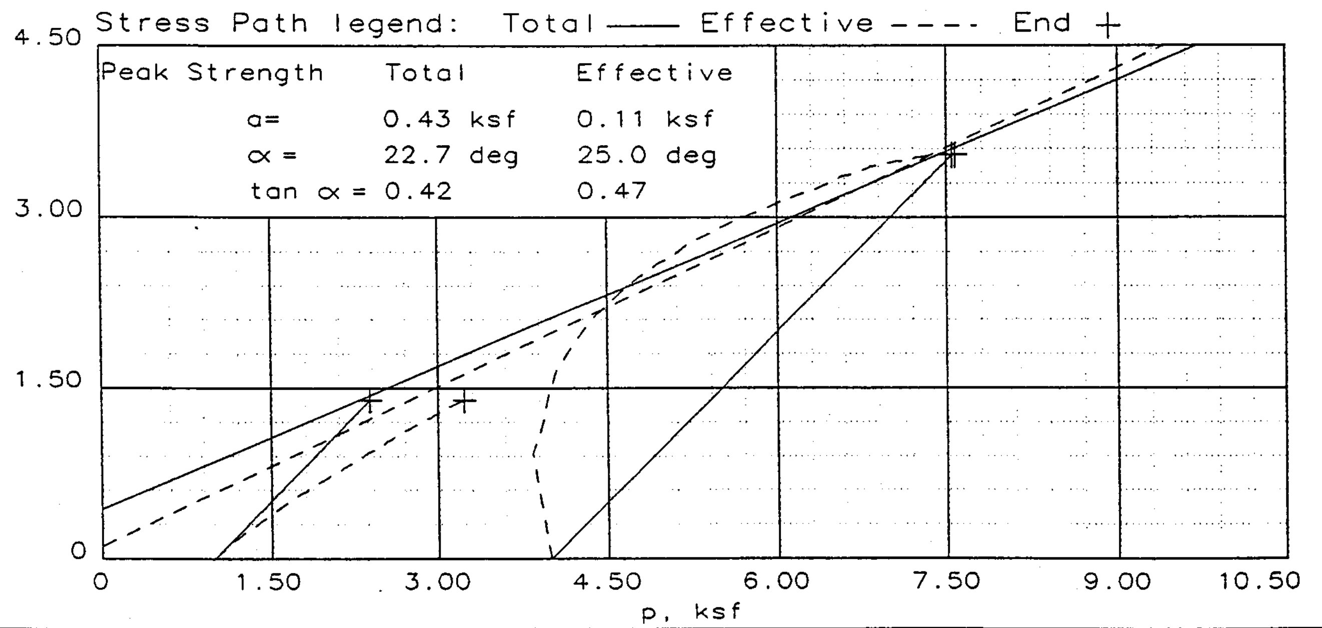
SAMPLE LOCATION: B - 8

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

TRIAXIAL SHEAR TEST REPORT

GEOTECHNOLOGIES, INC., P.A.





Client: G.N. RICHARDSON & ASSOC

Project: HALIFAX 5

Location: B - 8

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

GeoTechnologies, Inc.

CONSOLIDATION TEST

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

Job Number: 1-95-1181 CB

Sample I.D. B - 4 Depth: 1 - 3'

Soil Description: RED ORANGE CLAYEY SILT

Notes: PRELOAD 500 \ SATURATED \ UNDISTURBED

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

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

Initial Reading	.0000
Preload Rebound Reading	.0294

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

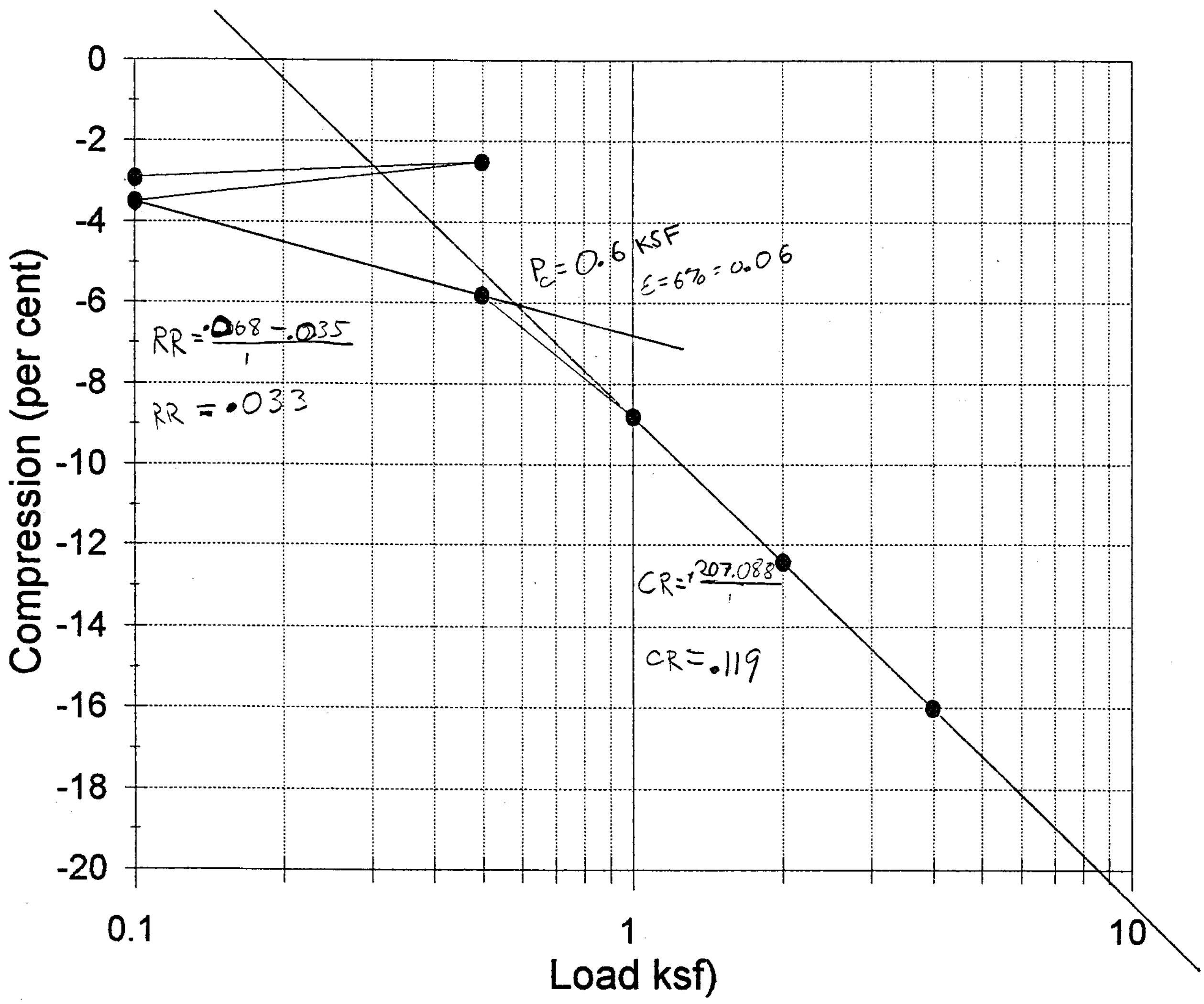
LOAD / psf	%E	Con. Coef.	%IC
100	0.4		90.0
500	2.9		93.3
100	2.5		80.0
500	3.5		77.4
1000	5.8	4.979	87.8
2000	8.8	3.136	91.2
4000	12.4	8.743	92.7
8000	16.0	5.371	86.0
16000			

NOTE: Consolidation Coefficient in Square Feet Per Day

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

Consolidation Test

B-4, 1'-3'



GeoTechnologies, Inc.

CONSOLIDATION TEST

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

Job Number: 1-95-1181 CB

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

Soil Description: RED ORANGE CLAYEY SAND

Notes: PRELOAD 500 \ SATURATED \ UNDISTURBED

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

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

Initial Reading	.0000
Preload Rebound Reading	.0032

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

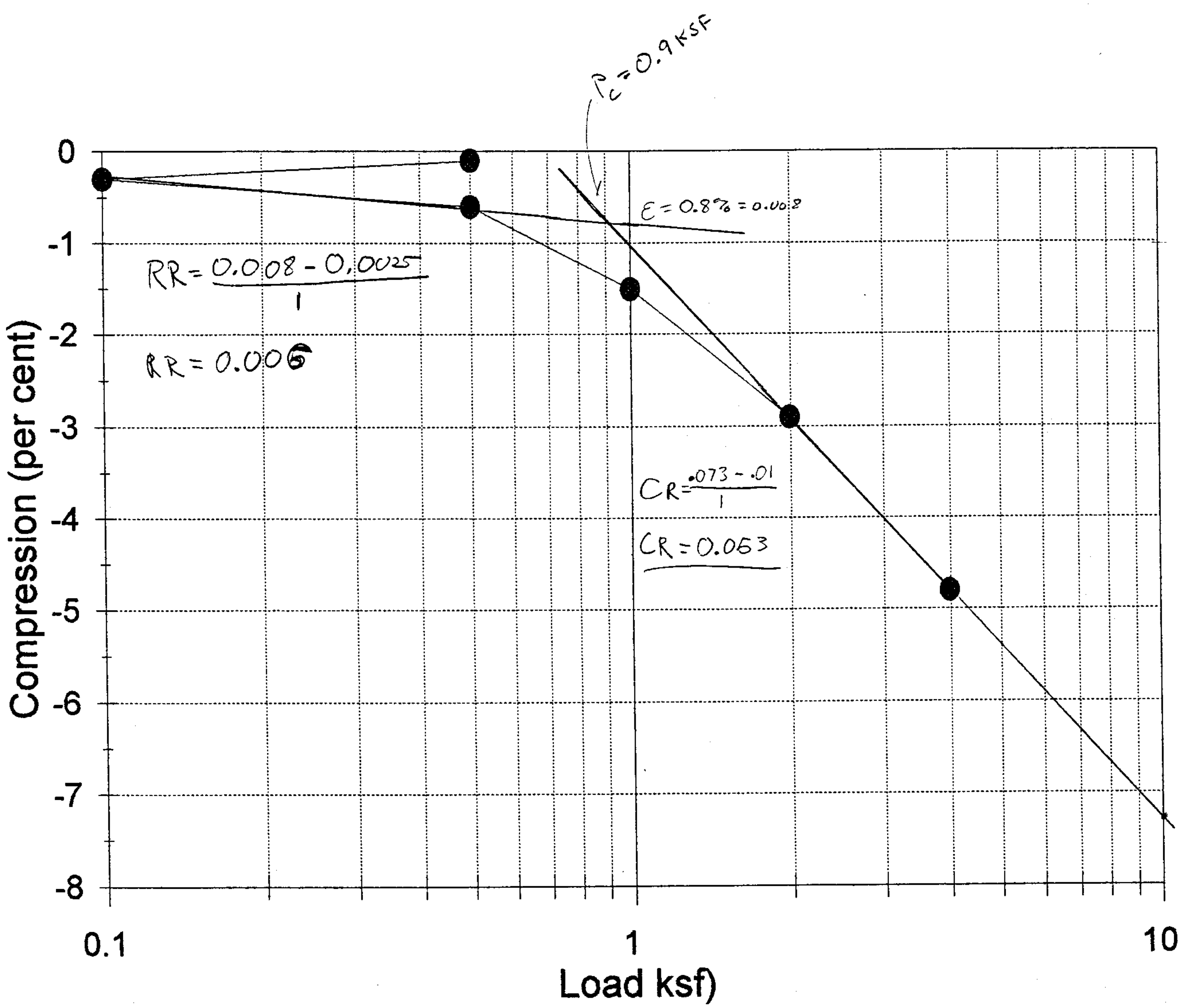
LOAD / psf	%E	Con. Coef.	%IC
100	0.1		80.0
500	0.3		92.6
100	0.1		92.3
500	0.3		95.8
1000	0.6	5.421	88.2
2000	1.5	10.710	89.7
4000	2.9	5.236	88.1
8000	4.8	10.124	88.7
16000			

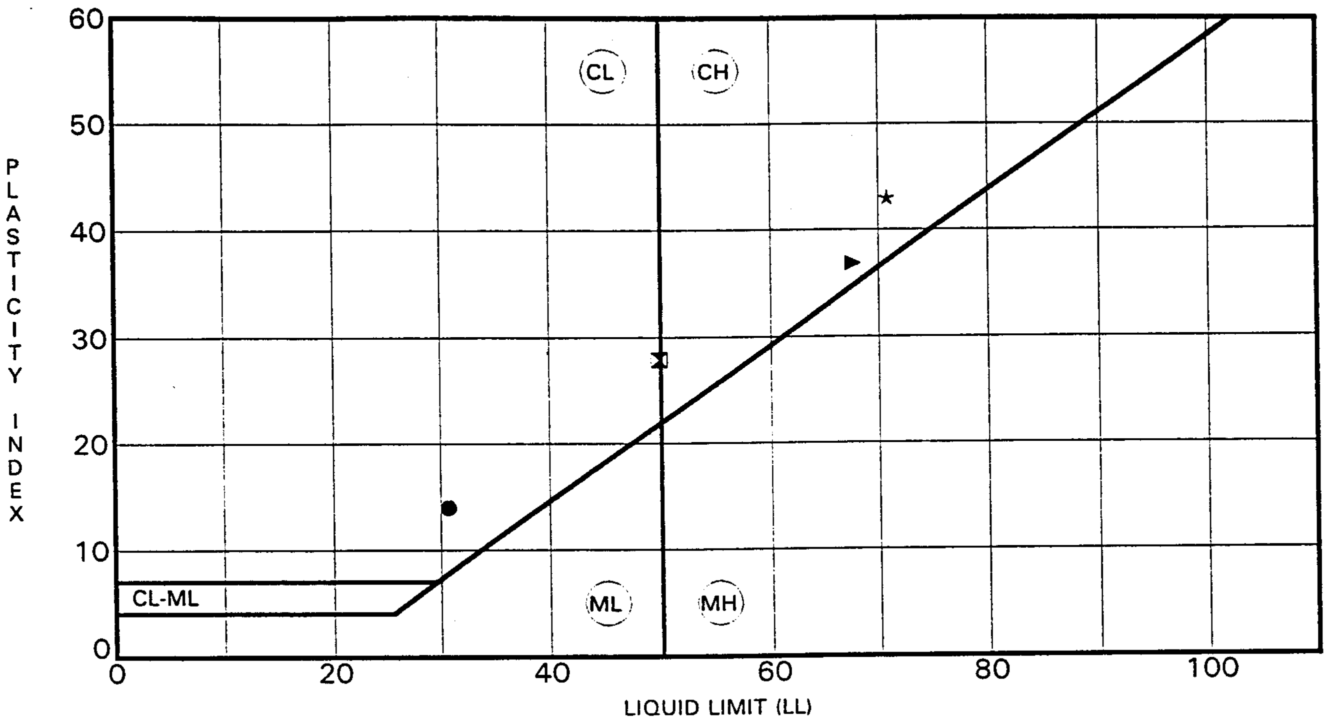
NOTE: Consolidation Coefficient in Square Feet Per Day

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

Consolidation Test

B-8, 5'-7'





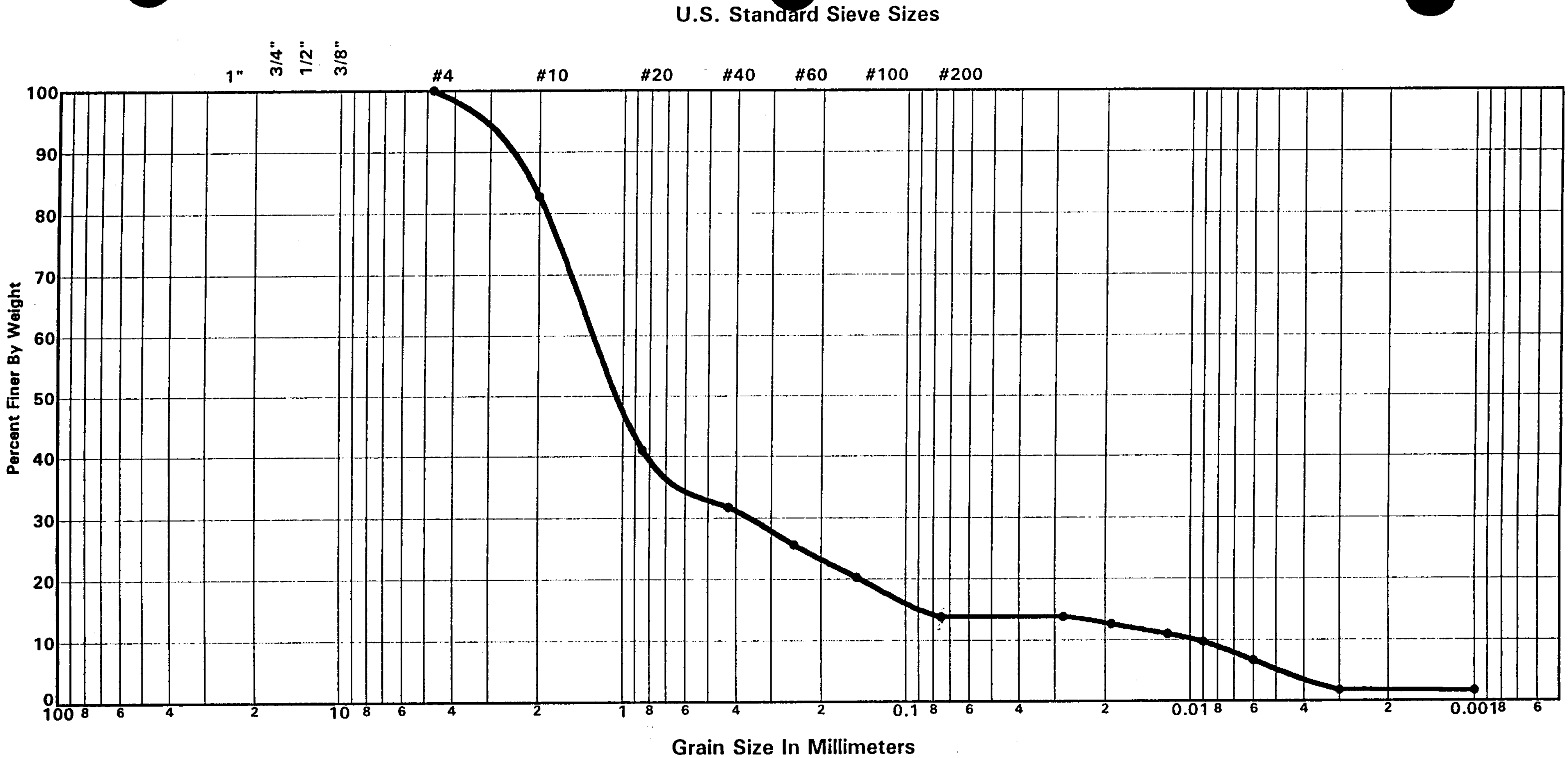
Specimen Identification		LL	PL	PI	Fines	Classification
●	B-4	31	17	14	13.8	Red Orange Clayey SILT (CL)
⧗	B-8-1	50	22	28	48.8	Red Orange Clayey SILT (CL/CH)
▶	G-2-A	68	31	37	43.8	Very Gravelly Reddish Brown Silty CLAY (CH)
★	G-6-A	71	28	43	43.2	Orange Slightly Sandy Silty CLAY (CH)

PROJECT Halifax-5 - Halifax, North Carolina

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

ATTERBERG LIMITS' RESULTS

Raleigh, North Carolina



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

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

Project:

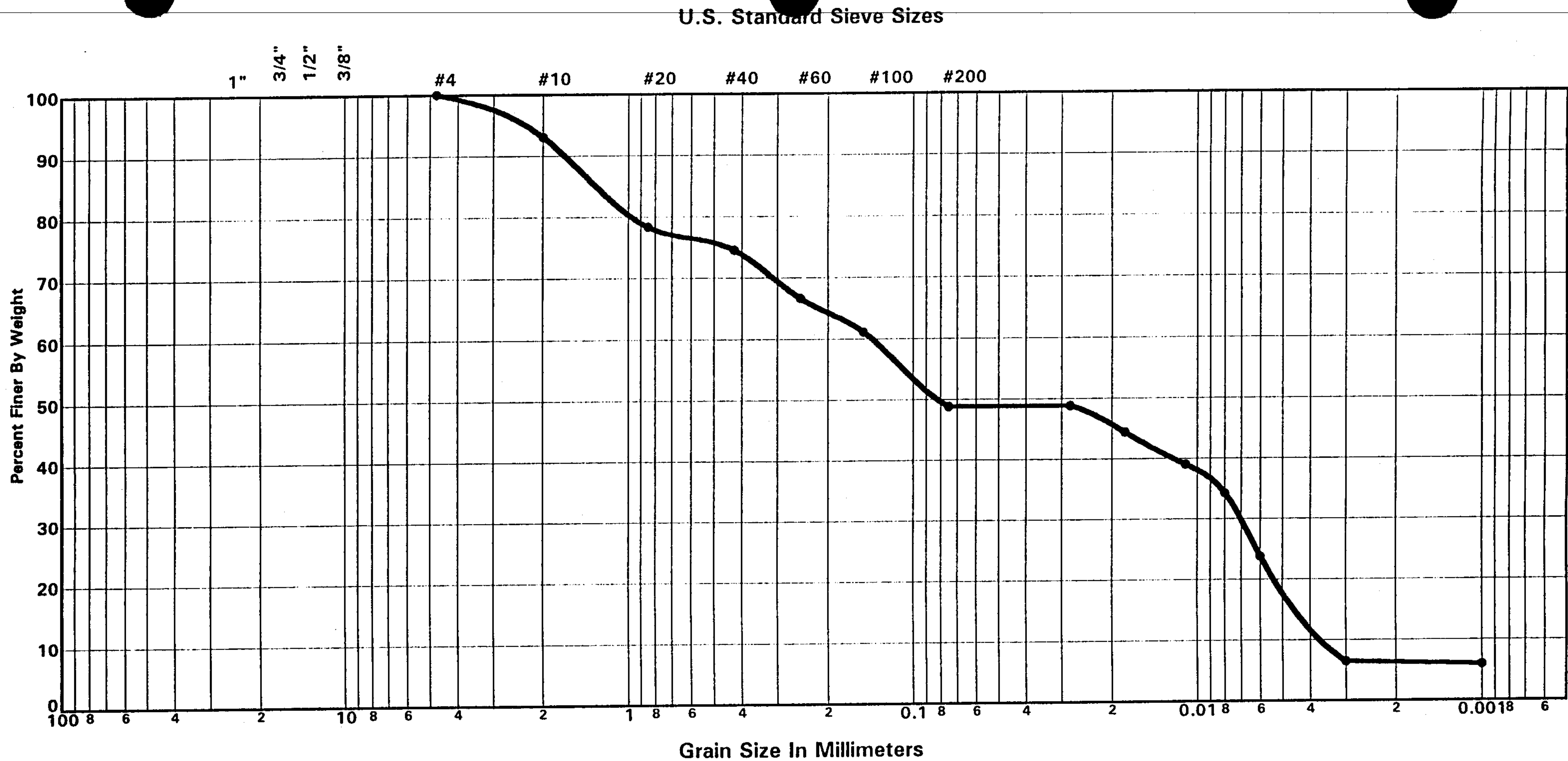
Halifax-5
Halifax, North Carolina

Job No.: 1-95-1181-CB

Date: 4/16/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.



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

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

Project:

Halifax-5
Halifax, North Carolina

Job No.: 1-95-1181-CB

Date: 4/16/96

GRAIN SIZE DISTRIBUTION

GeoTechnologies, Inc.

Appendix F

G. N. Richardson and Associates

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

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

Where:		
	Lw = Height of Water Column in Well =	12.63
	Le = Screened Interval Open to Aquifer =	12.63
	Rw = Radius of Well Including Sand Pack	0.167
	Rc = Radius of Well Casing =	0.083
	H = Aquifer Thickness to First Aquitard =	22
	Yo = Relative Height of Water at Time Zer	0.67
	Yt = Relative Height of Water at Time t =	0.15
	n = Porosity =	0.2
	Time Tt (in minutes) =	2.5
	H - Lw =	9.37
	Yo/Yt =	4.466667
	Lw/Rw =	75.62874
	ln(H-Lw)/Rw =	4.027275

Correction for Sandpack:

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

Req = 0.013845

Req = 0.117663

Evaluation of A and B:

Le/Rw = 75.62874

From Attached Graph of A and B:

A =	3.6
B =	0.6

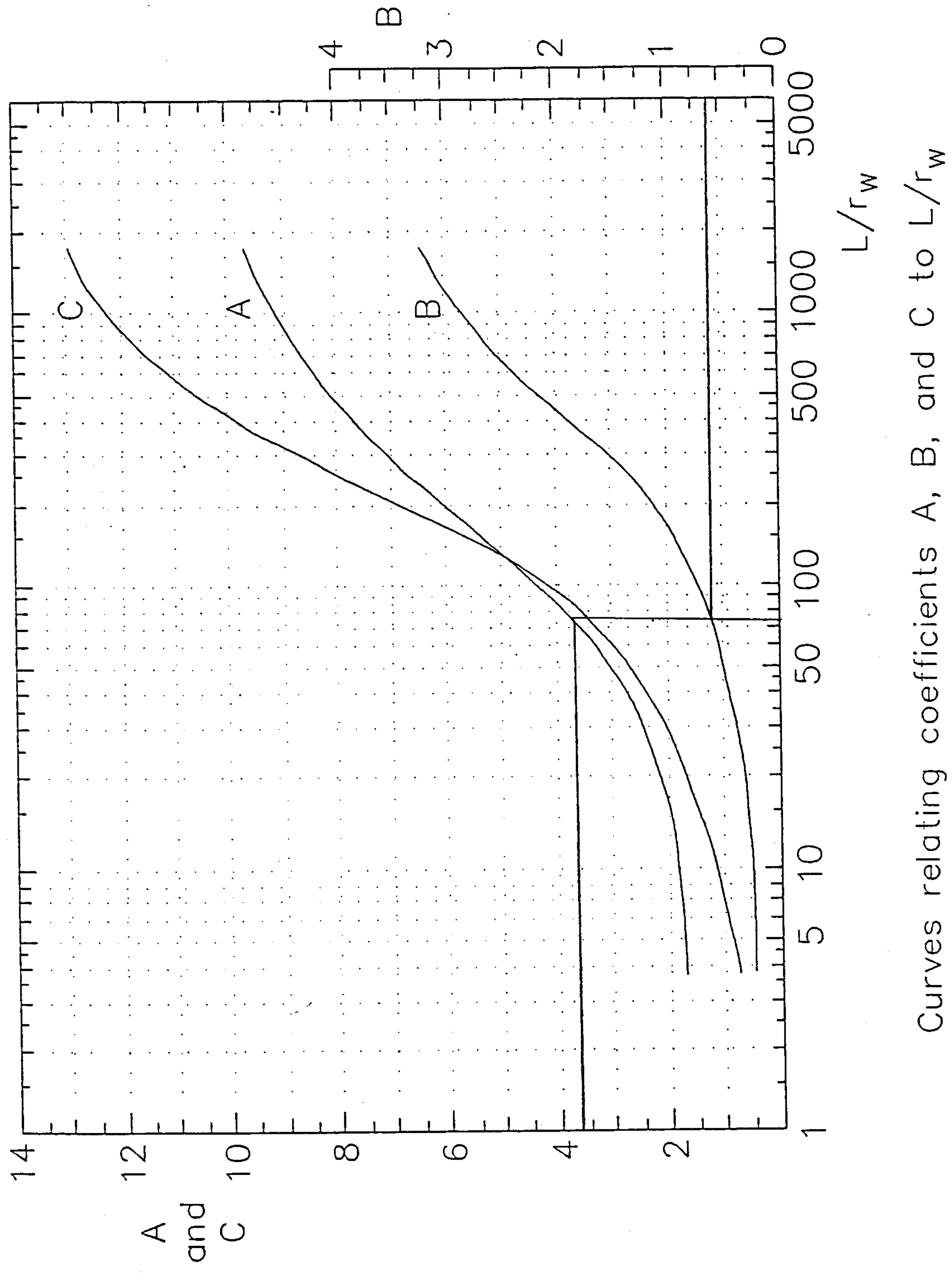
ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-

ln Re/Rw= 3.987331 exp-1

ln Re/Rw= 0.250794

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

K =	0.000222 Ft/Min	or	0.000113 CM/Sec	
K =	0.319069 Ft/Day			



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

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

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

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County
GY-3 15' screened section

G. N. Richardson and Associates

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

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

Where:

Lw = Height of Water Column in Well =	12.63
Le = Screened Interval Open to Aquifer =	10
Rw = Radius of Well Including Sand Pack	0.167
Rc = Radius of Well Casing =	0.083
H = Aquifer Thickness to First Aquitard =	22
Yo = Relative Height of Water at Time Zer	0.67
Yt = Relative Height of Water at Time t =	0.15
n = Porosity =	0.2
Time Tt (in minutes) =	2.5
H - Lw =	9.37
Yo/Yt =	4.466667
Lw/Rw =	75.62874
ln(H-Lw)/Rw =	4.027275

Correction for Sandpack:

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

Req = 0.013845

Req = 0.117663

Evaluation of A and B:

Le/Rw = 59.88024

From Attached Graph of A and B:

A =	2.65
B =	0.4

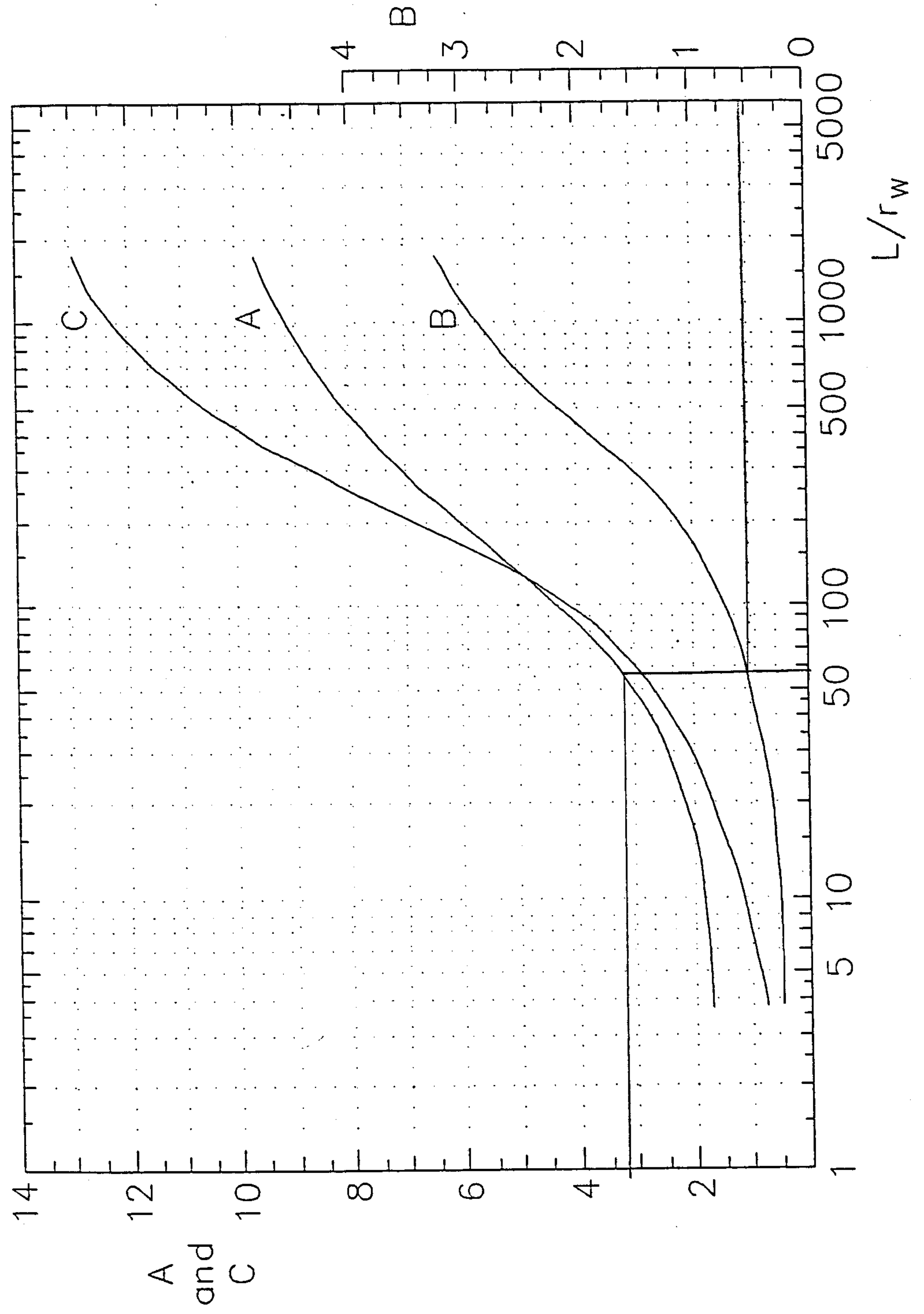
ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-

ln Re/Rw= 3.011277 exp-1

ln Re/Rw= 0.332085

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

K =	0.000371	Ft/Min	or	0.000188	CM/Sec
K =	0.533604	Ft/Day			



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

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

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

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County
GY-3 10' Screen

G. N. Richardson and Associates

Client: Halifax County
Project: Halifax County Landfill

Proj. No. Halifax-4
Sheet: 1/1
Date: 5/97
Well: GY-3
Reference: Bouwer, 1989

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

Where:

Lw = Height of Water Column in Well =	12.63
Le = Screened Interval Open to Aquifer =	5
Rw = Radius of Well Including Sand Pack	0.167
Rc = Radius of Well Casing =	0.083
H = Aquifer Thickness to First Aquitard =	22
Yo = Relative Height of Water at Time Zer	0.67
Yt = Relative Height of Water at Time t =	0.15
n = Porosity =	0.2
Time Tt (in minutes) =	2.5
H - Lw =	9.37
Yo/Yt =	4.46666667
Lw/Rw =	75.6287425
ln(H-Lw)/Rw =	4.02727456

Correction for Sandpack:

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

Req = 0.013845
Req = 0.117663

Evaluation of A and B:

Le/Rw = 29.94012

From Attached Graph of A and B:

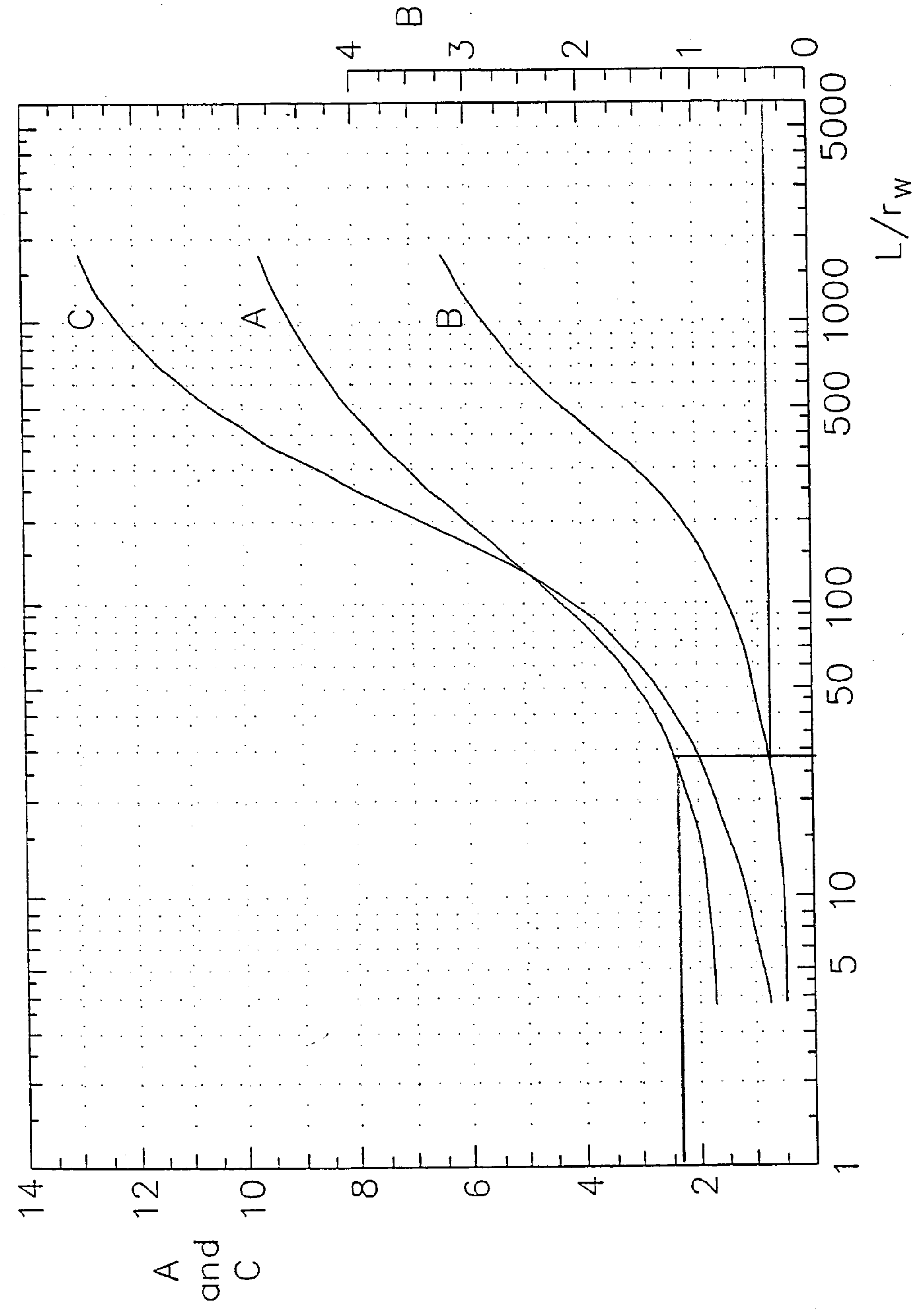
A = 2.65
B = 0.4

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

ln Re/Rw= 3.011277 exp-1
ln Re/Rw= 0.332085

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

K = 0.000741 Ft/Min or 0.000376 CM/Sec
K = 1.067208 Ft/Day

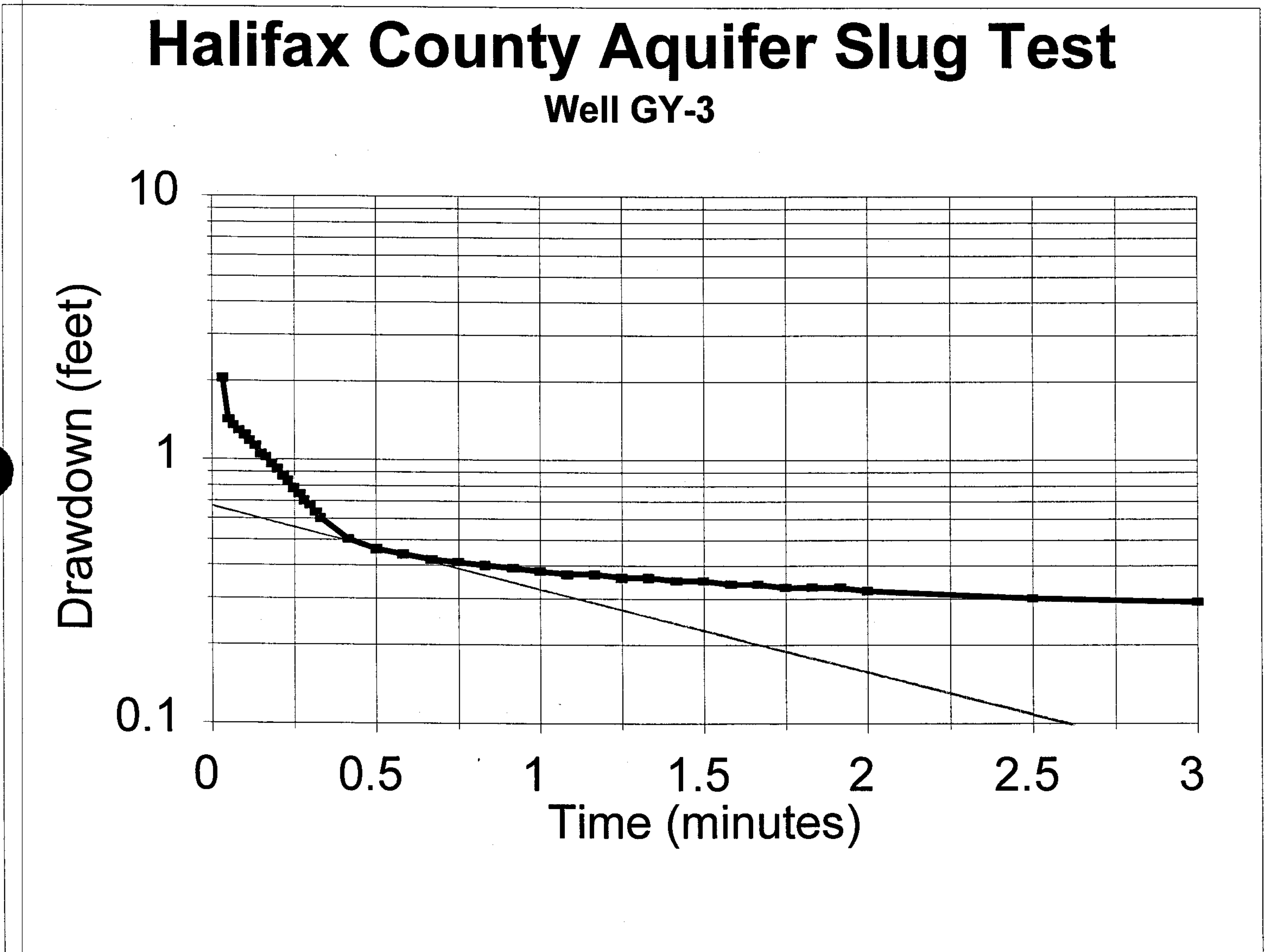


Curves relating coefficients A, B, and C to L/r_w

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

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

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County
GY-3 5' Screened Section


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

Halifax County GY-3 Slug Test

SE1000B
Environmental Logger
05/15 20:52

Unit# 00799 Test# 4

INPUT 1: Level (M) TOC

Reference 36.38
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 14:26

Elapsed Time	Value
0.0000	36.33
0.0033	36.35
0.0066	37.05
0.0099	38.12
0.0133	38.05
0.0166	38.40
0.0200	38.24
0.0233	38.87
0.0266	38.56
0.0300	37.44
0.0333	38.42
0.0500	37.80
0.0666	37.73
0.0833	37.67
0.1000	37.62
0.1166	37.56
0.1333	37.51
0.1500	37.43
0.1666	37.40
0.1833	37.34
0.2000	37.30
0.2166	37.25
0.2333	37.21
0.2500	37.16
0.2666	37.12

0.2833	37.08
0.3000	37.05
0.3166	37.01
0.3333	36.98
0.4167	36.88
0.5000	36.84
0.5833	36.82
0.6667	36.80
0.7500	36.79
0.8333	36.78
0.9167	36.77
1.0000	36.76
1.0833	36.75
1.1667	36.75
1.2500	36.74
1.3333	36.74
1.4166	36.73
1.5000	36.73
1.5833	36.72
1.6667	36.72
1.7500	36.71
1.8333	36.71
1.9167	36.71
2.0000	36.70
2.5000	36.68
3.0000	36.67
3.5000	36.65
4.0000	36.64
4.5000	36.63
5.0000	36.61
5.5000	36.61
6.0000	36.60
6.5000	36.59
7.0000	36.58
7.5000	36.58
8.0000	36.57
8.5000	36.56
9.0000	36.55
9.5000	36.54
10.0000	36.52
12.0000	36.50
14.0000	36.49

16.0000	36.48
18.0000	36.47
20.0000	36.46
22.0000	36.46
24.0000	36.45
26.0000	36.44
28.0000	36.43
30.0000	36.43
32.0000	36.43

G. N. Richardson and Associates

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

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

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

Correction for Sandpack:

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

Req = 0.013845

Req = 0.117663

Evaluation of A and B:

Le/Rw = 35.08982

From Attached Graph of A and B:

A =	2.65
B =	0.4

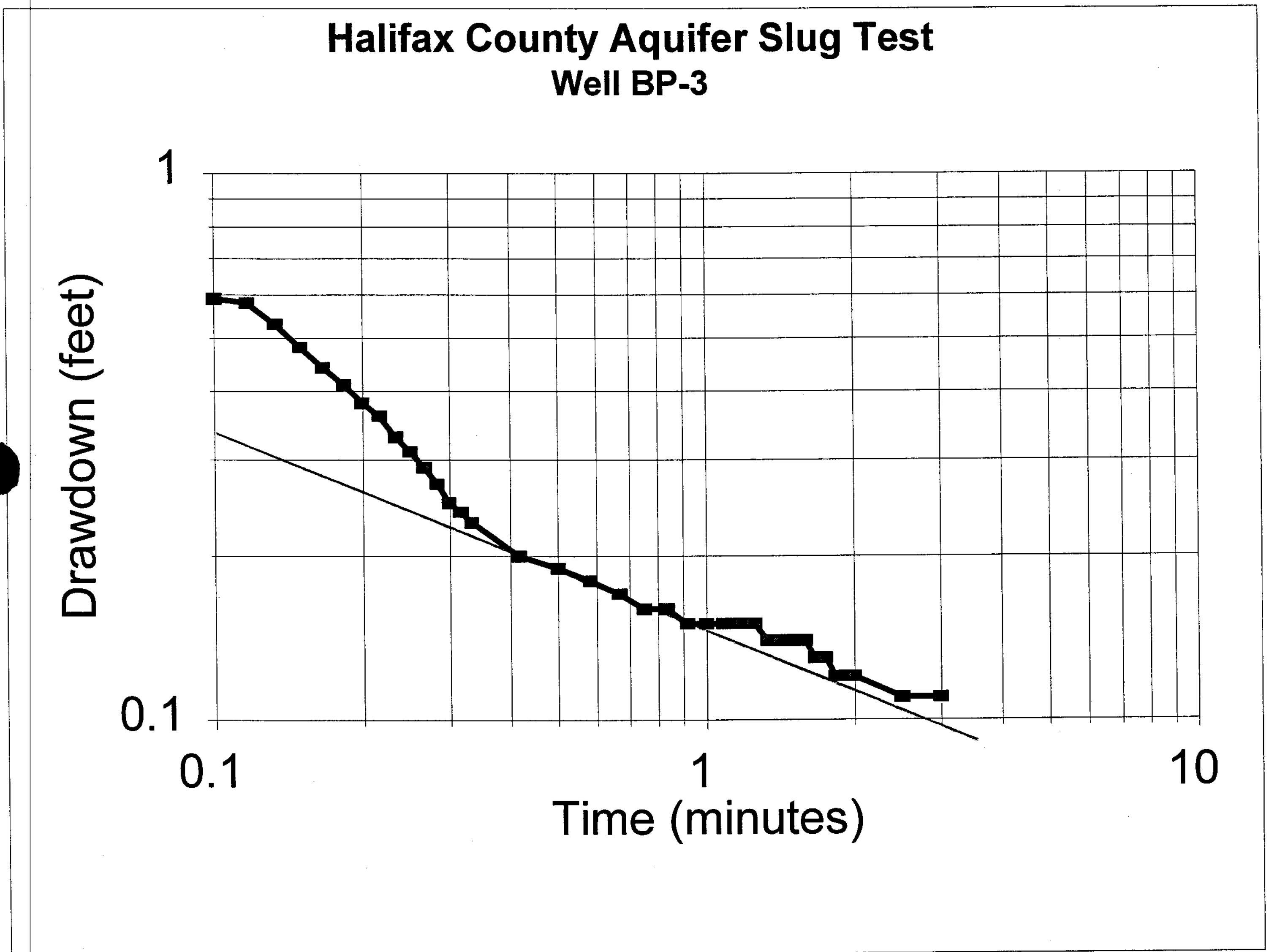
ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-

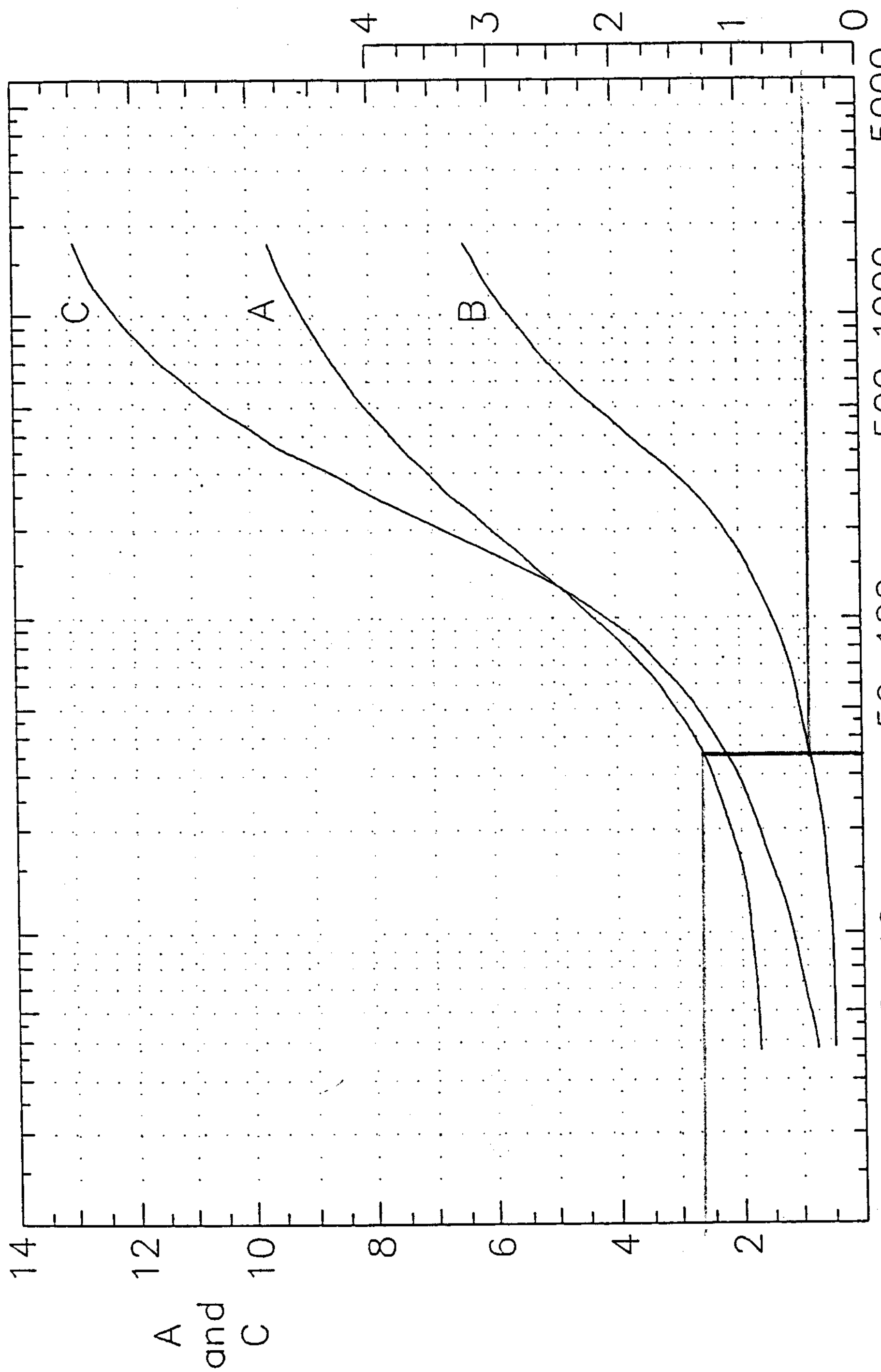
ln Re/Rw= 3.011277 exp-1

ln Re/Rw= 0.332085

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

K =	0.000204 Ft/Min	or	0.000104	CM/Sec
K =	0.294154 Ft/Day			


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



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

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

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919-828-0577

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

Halifax County BP-3 Slug Test

SE1000B
Environmental Logger
05/16 14:09

Unit# 00799 Test# 0

INPUT 1: Level (M) TOC

Reference 43.34
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 07:40

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

Halifax BP-3 Slug Test Page 2

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

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

G. N. Richardson and Associates

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

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

Where:	Lw = Height of Water Column in Well =	14.03
	Le = Screened Interval Open to Aquifer =	10
	Rw = Radius of Well Including Sand Pack	0.167
	Rc = Radius of Well Casing =	0.083
	H = Aquifer Thickness to First Aquitard =	40
	Yo = Relative Height of Water at Time Zer	0.81
	Yt = Relative Height of Water at Time t =	0.62
	n = Porosity =	0.2
	Time Tt (in minutes) =	2.5
	H - Lw =	25.97
	Yo/Yt =	1.306452
	Lw/Rw =	84.01198
	ln(H-Lw)/Rw =	5.046703

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 59.88024

From Attached Graph of A and B:

A = 3.2

B = 0.5

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

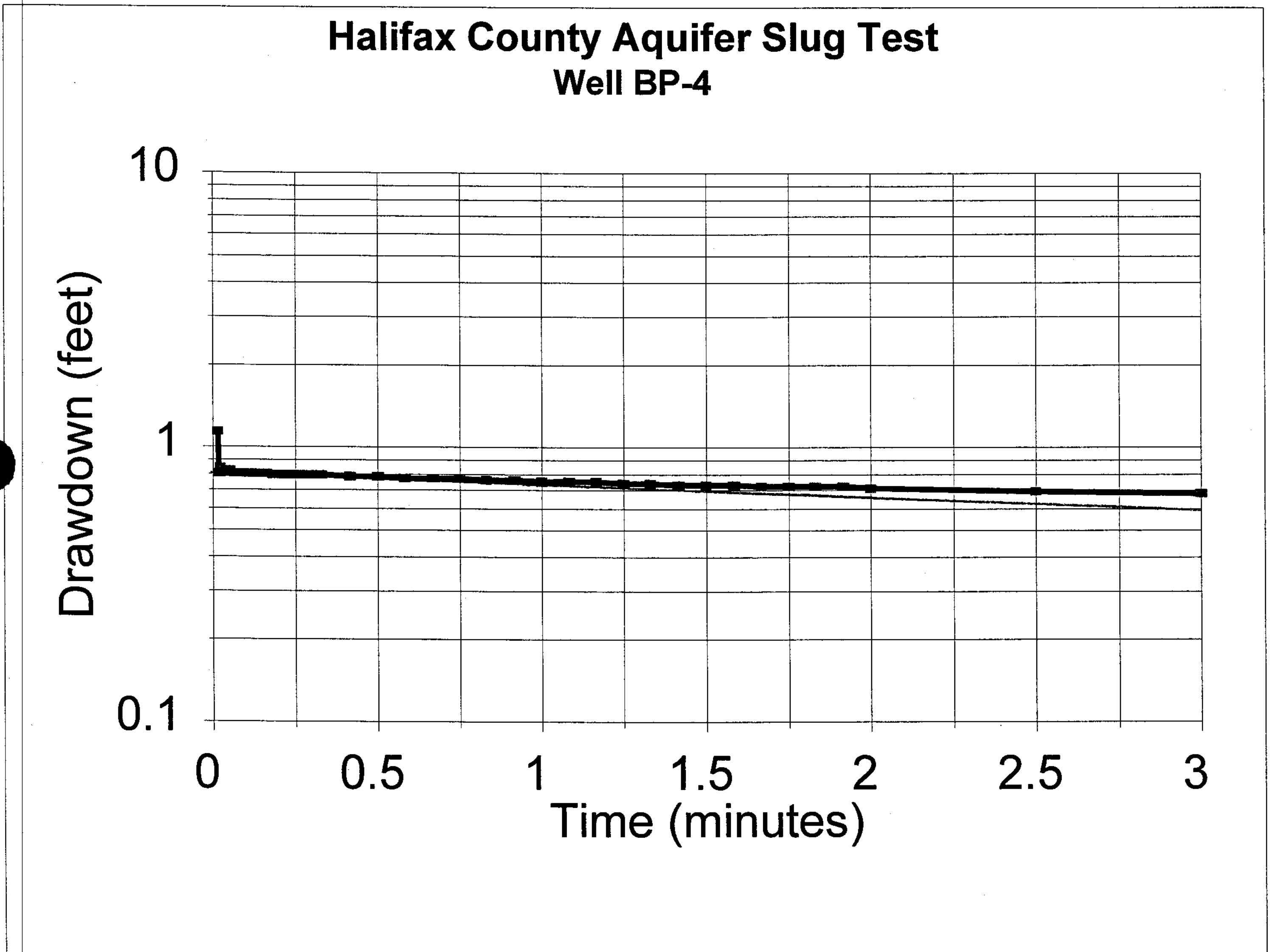
ln Re/Rw= 3.490393 exp-1

ln Re/Rw= 0.286501

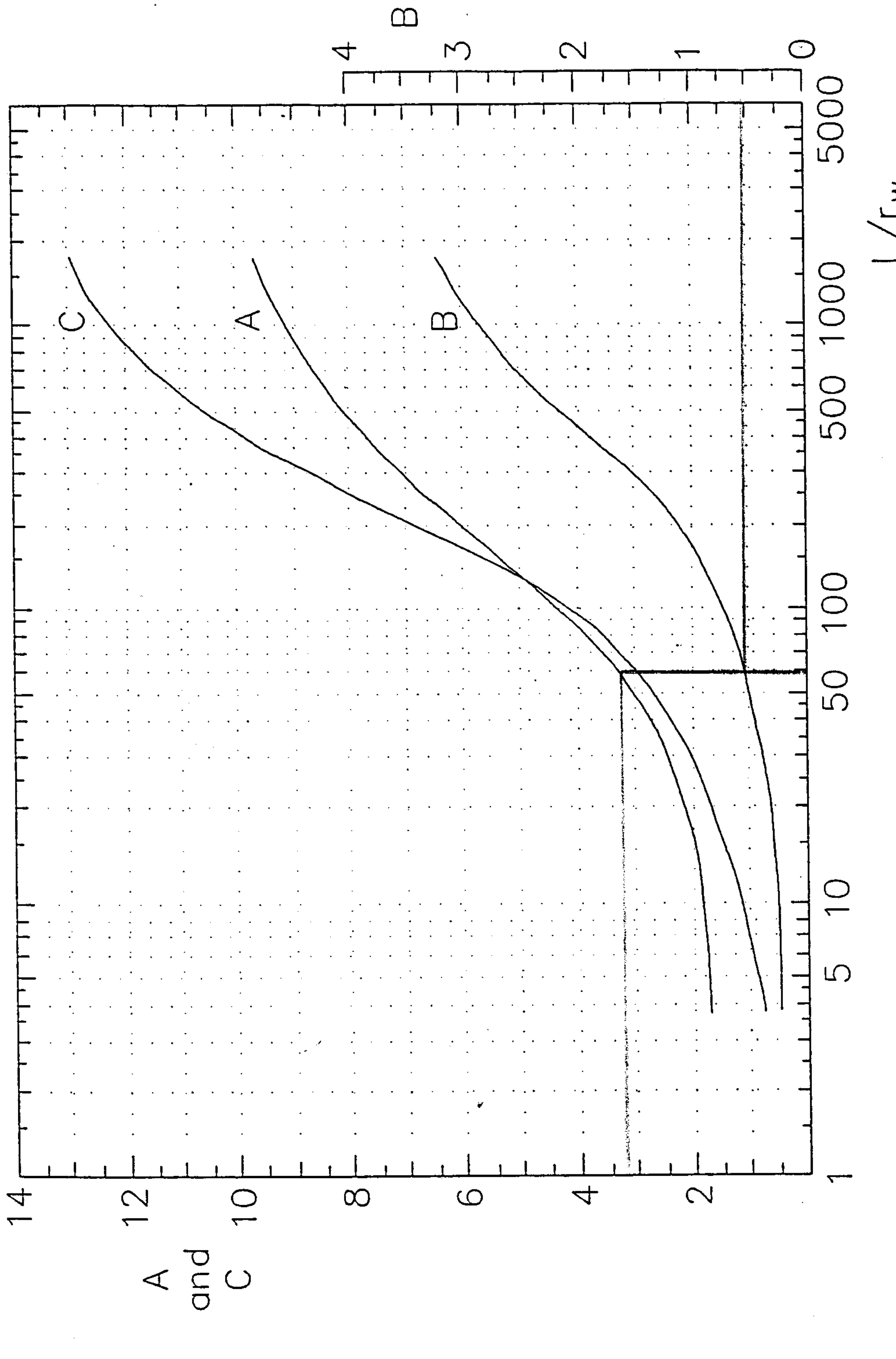
K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le

K = 0.001532 Ft/Min or 0.000778 CM/Sec

K = 2.205673 Ft/Day



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



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

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

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

Halifax County BP-4 Slug Test

SE1000B
Environmental Logger
05/15 20:51

Unit# 00799 Test# 3

INPUT 1: Level (M) TOC

Reference 35.93
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 13:16

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

Halifax County BP-4 Slug Test Page 2

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

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

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-6
		Referenc	Bouwer, 1989

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

Where:		
	Lw = Height of Water Column in Well =	13.6
	Le = Screened Interval Open to Aquifer =	10
	Rw = Radius of Well Including Sand Pack	0.167
	Rc = Radius of Well Casing =	0.083
	H = Aquifer Thickness to First Aquitard =	40
	Yo = Relative Height of Water at Time Zer	1
	Yt = Relative Height of Water at Time t =	0.2
	n = Porosity =	0.2
	Time Tt (in minutes) =	2.75
	H - Lw =	26.4
	Yo/Yt =	5
	Lw/Rw =	81.43713
	ln(H-Lw)/Rw =	5.063125

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 59.88024

From Attached Graph of A and B:

A =	3.6
B =	0.6

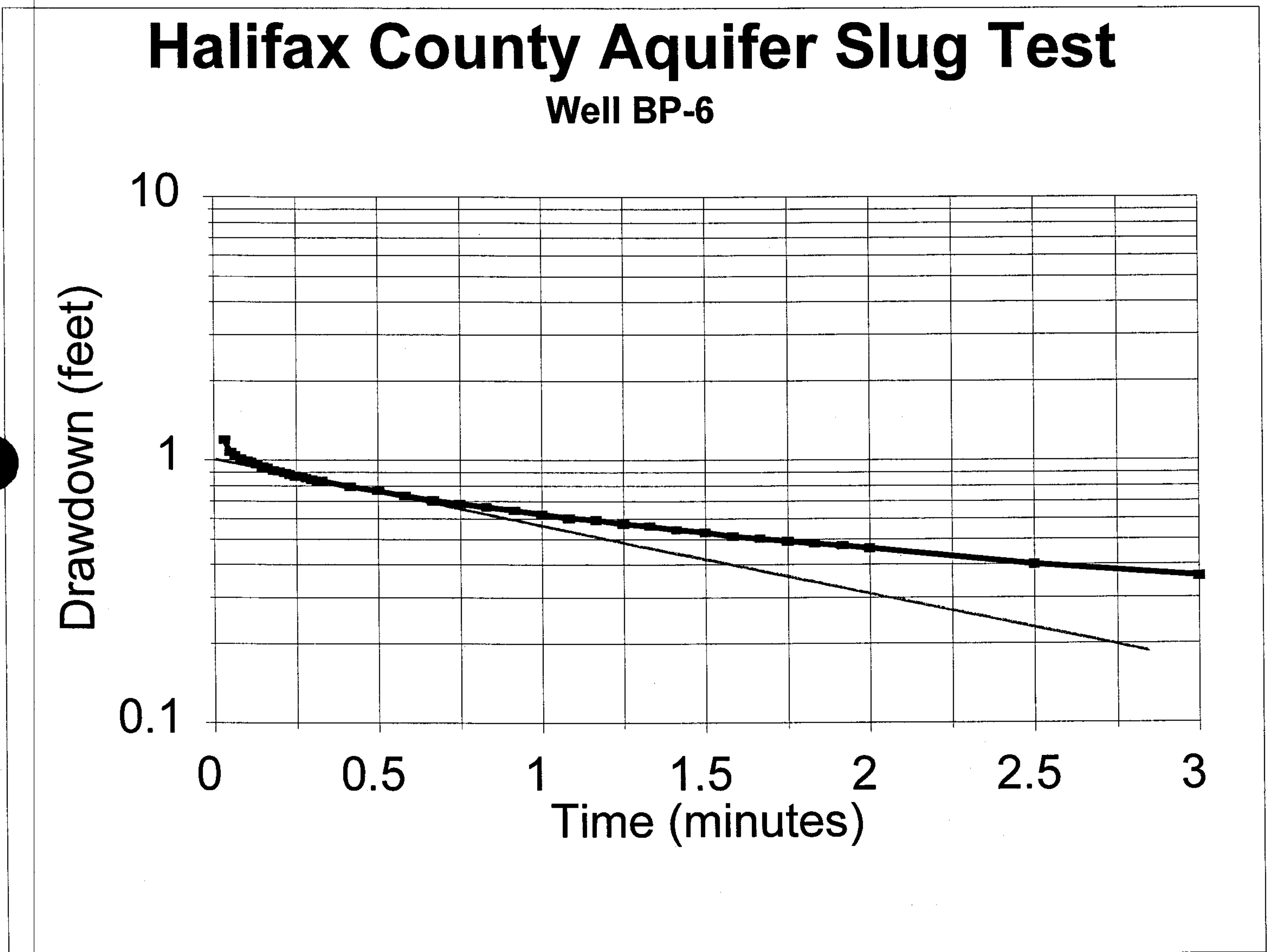
ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-

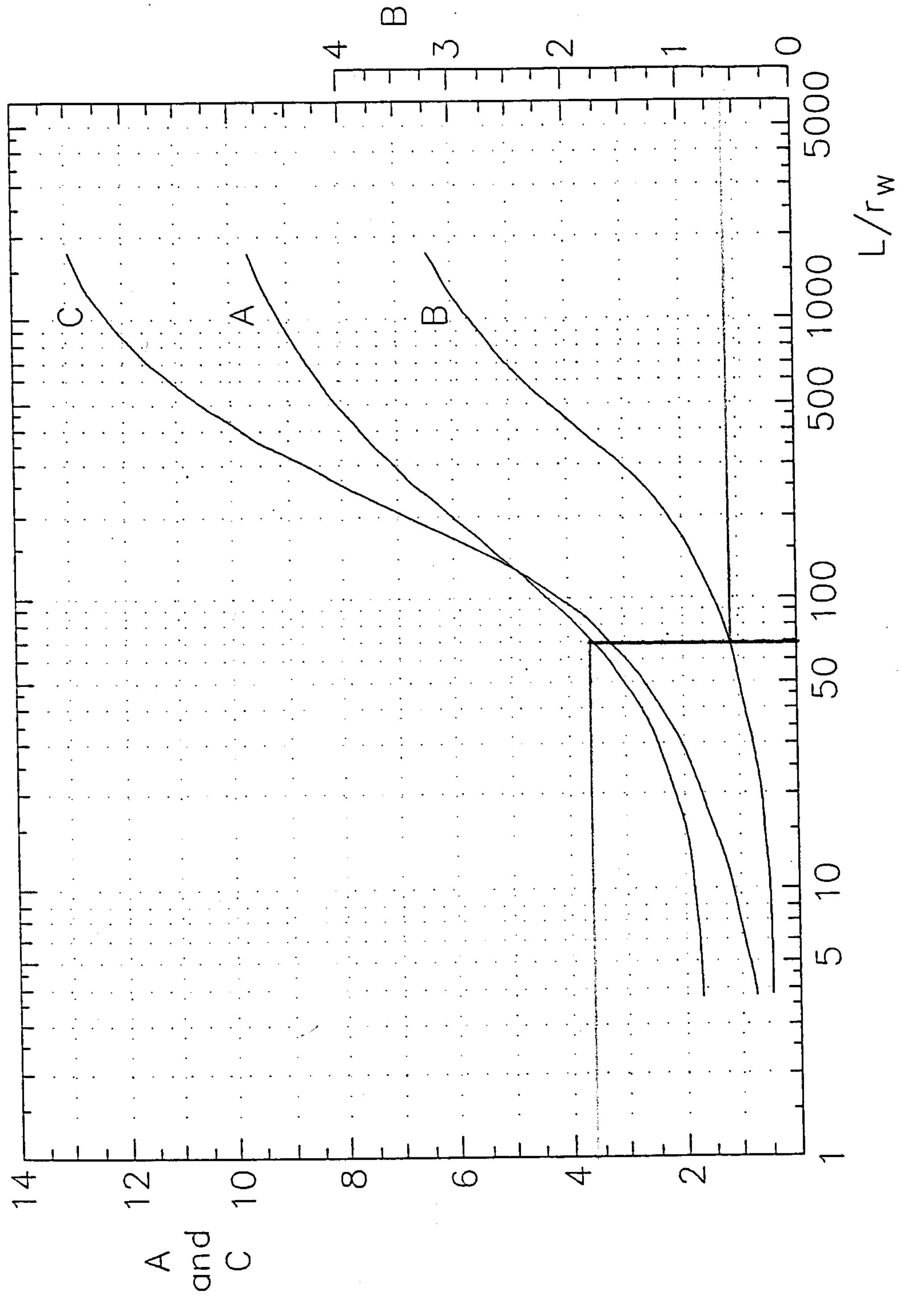
ln Re/Rw= 3.900742 exp-1

ln Re/Rw= 0.256361

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

K =	0.007502	Ft/Min	or	0.003811	CM/Sec
K =	10.80256	Ft/Day			


Halifax County Aquifer Slug Test
Well BP-6
10
1
0.1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)



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

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

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COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-7b

Halifax County BP-6 Slug Test

SE1000B
Environmental Logger
05/16 14:11

Unit# 00799 Test# 1

INPUT 1: Level (M) TOC

Reference 14.47
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 08:35

Elapsed Time	Value
0.0000	14.37
0.0033	14.61
0.0066	16.52
0.0099	16.46
0.0133	16.18
0.0166	15.75
0.0200	15.59
0.0233	16.38
0.0266	15.43
0.0300	15.62
0.0333	15.66
0.0500	15.54
0.0666	15.51
0.0833	15.48
0.1000	15.46
0.1166	15.45
0.1333	15.43
0.1500	15.41
0.1666	15.40
0.1833	15.38
0.2000	15.37
0.2166	15.36
0.2333	15.35
0.2500	15.34
0.2666	15.33

Halifax County BP-6 Slug Test

0.2833	15.32
0.3000	15.31
0.3166	15.30
0.3333	15.30
0.4167	15.26
0.5000	15.23
0.5833	15.20
0.6667	15.17
0.7500	15.15
0.8333	15.13
0.9167	15.11
1.0000	15.09
1.0833	15.07
1.1667	15.06
1.2500	15.04
1.3333	15.03
1.4166	15.01
1.5000	15.00
1.5833	14.98
1.6667	14.97
1.7500	14.96
1.8333	14.95
1.9167	14.94
2.0000	14.93
2.5000	14.87
3.0000	14.83
3.5000	14.79
4.0000	14.76
4.5000	14.73
5.0000	14.71
5.5000	14.69
6.0000	14.67
6.5000	14.65
7.0000	14.64
7.5000	14.63
8.0000	14.62
8.5000	14.61
9.0000	14.60
9.5000	14.59
10.0000	14.58
12.0000	14.56
14.0000	14.55
16.0000	14.53

18.0000	14.52
20.0000	14.52
22.0000	14.51
24.0000	14.52
26.0000	14.52
28.0000	14.52
30.0000	14.52
32.0000	14.51
34.0000	14.51
36.0000	14.51

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-7
		Reference:	Bouwer, 1989

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

Where:

Lw = Height of Water Column in Well =	19.67
Le = Screened Interval Open to Aquifer =	5
Rw = Radius of Well Including Sand Pack	0.167
Rc = Radius of Well Casing =	0.083
H = Aquifer Thickness to First Aquitard =	40
Yo = Relative Height of Water at Time Zer	1.51
Yt = Relative Height of Water at Time t =	0.5
n = Porosity =	0.2
Time Tt (in minutes) =	2.5
H - Lw =	20.33
Yo/Yt =	3.02
Lw/Rw =	117.784431
ln(H-Lw)/Rw =	4.80185909

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 29.94012

From Attached Graph of A and B:

A = 2.5

B = 0.35

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

ln Re/Rw= 2.786797 exp-1

ln Re/Rw= 0.358835

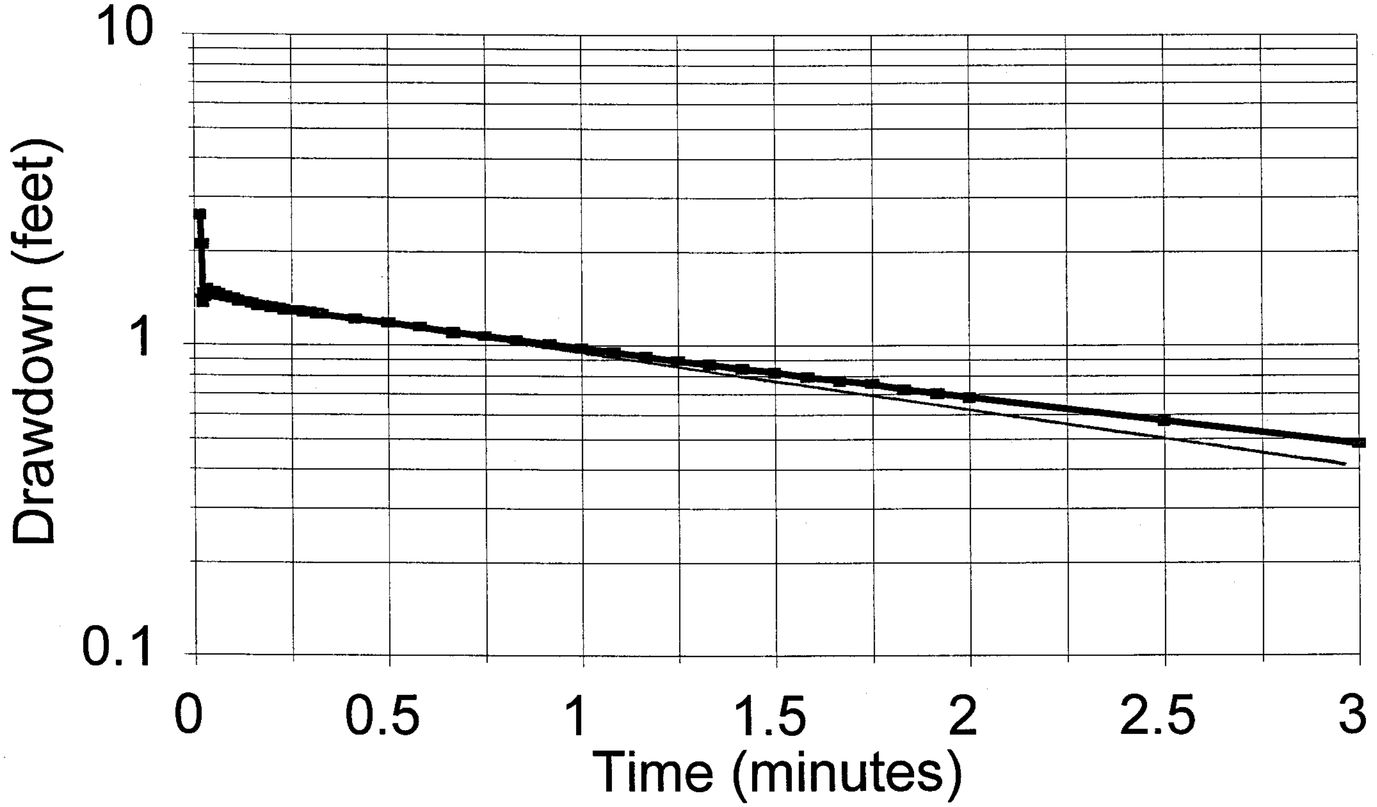
K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le

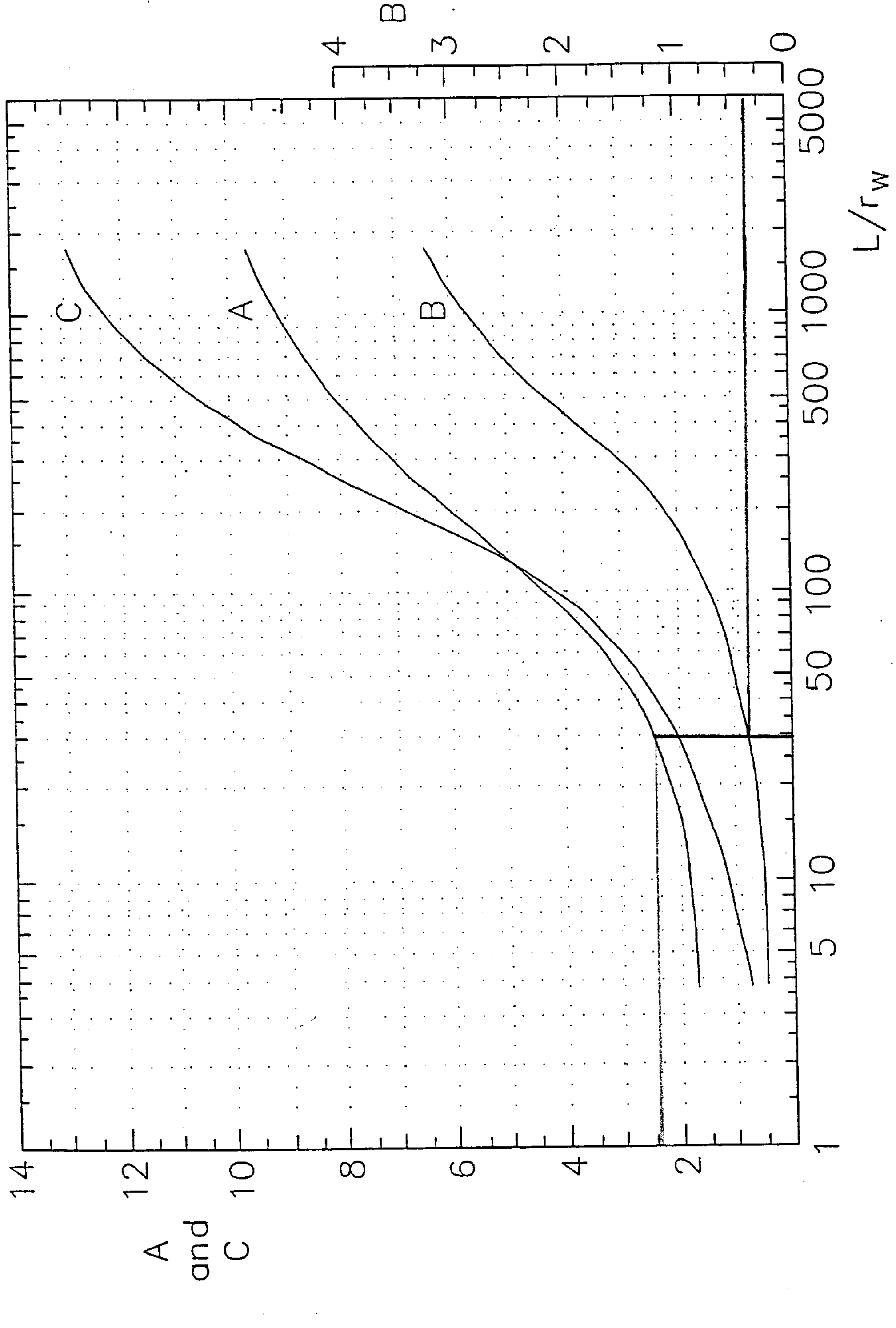
K = 0.015864 Ft/Min or 0.008059 CM/Sec

K = 22.84443 Ft/Day

Halifax County Aquifer Slug Test

Well BP-7





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

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

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919-828-0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-7

Halifax County BP-7 Slug Test

SE1000B
Environmental Logger
05/16 14:12

Unit# 00799 Test# 2

INPUT 1: Level (M) TOC

Reference 5.64
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 09:22

Elapsed Time	Value
0.0000	5.61
0.0033	5.63
0.0066	6.28
0.0099	7.86
0.0133	8.03
0.0166	7.26
0.0200	7.74
0.0233	7.00
0.0266	7.10
0.0300	7.16
0.0333	7.15
0.0500	7.12
0.0666	7.10
0.0833	7.07
0.1000	7.05
0.1166	7.03
0.1333	7.01
0.1500	7.00
0.1666	6.98
0.1833	6.97
0.2000	6.96
0.2166	6.95
0.2333	6.94
0.2500	6.93
0.2666	6.93

Halifax County BP-7 Slug Test Page 2

0.2833	6.92
0.3000	6.91
0.3166	6.90
0.3333	6.89
0.4167	6.85
0.5000	6.82
0.5833	6.78
0.6667	6.74
0.7500	6.71
0.8333	6.68
0.9167	6.65
1.0000	6.62
1.0833	6.59
1.1667	6.56
1.2500	6.53
1.3333	6.51
1.4166	6.48
1.5000	6.46
1.5833	6.43
1.6667	6.41
1.7500	6.39
1.8333	6.36
1.9167	6.34
2.0000	6.32
2.5000	6.21
3.0000	6.12
3.5000	6.04
4.0000	5.98
4.5000	5.92
5.0000	5.88
5.5000	5.84
6.0000	5.81
6.5000	5.78
7.0000	5.76
7.5000	5.74
8.0000	5.73
8.5000	5.71
9.0000	5.70
9.5000	5.69
10.0000	5.69
12.0000	5.67
14.0000	5.66

16.0000	5.65
18.0000	5.65
20.0000	5.65
22.0000	5.65
24.0000	5.65
26.0000	5.65

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-8
		Referenc	Bouwer, 1989

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

Where:		
	Lw = Height of Water Column in Well =	17.53
	Le = Screened Interval Open to Aquifer =	5
	Rw = Radius of Well Including Sand Pack	0.167
	Rc = Radius of Well Casing =	0.083
	H = Aquifer Thickness to First Aquitard =	40
	Yo = Relative Height of Water at Time Zer	1
	Yt = Relative Height of Water at Time t =	0.83
	n = Porosity =	0.2
	Time Tt (in minutes) =	3
	H - Lw =	22.47
	Yo/Yt =	1.204819
	Lw/Rw =	104.9701
	ln(H-Lw)/Rw =	4.901943

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 29.94012

From Attached Graph of A and B:

A = 2.5

B = 0.35

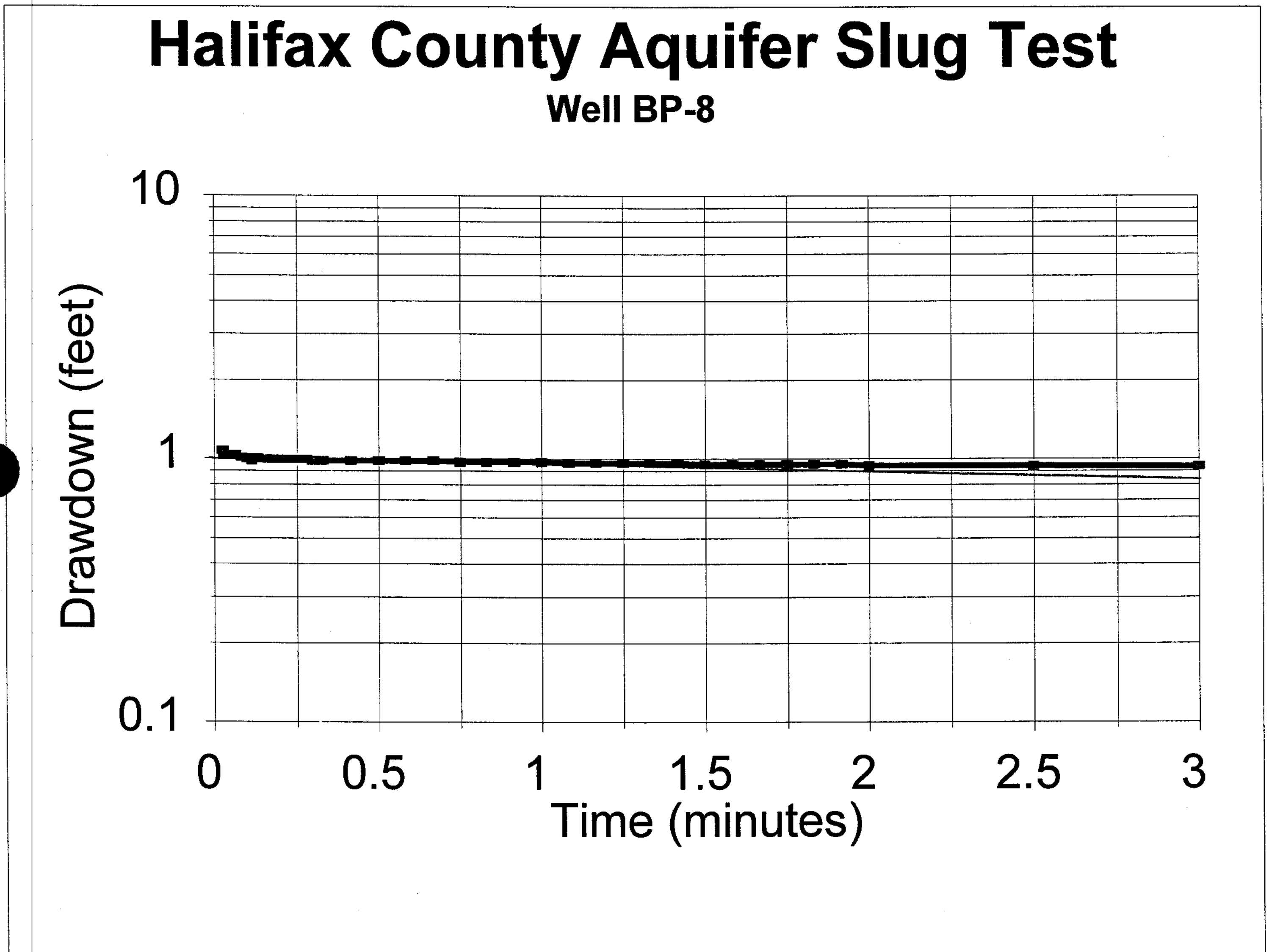
ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-

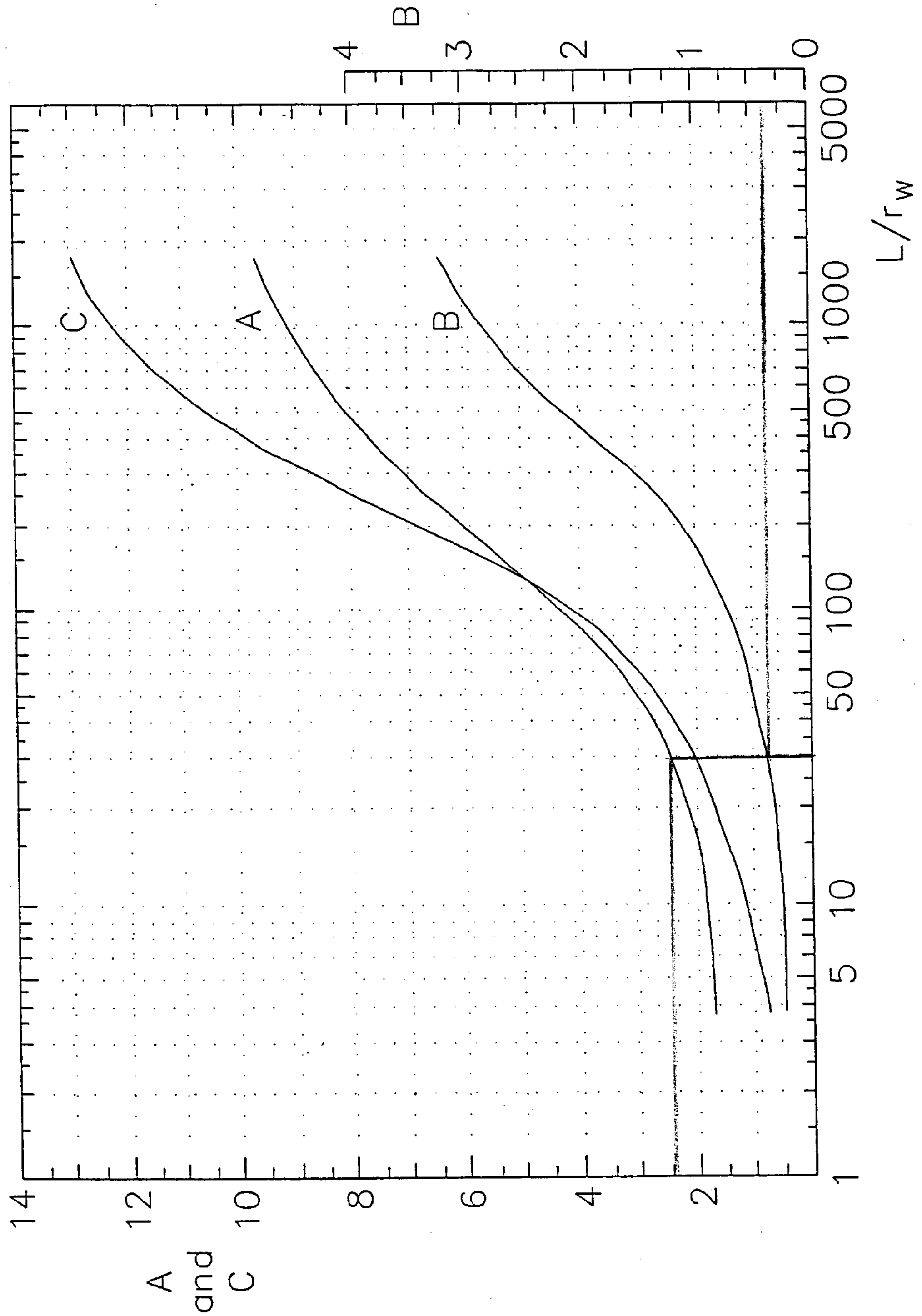
ln Re/Rw= 2.793676 exp-1

ln Re/Rw= 0.357951

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

K =	0.002223 Ft/Min	or	0.001129	CM/Sec
K =	3.201452 Ft/Day			


Halifax County Aquifer Slug Test
Well BP-8
10
1
0.1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)



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

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

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

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-8

Halifax County BP-8 Slug Test

SE1000B
Environmental Logger
05/16 14:17

Unit# 00799 Test# 4

INPUT 1: Level (M) TOC

Reference 16.68
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 12:06

Elapsed Time	Value
0.0000	16.96
0.0033	17.54
0.0066	17.94
0.0099	17.94
0.0133	17.37
0.0166	17.24
0.0200	17.86
0.0233	17.45
0.0266	17.75
0.0300	17.71
0.0333	17.71
0.0500	17.71
0.0666	17.71
0.0833	17.69
0.1000	17.68
0.1166	17.66
0.1333	17.68
0.1500	17.67
0.1666	17.67
0.1833	17.67
0.2000	17.67
0.2166	17.67
0.2333	17.67
0.2500	17.67
0.2666	17.67

Halifax County BP-8 Slug Test Page 2

0.2833	17.67
0.3000	17.66
0.3166	17.66
0.3333	17.66
0.4167	17.66
0.5000	17.66
0.5833	17.66
0.6667	17.66
0.7500	17.65
0.8333	17.65
0.9167	17.65
1.0000	17.65
1.0833	17.64
1.1667	17.64
1.2500	17.64
1.3333	17.64
1.4166	17.64
1.5000	17.63
1.5833	17.63
1.6667	17.63
1.7500	17.63
1.8333	17.63
1.9167	17.63
2.0000	17.62
2.5000	17.62
3.0000	17.61
3.5000	17.60
4.0000	17.59
4.5000	17.58
5.0000	17.57
5.5000	17.56
6.0000	17.55
6.5000	17.55
7.0000	17.54
7.5000	17.53
8.0000	17.52
8.5000	17.51
9.0000	17.50
9.5000	17.49
10.0000	17.48
12.0000	17.45
14.0000	17.42

Halifax County BP-8 Slug Test Page 3

16.0000	17.39
18.0000	17.36
20.0000	17.33
22.0000	17.30
24.0000	17.27
26.0000	17.25
28.0000	17.22
30.0000	17.20
32.0000	17.17
34.0000	17.14
36.0000	17.12
38.0000	17.10
40.0000	17.08
42.0000	17.06
44.0000	17.03
46.0000	17.01
48.0000	16.99
50.0000	16.96
52.0000	16.94
54.0000	16.93
56.0000	16.90

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-9
		Referenc	Bouwer, 1989

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

Where:	Lw = Height of Water Column in Well =	19.77
	Le = Screened Interval Open to Aquifer =	10
	Rw = Radius of Well Including Sand Pack	0.167
	Rc = Radius of Well Casing =	0.083
	H = Aquifer Thickness to First Aquitard =	40
	Yo = Relative Height of Water at Time Zer	1.55
	Yt = Relative Height of Water at Time t =	1.09
	n = Porosity =	0.2
	Time Tt (in minutes) =	2
	H - Lw =	20.23
	Yo/Yt =	1.422018
	Lw/Rw =	118.3832
	ln(H-Lw)/Rw =	4.796928

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 59.88024

From Attached Graph of A and B:

A =	3.4
B =	0.5

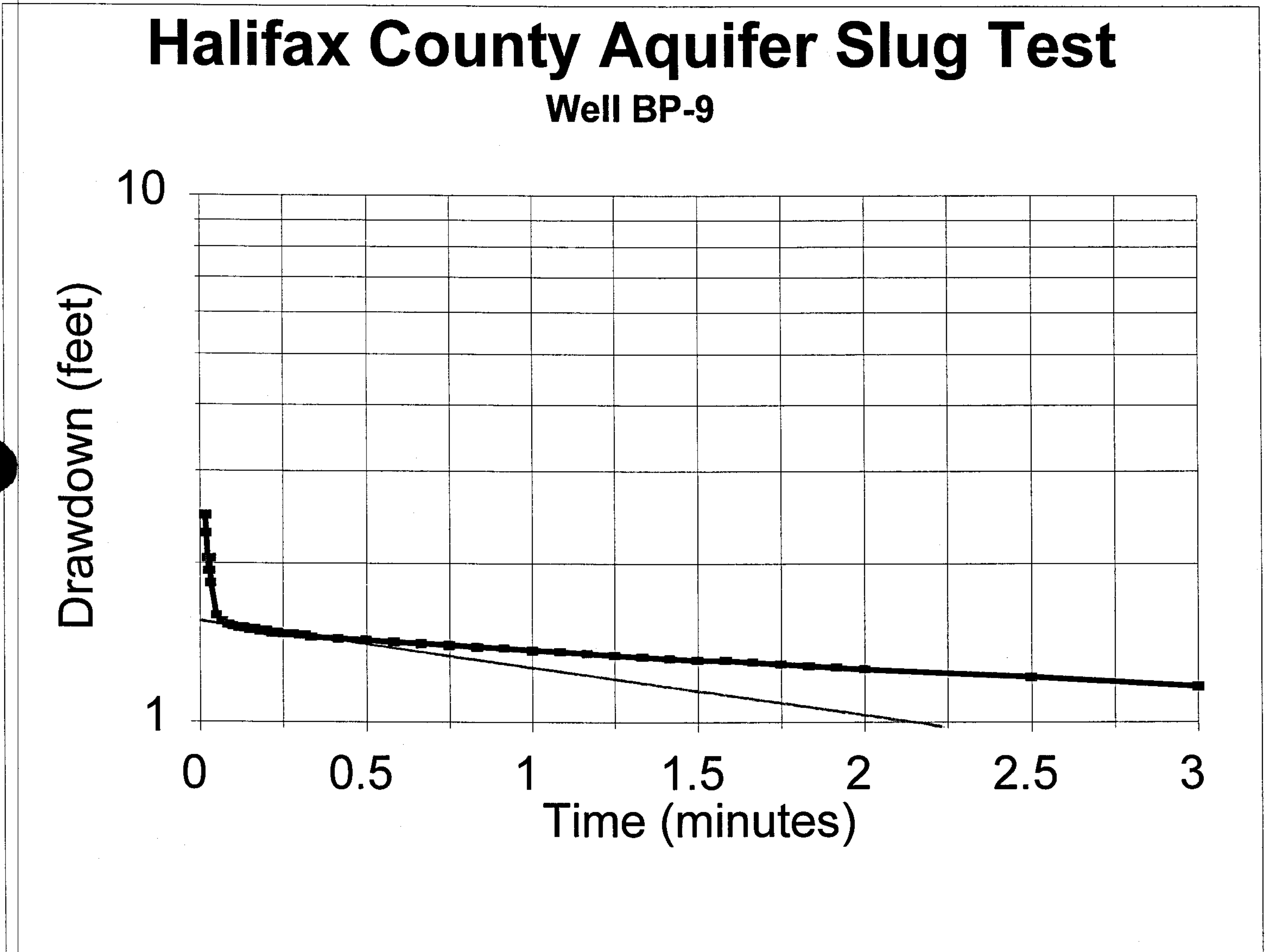
ln Re/Rw = [1.1/ln Lw/Rw + A + B ln[(H-Lw)/Rw] / Le/Rw] exp-

ln Re/Rw= 3.670473 exp-1

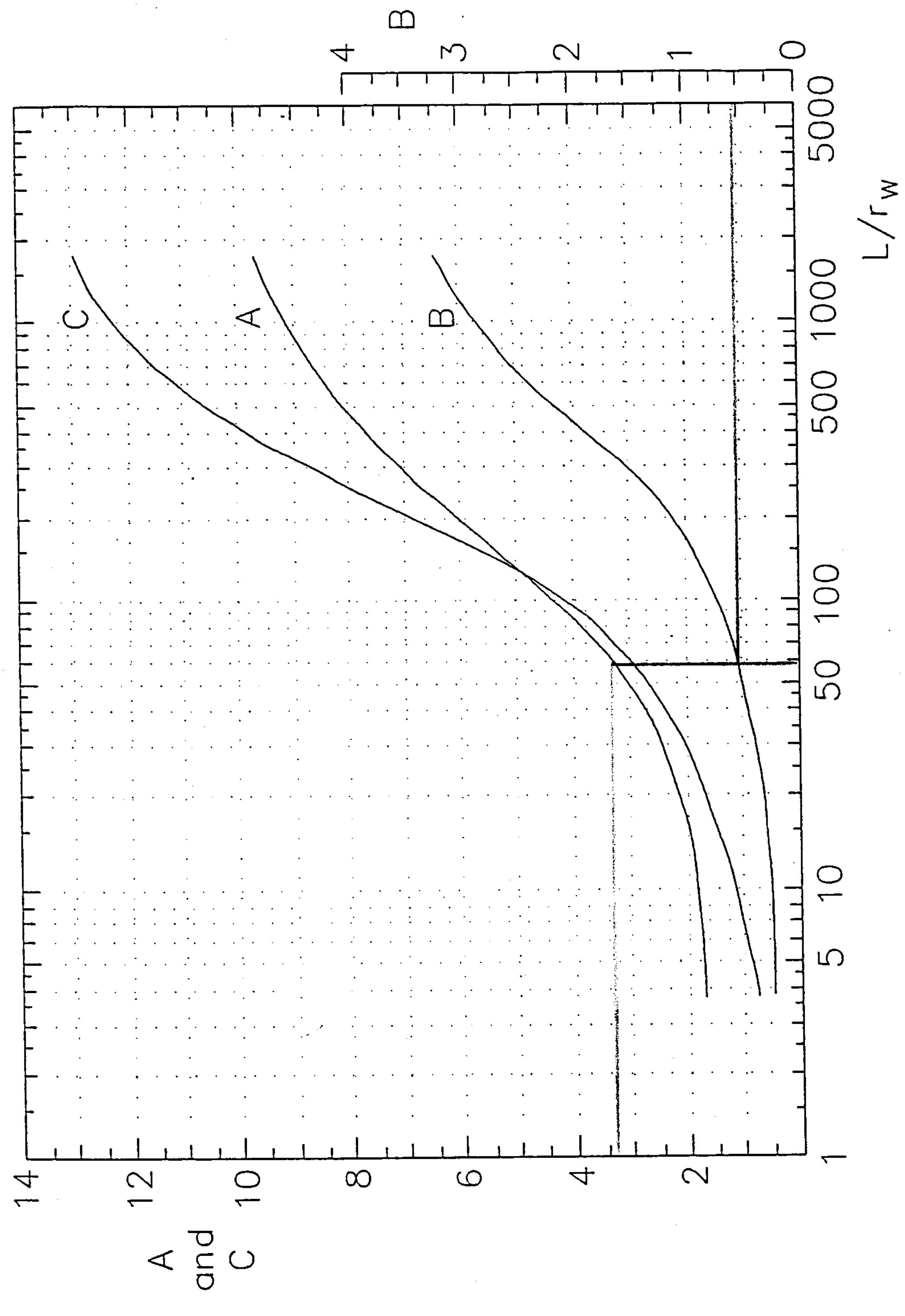
ln Re/Rw= 0.272444

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

K =	0.002398	Ft/Min	or	0.001218	CM/Sec
K =	3.453174	Ft/Day			



Halifax County Aquifer Slug Test
Well BP-9
10
1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)



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

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

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COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-9

Halifax County BP-9 Slug Test

SE1000B
Environmental Logger
05/15 20:47

Unit# 00799 Test# 1

INPUT 1: Level (M) TOC

Reference 18.98
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 11:23

Elapsed Time	Value
0.0000	18.87
0.0033	18.87
0.0066	19.06
0.0099	20.64
0.0133	21.10
0.0166	21.45
0.0200	21.26
0.0233	21.02
0.0266	20.91
0.0300	21.02
0.0333	20.81
0.0500	20.57
0.0666	20.53
0.0833	20.51
0.1000	20.50
0.1166	20.49
0.1333	20.49
0.1500	20.48
0.1666	20.48
0.1833	20.47
0.2000	20.47
0.2166	20.46
0.2333	20.46
0.2500	20.45
0.2666	20.45

Halifax County BP-9 Slug Test Page 2

0.2833	20.45
0.3000	20.44
0.3166	20.44
0.3333	20.43
0.4167	20.42
0.5000	20.41
0.5833	20.40
0.6667	20.39
0.7500	20.38
0.8333	20.37
0.9167	20.36
1.0000	20.35
1.0833	20.34
1.1667	20.33
1.2500	20.32
1.3333	20.31
1.4166	20.30
1.5000	20.29
1.5833	20.29
1.6667	20.28
1.7500	20.27
1.8333	20.26
1.9167	20.25
2.0000	20.24
2.5000	20.20
3.0000	20.15
3.5000	20.11
4.0000	20.07
4.5000	20.03
5.0000	20.00
5.5000	19.96
6.0000	19.93
6.5000	19.90
7.0000	19.87
7.5000	19.84
8.0000	19.81
8.5000	19.78
9.0000	19.75
9.5000	19.73
10.0000	19.70
12.0000	19.61
14.0000	19.53

16.0000	19.47
18.0000	19.41
20.0000	19.36
22.0000	19.31
24.0000	19.27
26.0000	19.24
28.0000	19.21
30.0000	19.18
32.0000	19.16
34.0000	19.14
36.0000	19.12
38.0000	19.10
40.0000	19.08
42.0000	19.06
44.0000	19.05
46.0000	19.03
48.0000	19.02
50.0000	19.02
52.0000	19.02
54.0000	19.01
56.0000	19.01
58.0000	19.02
60.0000	19.01
62.0000	19.01
64.0000	19.02
66.0000	19.01
68.0000	19.01
70.0000	19.01
72.0000	19.01
74.0000	19.01
76.0000	19.01
78.0000	19.00

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-10
		Referenc	Bouwer, 1989

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

Where:	Lw = Height of Water Column in Well =	11.19
	Le = Screened Interval Open to Aquifer =	5
	Rw = Radius of Well Including Sand Pack	0.167
	Rc = Radius of Well Casing =	0.083
	H = Aquifer Thickness to First Aquitard =	40
	Yo = Relative Height of Water at Time Zer	1
	Yt = Relative Height of Water at Time t =	0.7
	n = Porosity =	0.2
	Time Tt (in minutes) =	0.65
	H - Lw =	28.81
	Yo/Yt =	1.428571
	Lw/Rw =	67.00599
	ln(H-Lw)/Rw =	5.150484

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 29.94012

From Attached Graph of A and B:

A = 2.5

B = 0.4

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

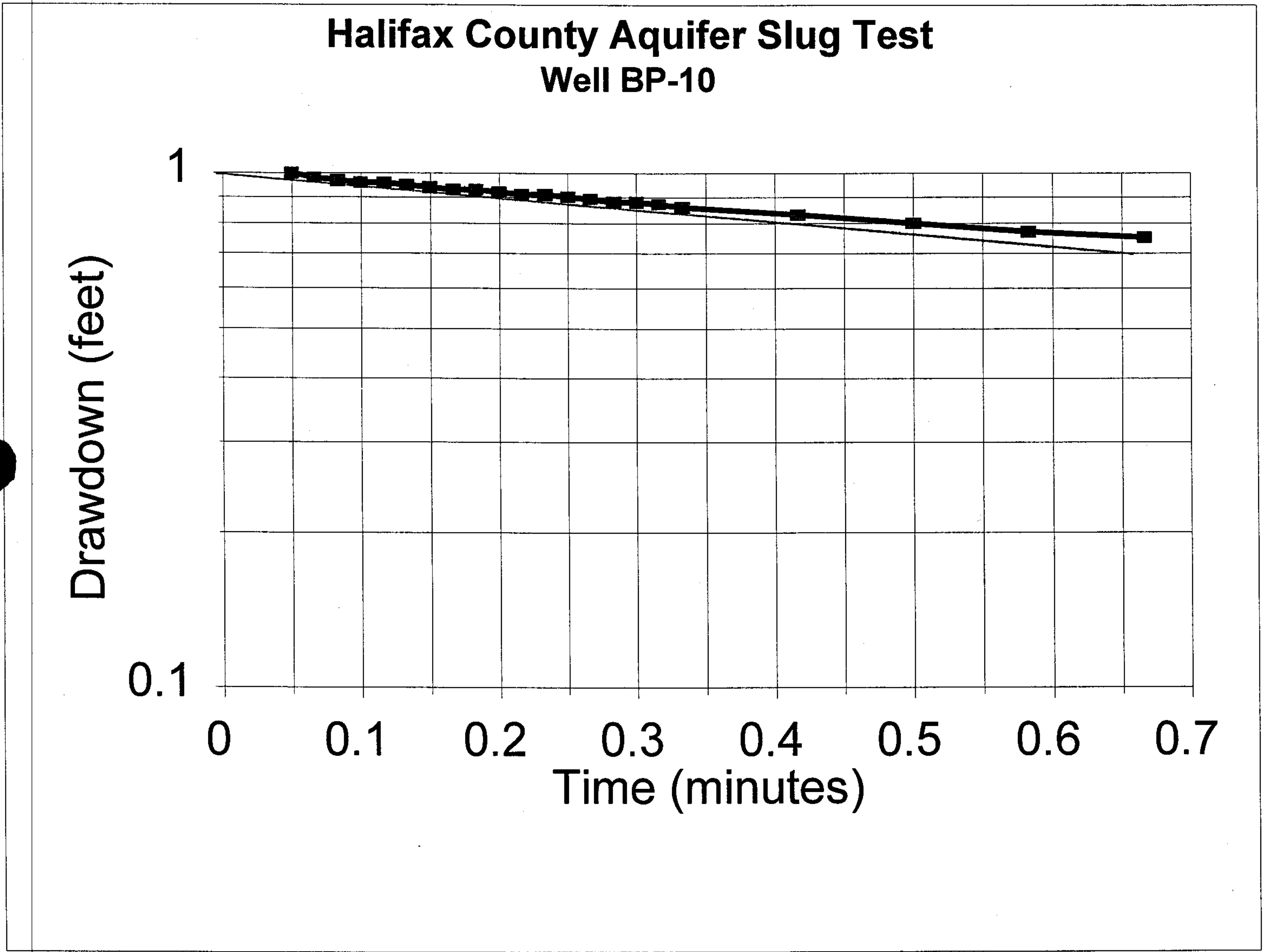
ln Re/Rw= 2.830417 exp-1

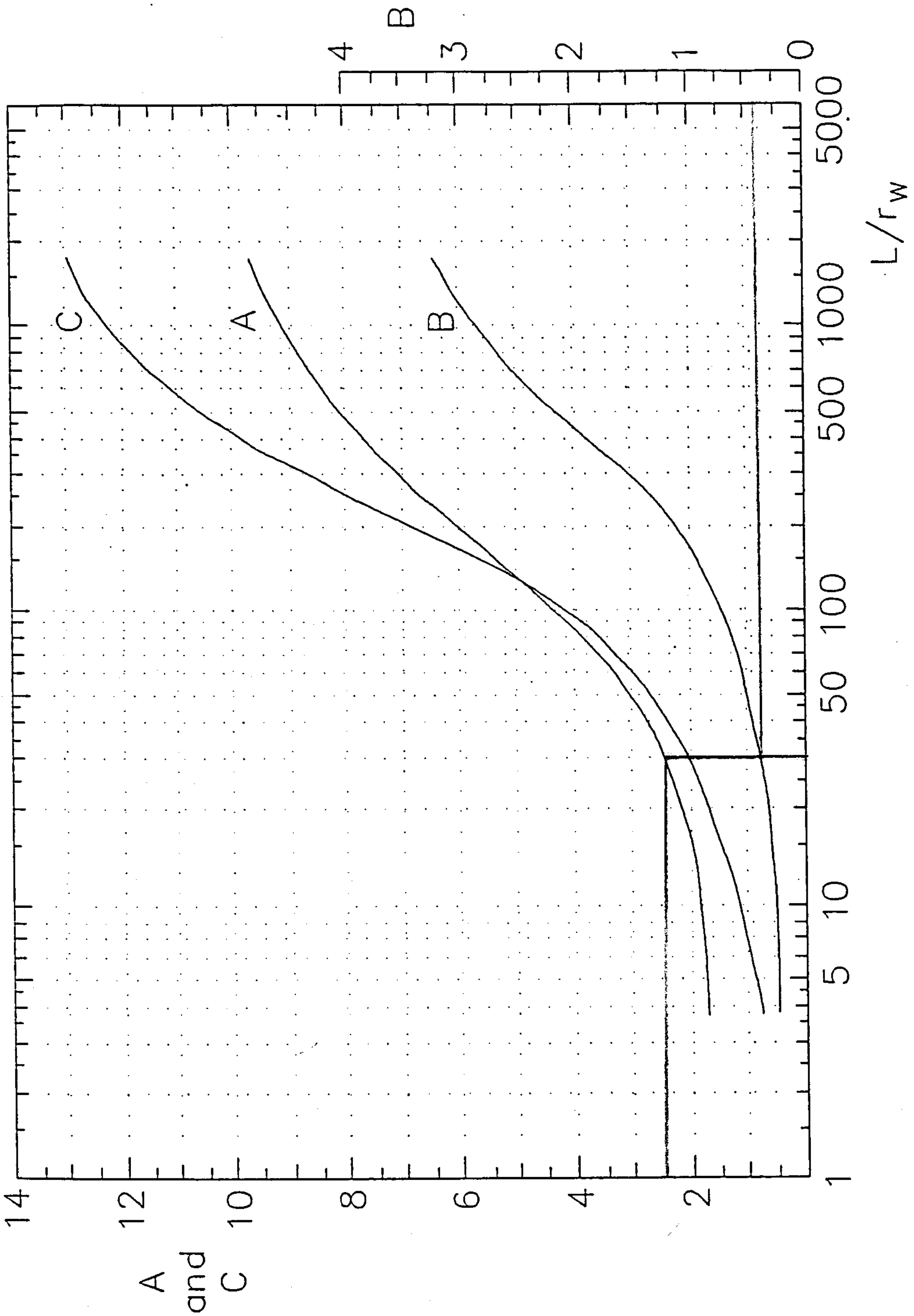
ln Re/Rw= 0.353305

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

K = 0.019387 Ft/Min or 0.009849 CM/Sec

K = 27.91716 Ft/Day


Halifax County Aquifer Slug Test
Well BP-10
1
0.1
Drawdown (feet)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
Time (minutes)



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

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919–828–0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-10

Halifax County BP-10 Slug Test

SE1000B
Environmental Logger
05/15 20:50

Unit# 00799 Test# 2

INPUT 1: Level (M) TOC

Reference 8.10
Scale factor 19.99
Offset - 0.05

Step# 0 05/15 12:49

Elapsed Time	Value
0.0000	8.04
0.0033	8.04
0.0066	8.06
0.0099	8.77
0.0133	9.75
0.0166	9.63
0.0200	9.76
0.0233	9.38
0.0266	9.53
0.0300	9.15
0.0333	9.08
0.0500	9.10
0.0666	9.08
0.0833	9.07
0.1000	9.06
0.1166	9.06
0.1333	9.05
0.1500	9.04
0.1666	9.03
0.1833	9.03
0.2000	9.02
0.2166	9.01
0.2333	9.01
0.2500	9.00
0.2666	8.99

Halifax County BP-10 Slug Test Page 2

0.2833	8.98
0.3000	8.98
0.3166	8.97
0.3333	8.96
0.4167	8.93
0.5000	8.90
0.5833	8.87
0.6667	8.85
0.7500	8.82
0.8333	8.79
0.9167	8.77
1.0000	8.75
1.0833	8.72
1.1667	8.70
1.2500	8.68
1.3333	8.66
1.4166	8.64
1.5000	8.62
1.5833	8.60
1.6667	8.58
1.7500	8.56
1.8333	8.55
1.9167	8.53
2.0000	8.51
2.5000	8.43
3.0000	8.36
3.5000	8.31
4.0000	8.26
4.5000	8.23
5.0000	8.20
5.5000	8.18
6.0000	8.17
6.5000	8.16
7.0000	8.15
7.5000	8.14
8.0000	8.14
8.5000	8.13
9.0000	8.13
9.5000	8.13
10.0000	8.13
12.0000	8.13
14.0000	8.13
16.0000	8.13

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-12
		Referenc	Bouwer, 1989

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

Where:

Lw = Height of Water Column in Well =	18.91
Le = Screened Interval Open to Aquifer =	5
Rw = Radius of Well Including Sand Pack	0.167
Rc = Radius of Well Casing =	0.083
H = Aquifer Thickness to First Aquitard =	22
Yo = Relative Height of Water at Time Zer	0.84
Yt = Relative Height of Water at Time t =	0.7
n = Porosity =	0.2
Time Tt (in minutes) =	2
H - Lw =	3.09
Yo/Yt =	1.2
Lw/Rw =	113.2335
ln(H-Lw)/Rw =	2.917933

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 29.94012

From Attached Graph of A and B:

A =	2.5
B =	0.4

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

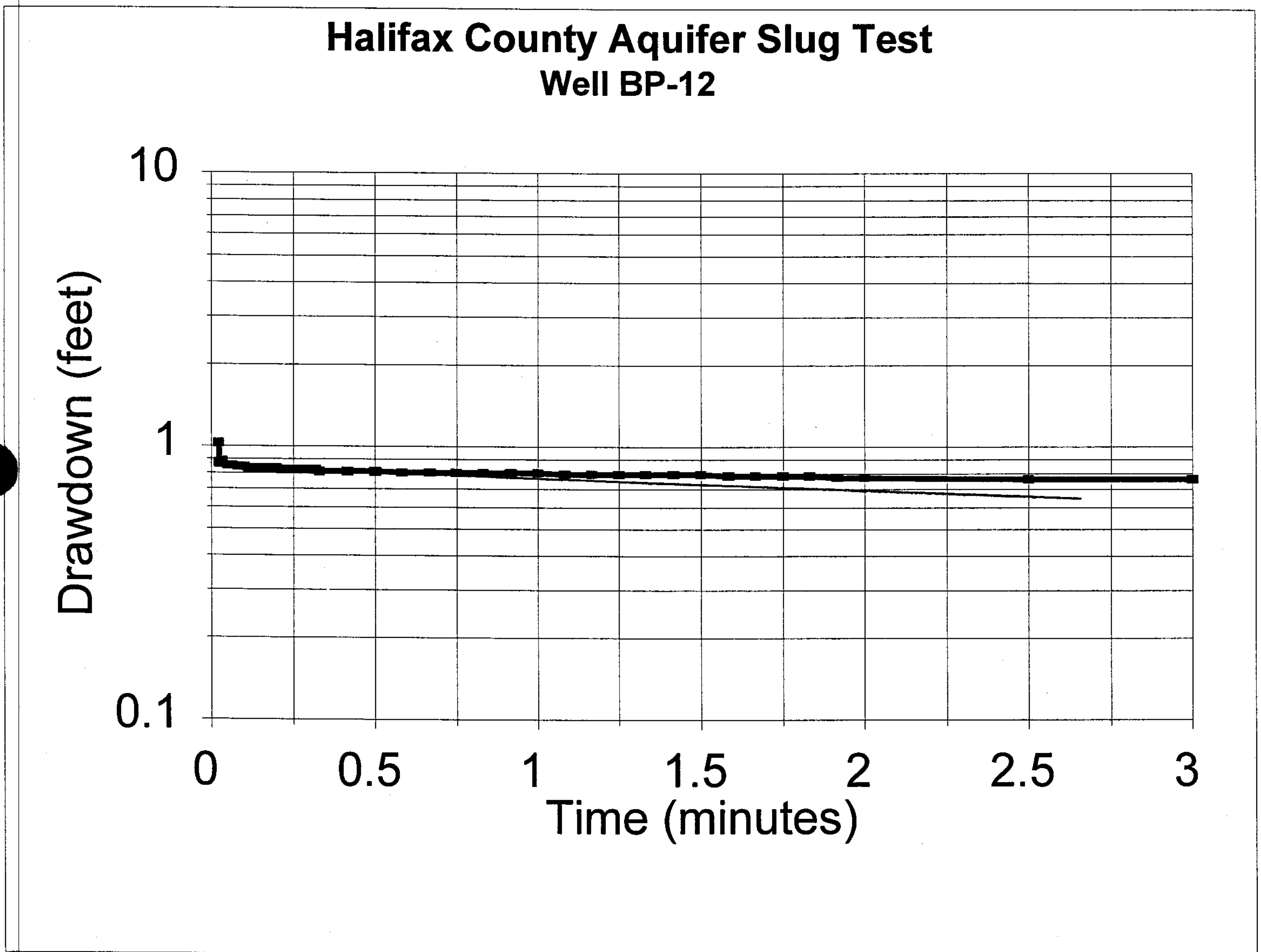
ln Re/Rw= 2.771569 exp-1

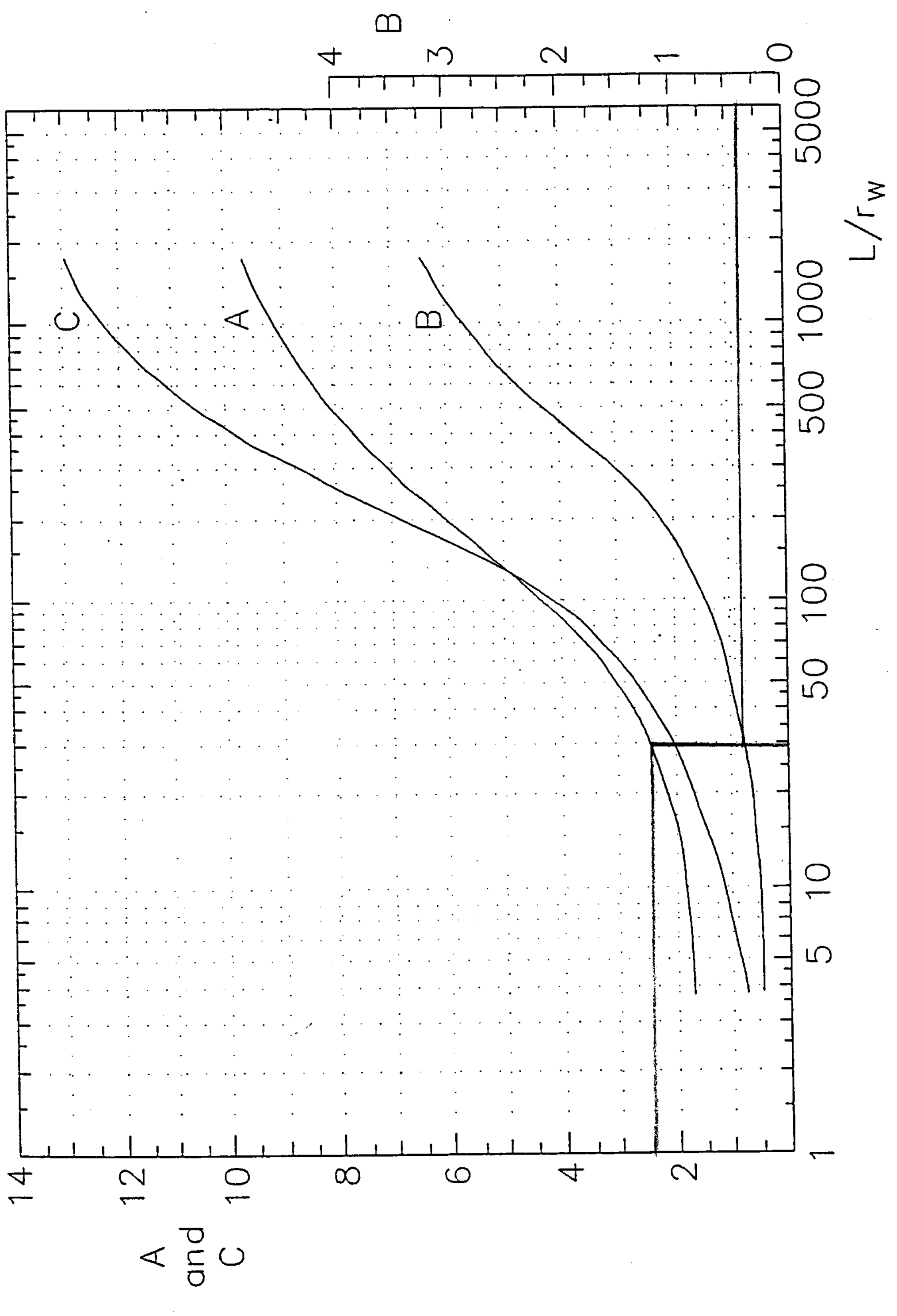
ln Re/Rw= 0.360807

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

K = 0.003289 Ft/Min or 0.001671 CM/Sec

K = 4.736362 Ft/Day


Halifax County Aquifer Slug Test
Well BP-12
10
1
0.1
Drawdown (feet)
0
0.5
1
1.5
2
2.5
3
Time (minutes)



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

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

G.N. RICHARDSON & ASSOC. 417 N. BOYLAN AVENUE RALEIGH N.C. 27603 919–828–0577	COEFFICIENT CURVE MATCHPOINT RISING HEAD AQUIFER TEST Halifax County Aquifer Slug Test BP-12

Halifax County BP-12 Slug Test

SE1000B
Environmental Logger
05/16 14:19

Unit# 00799 Test# 5

INPUT 1: Level (M) TOC

Reference 12.02
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 13:08

Elapsed Time	Value
0.0000	11.93
0.0033	11.93
0.0066	12.47
0.0099	13.92
0.0133	14.04
0.0166	12.58
0.0200	12.83
0.0233	13.05
0.0266	12.89
0.0300	12.89
0.0333	12.90
0.0500	12.87
0.0666	12.87
0.0833	12.86
0.1000	12.86
0.1166	12.85
0.1333	12.85
0.1500	12.85
0.1666	12.85
0.1833	12.85
0.2000	12.85
0.2166	12.84
0.2333	12.84
0.2500	12.84
0.2666	12.84

0.2833	12.84
0.3000	12.84
0.3166	12.84
0.3333	12.83
0.4167	12.83
0.5000	12.83
0.5833	12.82
0.6667	12.82
0.7500	12.82
0.8333	12.82
0.9167	12.82
1.0000	12.82
1.0833	12.81
1.1667	12.81
1.2500	12.81
1.3333	12.81
1.4166	12.81
1.5000	12.81
1.5833	12.80
1.6667	12.80
1.7500	12.80
1.8333	12.80
1.9167	12.79
2.0000	12.79
2.5000	12.78
3.0000	12.78
3.5000	12.77
4.0000	12.76
4.5000	12.76
5.0000	12.75
5.5000	12.75
6.0000	12.74
6.5000	12.73
7.0000	12.73
7.5000	12.72
8.0000	12.71
8.5000	12.71
9.0000	12.70
9.5000	12.69
10.0000	12.69
12.0000	12.66
14.0000	12.64

16.0000	12.62
18.0000	12.60
20.0000	12.58
22.0000	12.56
24.0000	12.54
26.0000	12.52
28.0000	12.51
30.0000	12.49
32.0000	12.47
34.0000	12.46
36.0000	12.44
38.0000	12.42
40.0000	12.41
42.0000	12.39
44.0000	12.38
46.0000	12.37

G. N. Richardson and Associates

Client:	Halifax County	**Proj. No.**	Halifax-4
		Sheet:	1/1
Project:	Halifax County Landfill	**Date:**	5/97
		Well:	BP-13
		Referenc	Bouwer, 1989

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

Where:

Lw = Height of Water Column in Well =	16.45
Le = Screened Interval Open to Aquifer =	5
Rw = Radius of Well Including Sand Pack	0.167
Rc = Radius of Well Casing =	0.083
H = Aquifer Thickness to First Aquitard =	40
Yo = Relative Height of Water at Time Zer	1.06
Yt = Relative Height of Water at Time t =	0.7
n = Porosity =	0.2
Time Tt (in minutes) =	2.25
H - Lw =	23.55
Yo/Yt =	1.514286
Lw/Rw =	98.50299
ln(H-Lw)/Rw =	4.948887

Correction for Sandpack:

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

Req = 1

Req = 1

Evaluation of A and B:

Le/Rw = 29.94012

From Attached Graph of A and B:

A =	2.5
B =	0.4

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

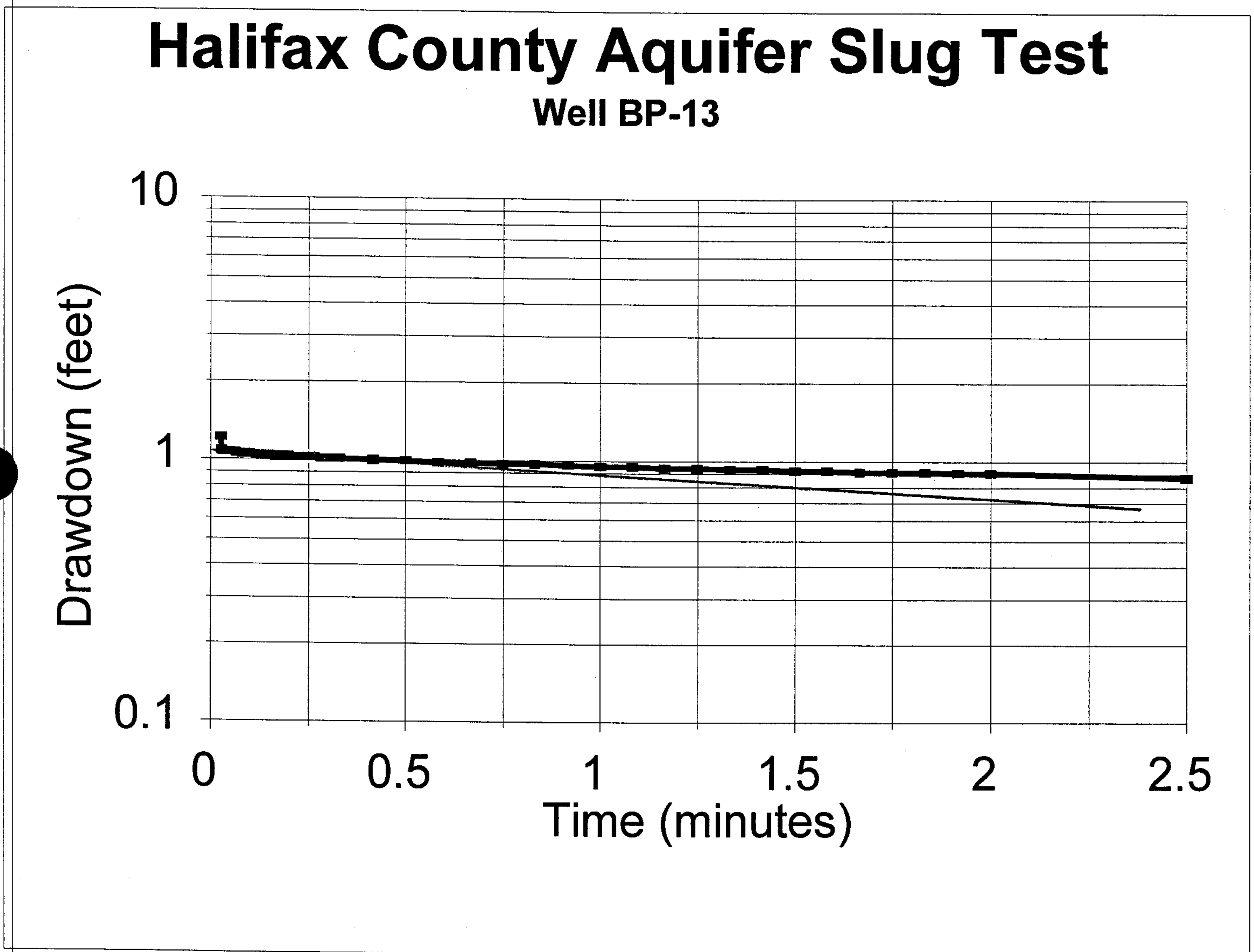
ln Re/Rw= 2.805764 exp-1

ln Re/Rw= 0.356409

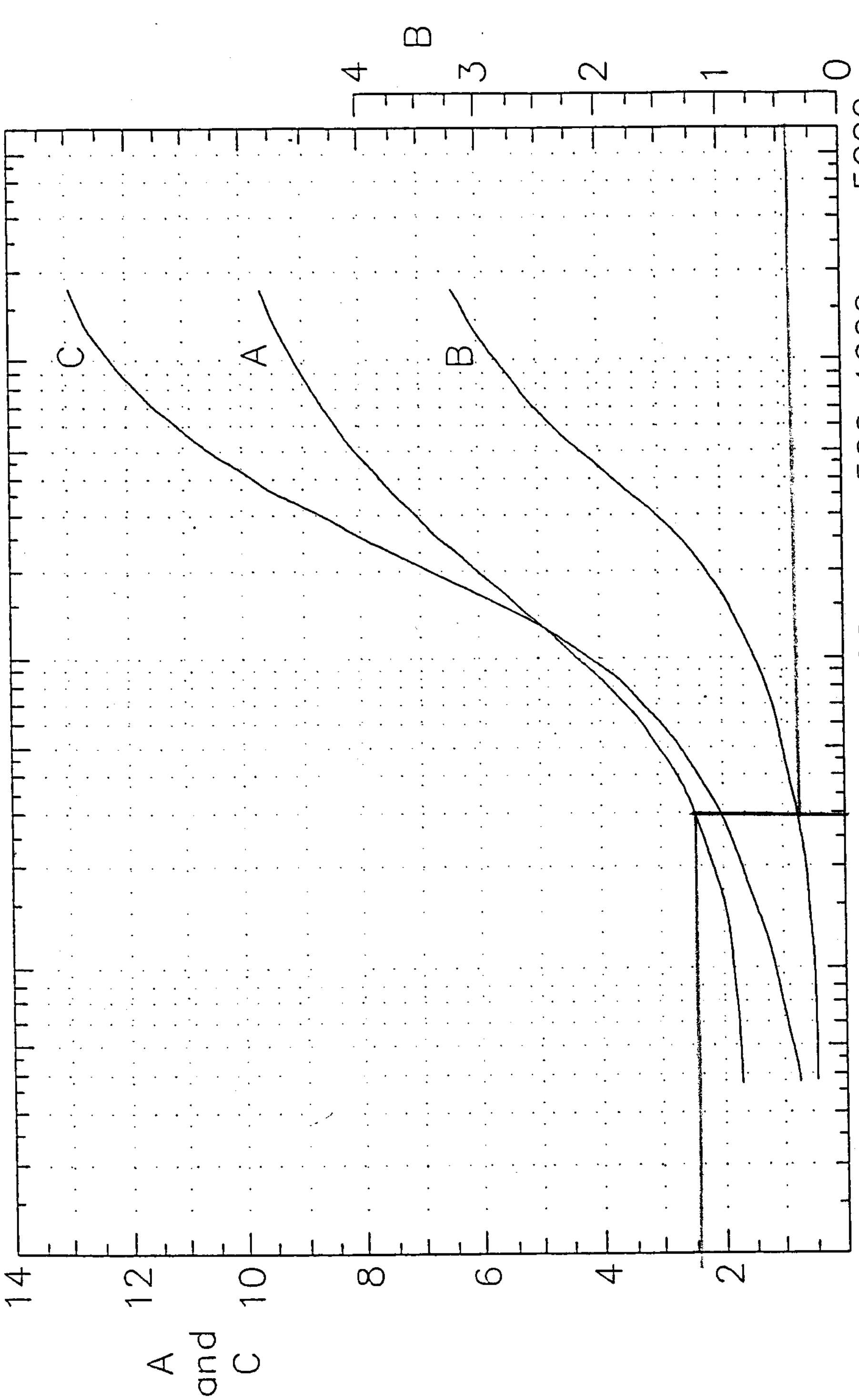
K = (Req) exp2 ln(Re/Rw)1/Tt ln(Yo/Yt) /2Le

K = 0.006573 Ft/Min or 0.003339 CM/Sec

K = 9.464947 Ft/Day



Halifax County Aquifer Slug Test
Well BP-13
Drawdown (feet)
10
1
0.1
0
0.5
1
1.5
2
2.5
Time (minutes)



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

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

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RALEIGH N.C. 27603
919–828–0577

COEFFICIENT CURVE MATCHPOINT
RISING HEAD AQUIFER TEST
Halifax County Aquifer Slug Test
BP-13

Halifax County BP-13 Slug Test

SE1000B
Environmental Logger
05/16 14:15

Unit# 00799 Test# 3

INPUT 1: Level (M) TOC

Reference 11.00
Scale factor 19.99
Offset - 0.05

Step# 0 05/16 10:59

Elapsed Time	Value
0.0000	10.94
0.0033	10.99
0.0066	11.64
0.0099	12.93
0.0133	12.74
0.0166	12.11
0.0200	12.08
0.0233	11.82
0.0266	12.21
0.0300	12.08
0.0333	12.07
0.0500	12.07
0.0666	12.06
0.0833	12.05
0.1000	12.05
0.1166	12.04
0.1333	12.04
0.1500	12.04
0.1666	12.03
0.1833	12.03
0.2000	12.03
0.2166	12.02
0.2333	12.02
0.2500	12.02
0.2666	12.02

0.2833	12.01
0.3000	12.01
0.3166	12.01
0.3333	12.01
0.4167	12.00
0.5000	11.99
0.5833	11.98
0.6667	11.98
0.7500	11.97
0.8333	11.97
0.9167	11.96
1.0000	11.95
1.0833	11.95
1.1667	11.94
1.2500	11.94
1.3333	11.93
1.4166	11.93
1.5000	11.92
1.5833	11.92
1.6667	11.91
1.7500	11.91
1.8333	11.91
1.9167	11.90
2.0000	11.90
2.5000	11.87
3.0000	11.85
3.5000	11.83
4.0000	11.81
4.5000	11.79
5.0000	11.77
5.5000	11.75
6.0000	11.73
6.5000	11.72
7.0000	11.70
7.5000	11.68
8.0000	11.67
8.5000	11.65
9.0000	11.64
9.5000	11.62
10.0000	11.61
12.0000	11.56
14.0000	11.51

16.0000	11.46
18.0000	11.42
20.0000	11.38
22.0000	11.35
24.0000	11.31
26.0000	11.27
28.0000	11.25
30.0000	11.22
32.0000	11.19
34.0000	11.17
36.0000	11.15
38.0000	11.12
40.0000	11.10
42.0000	11.09
44.0000	11.07
46.0000	11.05
48.0000	11.03
50.0000	11.02
52.0000	11.00
54.0000	10.99
56.0000	10.98
58.0000	10.96
60.0000	10.95

Appendix G

Sampling and Analysis Plan
Halifax County C&D Landfill

Permit No. 42-04

Prepared for:
Halifax County
Department of Public Works
Halifax, North Carolina

The water quality monitoring plan for this facility has been prepared by a qualified geologist who is licensed to practice in the state of North Carolina. The plan has been prepared based on knowledge of site conditions and familiarity with North Carolina solid waste rules and industry standard protocol. The water quality monitoring plan described herein should provide reasonably effective early detection of a chronic release of hazardous constituents into the ground or surface waters of the state, due to or caused by activities at the landfill. No other warranties, expressed or implied, are made.

Joan A. Finkbeiner
Joan A. Finkbeiner, P.G.
Project Hydrogeologist

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

NORTH CAROLINA LICENSED SEAL 883 GEOLOGIST G. DAVID GARRETT

8/25/97

August 1997

G.N. Richardson & Associates
Engineering and Geological Services
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Raleigh, North Carolina 27603

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1.0 Introduction

1.1 Plan Description

This site is a MSW landfill (scheduled closure date is January 1, 1998) and a new C&D landfill located east of the closed MSW landfill. Both landfills are located within the permitted facility boundary at the Halifax County Landfill (Permit 42-04). The ground water monitoring network includes nine monitoring wells (MW-1, MW-2a, MW-3ad, MW-6s, MW-6d, MW-7s, MW-7d, MW-15, MW-16a) and three surface water sampling locations (SW-1, SW-2 and SW-3), located about the MSW landfill as shown in Figure 1. These sampling locations have been in service for several years. Monitoring of the closed landfill will continue without modification.

The ground water monitoring program will be modified upon completion of the planned C&D landfill with two new monitoring wells (MW-17 and MW-18) and one new surface water sampling location (SW-4). This revised Sampling and Analysis Plan (SAP) is submitted due to planned modifications to the site monitoring program required for the planned C&D landfill. This plan is based in part on ground water studies for both landfill sites. Ground water flow directions based on these studies are shown in Figure 2. This plan does not pertain to or modify the ground water monitoring program for the nearby ash monofill.

1.2 Regulatory Requirements

North Carolina Solid Waste Management rules, 15A NCAC 13B, Section .1630 through .1637, and Section .0504 (1) (g) (iv) specify that the owner/operator must provide a monitoring program for a ground water and surface water sampling. This Sampling and Analysis Plan (SAP) has been designed to provide accurate results of ground and surface water quality at the upgradient and downgradient sampling locations. The SAP will address the following subjects:

- Ground water sample collection
- Sample preservation and shipment
- Analytical procedures
- Chain-of-custody
- Quality assurance/quality control (QA/QC)
- Sampling locations and frequency.

The methods and procedures described in the following sections are intended to gather true and representative samples and test data. Field procedures are presented in their general order of implementation. Equipment requirements are presented in each section, and quality assurance and record keeping requirements are presented in the latter sections.

2.0 Ground and Surface Water Sample Collection

Table 1 presents a summary description of ground water monitoring wells and surface water sampling points. Figure 1 shows the monitoring well locations and surface sampling points. Ground water samples will be collected from each of the monitor wells and from the surface water sampling locations on a semi-annual schedule. An exception is made for monitoring wells MW-6d and MW-7d, which will be monitored on a bi-annual schedule due to their historical lack of contaminants.

2.1 Static Water Level Measurements

Static water level elevations will be measured prior to any purging or sampling activities. These data will be used to monitor changes in site hydrogeologic conditions. The following measurements will be recorded in a dedicated field book prior to sample collection:

- Elevation of water level (to the nearest 0.01 foot)
- Total depth of well
- Height of water column in the riser
- Changes in condition of well and surroundings.

An electronic water level indicator shall be used to accurately measure water elevations to within 0.01 foot. Each well shall have a permanent, easily identified reference point from which all water level measurements will be taken. The reference point shall be marked and the elevation surveyed by a Registered Land Surveyor. The static water level and total depth shall be used to calculate the volume of water in the well. The static water measuring device shall be constructed of inert materials, such as stainless steel and Teflon®. Between well measurements the device shall be thoroughly decontaminated by washing with non-phosphate soap and triple rinsing with deionized water to prevent cross contamination.

2.2 Detection of Immiscible Layers

The monitoring wells are designed such that the screened interval intersects the water table to allow detection of light nonaqueous phase liquids (LNAPLS) prior to purging and sampling. The following procedures shall be used to detect immiscible layers at all monitoring wells with known ground water impact. The appropriate procedure will be repeated until the immiscible phase liquid is removed from the well prior to sample collection.

A clear Teflon® bailer shall be lowered into the well until it intersects the water table and allowed to penetrate the water table about 6 inches. The bailer shall be retrieved and the sample will be observed to identify the presence of a light phase immiscible layer. If an immiscible layer is present, the bailer shall again be lowered into the well and allowed to penetrate the water table for the full depth of the bailer. The thickness of the light phase immiscible layer, if present, shall then be recorded in a dedicated field logbook. Should the thickness of the light phase immiscible layer be greater than the length of the bailer, an interface probe shall be used to determine the thickness of the layer. The depth of the water table shall be recorded.

Dense phase immiscible layer shall be detected by lowering the bailer (or interface probe, if used) to the bottom of the well and retrieving it. Any dense phase immiscible compounds observed in the sample will be observed and recorded. A sample of any detected immiscible layers shall be collected in an appropriate sampling bottle for analysis. All immiscible phase liquids shall be removed prior to sampling the well.

The procedure for collecting and/or removing light phase immiscible layer will depend on the thickness the floating layer. If the thickness of the light phase is two (2) feet or greater, a bottom valve bailer shall be lowered slowly until contact is made with the immiscible/water interface depth, determined by previous measurements. If the thickness of the light phase is less than two (2) feet, a bottom valve bailer must be modified to allow the sample to enter from the top. The bottom check valve shall be disassembled and a piece of 2-inch diameter Teflon® disk shall be inserted above the ball seat to seal off the bottom valve.

The ball from the top check valve shall be removed. The additional buoyancy shall be overcome with a length of stainless steel pipe placed on the retrieval line above the bailer. The bailer will be lowered until the top is level with the surface of the light immiscible phase, The bailer will be lowered one-half the thickness of the light immiscible phase, then retrieved.

The procedure to collect dense phase immiscibles will be to use a double check valve bailer. The bailer will be lowered in a controlled manner, then slowly retrieved to retain the dense phase immiscible liquid. Based on past experience with ground water monitoring programs for landfills, it is unlikely that immiscible layers will be detected. Should collection of immiscible phase fluids become necessary on a regular basis, the ground water monitoring protocol shall be re-evaluated and modified as appropriate.

2.3 Monitoring Well Evacuation

Following measurement of the static water elevation in all of the wells, individual wells will be purged of all stagnant water. The stagnant water, which is not representative of true aquifer conditions, must be removed to insure that fresh formation water can be sampled. A minimum of three well volumes will be removed prior to sampling the well.

The well volume for 2-inch diameter wells will be calculated using the following equation:

$$V = (TD - SWL) \times C$$

Where:

V	=	One well volume
TD	=	Total depth of the well (in feet)
SWL	=	Static water level (in feet)
C	=	Volume constant for given well diameter (gallons/foot)
		C = 0.163 gal/ft for two-inch diameter wells.

Well completion depth data are included in Table 2. Determining the well volume in gallons will allow the sampler to determine the amount of ground water to purge in order to remove a minimum of three to five well volumes (or until the well is purged dry). Wells will be purged at a rate which will not cause recharge water to be excessively agitated. Dry and low recharge rates, and the total purged volume will be noted in field observations. Should impacted ground water be detected, purge water will be managed to prevent possible soil contamination (either through containment, or treatment on-site).

Prior to purging, new latex or nitrile surgical gloves will be donned. Each well will be purged in such a way that water is removed from the bottom of the screened interval. During the well purging process, field measurements (i.e., pH, temperature, and specific conductance) will be collected at regular intervals, and reported in a tabular format. The well will be purged until field measurements stabilize (to within 10% of each other) or until the well is dry. Stabilization of these measurements will indicate that fresh formation water is present in the well. Field measurements of pH, temperature, and conductivity will be obtained by using a combination water quality meter. Data collected will be recorded in a field log book.

A new, disposable fluorocarbon resin (Teflon®) or inert plastic bailer with bottom check valve will be used to evacuate each well. A new Teflon®-coated stainless steel, inert monofilament line or new nylon rope will be used to retrieve the bailer. Clean, disposable latex or nitrile surgical gloves will be used at each well, and appropriate measures will be taken to prevent surface soils and other contaminant sources from contacting the purging equipment. Non-dedicated field equipment (field measuring devices) will be thoroughly decontaminated between wells by disassembling and washing with (non-phosphate) soapy, de-ionized water and triple rinsed using de-ionized water.

Should dedicated pumps be used, a minimum of three to five well volumes (or until the well is purged dry) will be purged from the well utilizing a dedicated pump. If the Micro-Purge® and/or Purge Saver® systems or similar purging systems are used, less water may be purged based upon the field parameters analyzed by these systems. Pumping shall be completed at a flowrate the aquifer can maintain, and so as to not agitate sediments. Only stainless steel and Teflon® pumps shall be used.

2.4 Ground Water Sample Collection

After purging activities are complete, ground water samples will be collected for laboratory analysis. Samples will only be collected after new latex or nitrile surgical gloves have been donned. The wells will be sampled using either disposable Teflon® bailers with bottom check valve, bottom emptying devices and Teflon® coated wire, inert monofilament line or new nylon rope, or by the use of dedicated pumps. Sampling will occur as soon after well recovery as possible. Wells which fail to produce an adequate sample volume within 24 hours of purging will not be sampled.

Temperature, pH, and specific conductance will be taken at the start and ending of sampling as a measure of purging efficiency and as a check on the stability of the water samples over time. Measurements of temperature, pH, and specific conductivity will be recorded for all water samples. The calibration of the pH, temperature, and conductivity meter will be completed at the beginning of each sampling event, according to the manufacturers' specifications and consistent with Test Methods for Evaluating Solid Waste - Physical/Chemical Methods (SW-846).

Ground water samples will be collected and contained in the order of volatilization sensitivity of the parameters as follows:

- Initial measurements of pH, temperature and conductivity
- Volatile Organics
- Total Metals
- Turbidity
- Final measurements of pH, temperature, and conductivity

All samples will be collected unfiltered. Samples for dissolved metal analysis, if subsequently required, will be prepared by field filtration using a decontaminated Nalgene® hand-operated filtering pump (or equivalent) or peristaltic pump and a disposable 0.45 micron filter cartridge specifically manufactured for this purpose.

All reusable sampling equipment including meter probes, and filtering pump (if used), which might contact aquifer water or samples, will be thoroughly decontaminated between wells by washing with non-phosphate soapy, de-ionized water and triple rinsing with deionized water.

Samples will be transferred directly from the Teflon® bailer into a container that has been specifically prepared for the preservation and storage of compatible parameters. A bottom emptying device provided with the bailer will be used to transfer samples from bailer to sample container to assure minimum agitation.

Blanks and duplicate samples will be taken and analyzed for the same parameters as ground water samples to insure cross-contamination has not occurred. One set of trip blanks, as described later in this document, will be collected before leaving the laboratory to insure that the sample containers or handling processes have not affected the quality of the samples. One set of field (equipment) blanks will be collected in the field at the time of sampling to insure that the field conditions, equipment used, and handling during sampling collection have not affected the quality of the samples.

A duplicate ground water sample may be collected from a single well as a check of laboratory accuracy. Blanks and duplicate containers, preservatives, handling, and transport procedures for surface water samples will be identical to those noted for ground water samples.

Sample containers shall be provided by the laboratory for each sampling event. Containers shall be cleaned by the laboratory based on the analyte of interest. Metal containers shall be thoroughly washed with non-phosphate detergent and tap water, and rinsed with (1:1) nitric acid, tap water, (1:1) hydrochloric acid, tap water, and deionized water, in that order. Organic sample containers shall be thoroughly washed with non-phosphate detergent in hot water and rinsed with tap water, distilled water, acetone, and pesticide quality hexane, in that order. Other sample containers shall be thoroughly washed with non-phosphate detergent and tap water, rinsed with tap water, and rinsed with deionized water. The laboratory shall provide proper preservatives in the sample containers prior to shipment.

2.5 Surface Water Sample Collection

Surface water samples shall be obtained from areas of minimal turbulence and aeration. The following procedure will be implemented regarding sampling of surface waters:

1. Put on new latex or nitrile surgical gloves.
2. Hold the bottle at the bottom with one hand, and with the other, remove the cap.
3. Push the sample container slowly into the water and tilt up towards the current to fill. A depth of about 6 inches is satisfactory. Do not completely immerse the container to avoid breaching the surface while filling the container.
4. If there is little current movement, the container should be moved slowly, in a lateral direction.

2.6 Equipment Decontamination

All non-dedicated equipment that will come in contact with the well casing and water, i.e. water level indicator, will be decontaminated. The procedure for decontaminating non-dedicated equipment as follows:

1. Clean item with tap water and phosphate-free laboratory detergent (Liquinox® or equivalent), using a brush if necessary to remove particulate matter and surface films.
2. Rinse thoroughly with tap water
3. Rinse thoroughly with deionized or distilled water and allow to air dry
4. Rinse thoroughly with high grade isopropanol and allow to air dry
5, Wrap with aluminum foil, if necessary, to prevent contamination of equipment during storage or transport.

3.0 Field QA/QC Program

Field Quality Assurance/Quality Control (QA/QC) requires the routine collection and analysis of two types of QC blanks, trip blanks and field blanks, to verify that the sample collection and handling process has not affected the quality of the samples. The following sampling blanks will be analyzed for all of the required monitoring parameters:

Trip Blank - Fill one of each type of sample bottle with distilled or deionized water, transport to the site, handle like a sample, and return to the laboratory for analysis. One set of trip blanks will be analyzed per sampling event. Trip blanks should be prepared by the laboratory and transported with the sample glassware prior to sampling.

Field blank - To insure that any non-dedicated sampling device has been effectively cleaned, fill the device with distilled or deionized water, while wearing clean latex or nitrile surgical gloves, transfer to sample bottles(s), and return to the laboratory for analysis. If the samples are collected with bailers, a minimum of one field blank for each day that samples are collected is required. If dedicated pumps are used for sample collection, field blank samples are not necessary.

Sampling blanks will be placed in bottles of the specific type required for the analyzed parameters and taken from a bottle pack specifically assembled by the laboratory for each ground water sampling event. Trip blanks will be taken prior to the sampling event and transported with the empty bottle packs. Field blanks will be placed in contact with field sampling equipment and returned to the laboratory in a manner identical to the handling procedure used for the samples.

Contaminants found in the trip blanks could be attributed to the following:

1. Interaction between the sample and the container
2. Contaminated source water
3. A handling procedure that alters the sample
4. Interaction with the sampling device
5. A field handling procedure which taints the retrieved sample.

The concentration levels of any contaminants found in the trip blank will be reported but will not be used to correct the ground water data. In the event that elevated parameter concentrations are found in any blank, the analysis will be flagged for future evaluation and possible resampling.

All field instruments utilized in the field to measure ground water characteristics will be calibrated prior to entering the field, and recalibrated in the field as required, to insure accurate measurement for each sample. The specific conductivity and pH meter shall be recalibrated utilizing two prepared solutions of known concentration in the range of anticipated values (between 4 and 10). A permanent thermometer, calibrated against a National Bureau of Standards Certified thermometer, will be used for temperature meter calibration.

4.0 Sample Preservation and Shipment

In order to insure sample integrity, preservation and shipment procedures will be carefully monitored. Proper storage and transport conditions must be maintained in order to preserve the integrity of the sample. Generally, ice and chemical ice packs will be used as sample preservatives, as recommended by the commercial laboratory. Dry ice is not to be used.

For VOC analysis, hydrochloric acid will be used for sample preservation as well as by maintaining the samples at a temperature of 4°C. Nitric acid will be used as the preservative for samples needing metals analysis. Samples shall be delivered to the analytical laboratory within a 24-hour period using an overnight delivery service, if needed, to insure holding times are not exceeded. Shipment and receipt of samples will be coordinated with the laboratory.

Once collected, samples will be placed on ice and cooled to a temperature of 4°C. Samples are to be packed in high impact polystyrene coolers so as to inhibit breakage or accidental spills. Custody seals shall be placed on the outside of the cooler, in a manner to detect tampering of the samples. Chain-of-Custody control for all samples will consist of the following:

1. Labels will be placed on individual sample containers in the field, indicating the site, date and time of sampling, well number, and preservation method used for the sample.

2. Sample containers will be individually secured or placed in a secured area in iced coolers

and will remain in the continuous possession of the field technician until transferral as provided by the Chain-of-Custody form has occurred.

3. Upon delivery to the laboratory, samples are given laboratory sample numbers and recorded into a logbook indicating client, well number, and date and time of delivery. The laboratory director or his designatee will sign the Chain-of-Custody control forms and formally receive the samples. The samples will be maintained at the appropriate temperature at all times.

5.0 Field Logbook

The field technician will keep an up-to-date logbook documenting important information pertaining to the technician's field activities. The field logbook will document the following:

- Site Name and Location
- Date and Time of Sampling
- Climatic Conditions Immediately Before and After Sampling Event
- Well Identification Number
- Presence of Immiscible Layers and Detection Method
- Well Static Water Level
- Well Depth
- Height of Water Column in Well
- Volume of Three (3) Well Volumes
- Purged Water Volume and Well Yield (High or Low)
- Pumping or Bailing Rate
- Time Well Purged
- Observations on Purging and Sampling Event
- Time of Sample Collection
- Temperature, pH, Turbidity, and Conductivity Readings (4x)
- Signature of Field Technician.

6.0 Laboratory Analysis

The ground water samples will be analyzed for parameters specified by North Carolina Solid Waste Management Rules. All analytical methods are taken from Test Methods For Evaluating Solid Waste - Physical/Chemical Methods (SW-846) or Methods For the Chemical Analysis of Water and Wastes. Analysis will be performed by a laboratory certified by the North Carolina DEHNR for the analyzed parameters.

Quality Assurance/Quality Control (QA/QC) procedures are to be utilized at all times. The owner/operator of the landfill is responsible for selecting a laboratory and insuring that they are utilizing proper QA/QC procedures. The laboratory must have a QA/QC program based upon specific routine procedures outlined in a written laboratory Quality Assurance/Quality Control Manual. The QA/QC procedures listed in the manual provide the lab with the necessary assurances and documentation for accuracy and precision of analytical determinations. Internal quality control checks shall be undertaken, regularly by the lab, to assess the precision and accuracy of analytical procedures.

The internal quality control checks include the use of calibration standards, standard references, duplicate samples and spiked or fortified samples. Calibration standards shall be verified against a standard reference obtained from an outside source. Calibration curves shall be developed using at least one blank and three standards. Samples shall be diluted if necessary to insure that analytical measurements fall on the linear portion of the calibration curve. Duplicate samples shall be processed at an average frequency of 10 percent to assess the precision of testing methods, and standard references shall be processed monthly to assess accuracy of analytical procedures. Spiked or fortified samples shall be carried through all stages of sample preparation and measurement to validate the accuracy of the analysis.

During the course of the analyses, quality control data and sample data shall be reviewed by the laboratory manager to identify questionable data and determine if the necessary QA/QC requirements are being followed. If a portion of the lab work is subcontracted, it is the responsibility of the contracted laboratory to verify that all subcontracted work is completed by certified laboratories, using identical QA/QC procedures.

7.0 Statistical Evaluation

All statistical analysis will be performed in accordance with North Carolina State Regulations 15A NCAC 13B.1632. Other references for methods to evaluate the data are taken from one or more of the following:

- EPA RCRA Ground Water Monitoring Draft Technical Guidance Document
- EPA Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities - Addendum to Interim Final Guidance.
-

The North Carolina Solid Waste Rules requires that the owner or operator of the landfill specify a statistical method outlined in these rules to evaluate ground water monitoring data. The goal of the statistical analysis is to determine whether statistically significant evidence of contamination exists and to identify the point of contamination. Upon receipt of each monitoring event's data, the statistical database of analyses will be updated. The North Carolina Solid Waste Rules provide several methods for statistical analysis of ground water data. These methods are:

1. Parametric analysis of variance (ANOVA)
2. Rank-based (non-parametric) ANOVA with multiple comparisons
3. Tolerance prediction interval
4. Control chart
5. Test of Proportions
6. An alternative statistical test method that meets the performance standards of 40 CFR 258.53 (h)

Statistical evaluation of monitoring data shall be performed for the duration of the monitoring program, including the post-closure care period. The choice of an appropriate statistical test depends on the type of monitoring, the nature of the data, and the proportion of values in the data set that are below detection limits. The statistical analysis should be conducted separately for each detected constituent in each well.

8.0 Record Keeping and Reporting

Copies of laboratory results and water quality reports shall be kept on file at the Halifax County Landfill office. Summary reports shall be submitted to the NC DWM for each sampling event.

8.1 Notifications

Should a statistically significant increase in ground water concentrations as defined in North Carolina Solid Waste Management rules be detected during monitoring, the owner/operator of the landfill shall notify the NC DWM within 14 days and will place a notice in the operating record as to which constituents increased. At such point the ground water monitoring program shall be re-evaluated and may require modification.

8.2 Well Abandonment/Rehabilitation

Should any monitoring well become irreversibly damaged or require rehabilitation, it shall be abandoned in accordance with the requirements of 15 NCAC 02C .0100. The abandonment will consist of plugging the well with a chemically inert, impermeable sealant, e.g. neat cement and/or bentonite-cement grout. Where possible, it is preferred to overdrill and remove well casing, screen and filter pack prior to grouting.

8.3 Additional Well Installation

The static ground water surface elevation shall be used to create potentiometric maps (see Figure 2) to evaluate ground water flow directions. This data will be used to verify correct placement of existing wells and, if required, determine locations for future monitoring wells. Should additional wells be required to monitor potential releases of solid waste constituents into the ground water, new well locations and depths will be submitted to the NCDSWM for approval.

All future monitoring wells shall be installed under the supervision of a geologist or engineer who is registered in North Carolina and who will certify to the NCDSWM that the installation complies with the North Carolina Regulations. Construction documentation for each new well shall be submitted by the registered geologist or engineer within 30 days after completion.

8.4 Implementation

This Sampling and Analysis Plan will become effective upon approval by NC DWM and will remain in effect until further modifications are approved. Sampling of the new wells for the planned C&D facility prior to waste placement shall be conducted in accordance with NC DWM guidelines. Sampling of the new wells and surface water location for the planned C&D facility will resume with the current semi-annual facility monitoring schedule. Sampling is currently scheduled for February and August of each year.

Table 1

Ground Water and Surface Water Monitoring Plan
Monitoring Well and Stream Sampling Locations

Halifax County Landfill

October, 1996

Monitoring Wells	Well Location	Monitoring Schedule
MW-1	Background well	Semi-annually
MW-2a	Down gradient well	Semi-annually
MW-3ad	Down gradient well	Semi-annually
MW-6s	Down gradient well	Semi-annually
MW-6d	Down gradient deep well	Bi-annually
MW-7s	Down gradient well	Semi-annually
MW-7d	Down gradient deep well	Bi-annually
MW-15	Up gradient well	Semi-annually
MW-16a	Up gradient well	Semi-annually
MW-17*	Up gradient of new C&D landfill	Semi-annually
MW-18*	Down gradient of new C&D landfill	Semi-annually
Stream Sampling Point	**Location of Sampling Point**	**Proposed Placement**
SW-1	Up gradient of Unlined MSW landfill	Existing Sampling Location (Already Monitored)
SW-2	Down gradient of Facility along Property Line	Existing Sampling Location (Already Monitored)
SW-3	Up gradient of Lined and Unlined MSWLF Units	Existing Sampling Location (Already Monitored)
SW-4*	Down gradient of New C&D Landfill	New Sampling Location

* Proposed for planned C&D landfill. See map for location and survey coordinates.

The sampling schedule is currently conducted in February and August of each plan year.
No changes to this schedule are proposed.

Table 2

Estimated Monitoring Well Completion Data

Halifax County Unlined Landfill

October, 1996

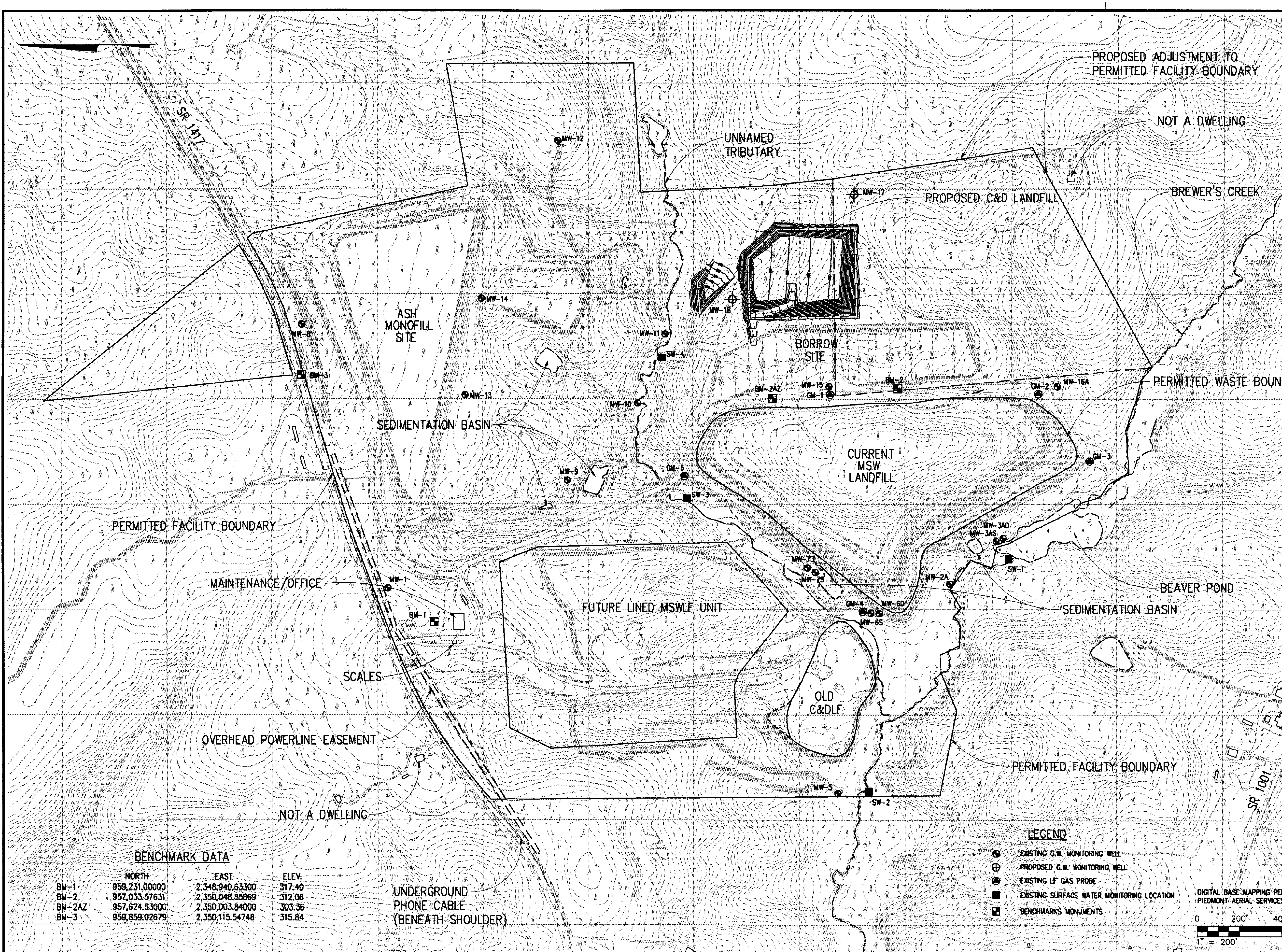
Monitoring Well	Top of Casing Elevation	Depth to Bottom, ft.	Screened Interval, ft.
MW-1	324.60	40	25.0 - 40.0
MW-2a	246.43	14	4.0 - 14.0
MW-3ad	252.68	19	9.0 - 19.0
MW-6s	253.26	23	8.0 - 23.0
MW-6d	253.22	40	25.0 - 40.0
MW-7s	250.44	17	2.5 - 17.5
MW-7d	249.09	40	25.0 - 40.0
MW-15	309.09	50	35.0 - 50.0
MW-16a	271.46	19	4.0 - 19.0
MW-17*	±310	±20	5.0 - 20.0
MW-18*	±280	±20	5.0 - 20.0

* Proposed for planned C&D landfill. Surface elevation and screen depths anticipated based on nearby test boring data. Actual depths will be determined based on conditions encountered during drilling.

All measurements given in feet.

Sampling and Analytical Schedule

	February	August
Old MSW Landfill	Appendix II	Appendix I and Triggered Appendix. II
New C&D Landfill	Appendix I	Appendix I
Surface Water Points	Appendix I	Appendix I



BENCHMARK DATA

	NORTH	EAST	ELEV.
BM-1	959,231.00000	2,348,940.63300	317.40
BM-2	957,033.57631	2,350,048.85869	312.06
BM-2AZ	957,624.53000	2,350,003.84000	303.36
BM-3	959,859.02679	2,350,115.54748	315.84

DATE	NO.	REVISION

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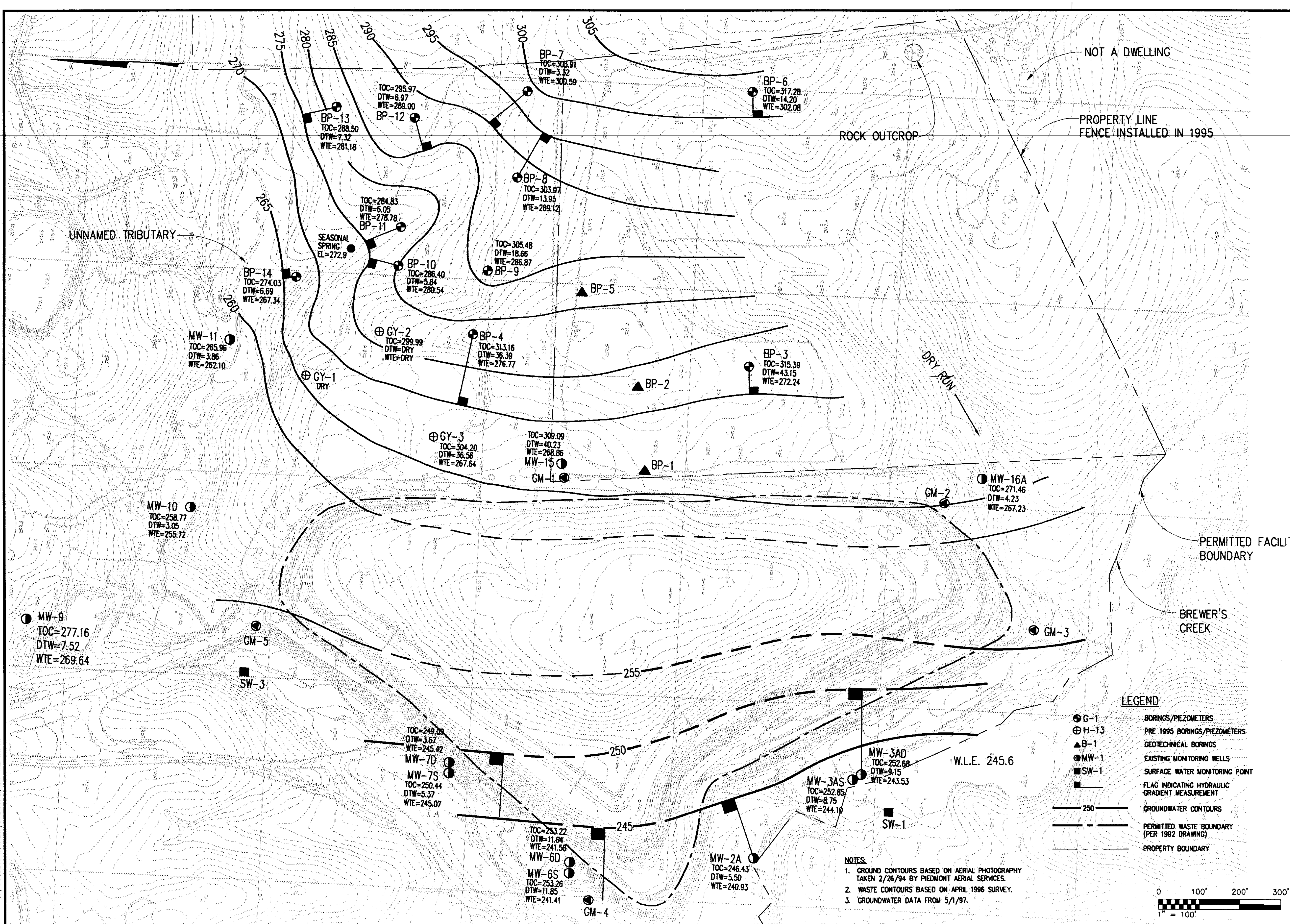
PROJECT TITLE: HALIFAX COUNTY LANDFILL SAMPLING AND ANALYSIS PLAN

DRAWING TITLE: FIGURE 1 GROUND WATER/SURFACE WATER SAMPLING LOCATIONS

DESIGNED BY:	DRAWN BY:
G.D.G.	A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO.	DRAWING NO.

D:\-CAD\HALIFAX-11\FIG-1.dwg DATE: AUG 29, 1997 TIME: 9:24 AM



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PROJECT TITLE:
HALIFAX COUNTY LANDFILL
SAMPLING AND ANALYSIS PLAN

DRAWING TITLE:
FIGURE 2
GROUND WATER POTENTIOMETRIC SURFACES AS OF 5/1/97

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO.	DRAWING NO.

D:\-CAD\HALIFAX-11\FIG-2.dwg DATE: AUG 29, 1997 TIME: 9:37 AM

Appendix H

Technical Specifications

Halifax County
Construction & Demolition Debris Landfill

Prepared for:

Halifax County Solid Waste Department

Halifax, North Carolina

August 1997

PERMIT ISSUE DOCUMENTS

G.N. Richardson & Associates, Inc.
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HALIFAX COUNTY
CONSTRUCTION & DEMOLITION DEBRIS LANDFILL

TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

SECTION 02110

SITE PREPARATION

Site Preparation: Site Preparation includes clearing, grubbing, and stripping operations which precede the construction of the landfill.

A. DESCRIPTION

1. General:

   a. The Contractor shall furnish all labor, material, and equipment to complete Site Preparation in accordance with the Contract Drawings and these Specifications.

   b. Principal items of work include:

      1. Notifying all authorities owning utility lines running to or on the property. Protect and maintain all utility lines to remain and cap those that are not required in accordance with instructions of the Utility Companies, and all other authorities having jurisdiction.

      2. Clearing the site within the clearing limits, including removal of grass, brush, shrubs, trees, loose debris, and other encumbrances except for trees to remain.

      3. Boxing and protecting all areas to be preserved.

      4. Removing all topsoil from designated areas and stockpiling on site where directed by the Engineer for future use.

      5. Disposing from the site all debris resulting from work under this Section.

2. Related Work:

   Related Contract Work is described in the following sections of the Specifications:

Work	Section
Excavation	02222
Embankment	02223

B. MATERIALS Not Used.

C. SUBMITTALS Not Used.

D. CONSTRUCTION

1. Clearing of the Site:

a. Clearing limits, as shown on the Contract Drawings, shall be established by the Contractor in the field using a Registered Surveyor. Once established, the clearing limits shall be inspected and approved by the Engineer prior to clearing the affected areas.

b. Before removal of topsoil, and start of excavation and grading operations, the areas within the clearing limits shown on the Contract Drawings shall be cleared and grubbed.

c. Clearing shall consist of cutting, removal, and satisfactory disposal of all trees, fallen timber, brush, bushes, rubbish, fencing, and other perishable and objectionable material within the areas to be excavated or other designated areas.

Should it become necessary to remove a tree, bush, brush, or other plants adjacent to the area to be excavated, the Contractor shall do so only after permission has been granted by the Engineer.

d. Excavation resulting from the removal of trees, roots, and the like shall be filled with suitable material, as approved by the Engineer, and thoroughly compacted per the requirements contained in Section 02223, Embankment, of these Specifications.

e. Unless otherwise shown or specified, the Contractor shall clear and grub a strip at least 15 feet wide along all permanent fence lines installed under this Contract.

f. In temporary construction easement locations, only those trees and shrubs shall be removed which are in actual interference with excavation or grading work under this Contract, and removal shall be subject to approval by the Engineer. However, the Engineer reserves the right to order additional trees and shrubs removed at no additional cost to the Owner, if such, in his opinion, they are too close to the work to be maintained or have become damaged due to the Contractor's operations.

2. <u>Stripping and Stockpiling Existing Topsoil:</u>

   a. Existing topsoil and sod on the site within areas designated on the Contract Drawings shall be stripped to whatever depth it may occur, and stored in locations directed by the Engineer.

   b. The topsoil shall be free of stones, roots, brush, rubbish, or other unsuitable materials before stockpiling.

   c. Care shall be taken not to contaminate the stockpiled topsoil with any unsuitable materials.

3. <u>Grubbing:</u>

   a. Grubbing shall consist of the removal and disposal of all stumps, roots, logs, sticks, and other perishable materials to a depth of at least 6 inches below ground surfaces.

   b. Large stumps located in areas to be excavated may be removed during grading operations, subject to the approval of the Engineer.

4. <u>Disposal of Cleared and Grubbed Material:</u>

   All trees, stumps, roots, bushes, and refuse shall be disposed of by burning or shall be removed from the site and disposed of by the Contractor. The Contractor shall receive written authorization from the Owner prior to burning. Any material other than plant growth shall not be burned. On-site and off-site disposal areas are subject to approval by the Engineer. Ashes and residue from burning operations shall be removed from the site and disposed of by the Contractor.

   All materials to be burned shall be piled neatly and burned when in suitable condition, so that all are reduced to ashes. Piling for burning shall be done in such a manner and in such locations as to cause the least fire risk with a minimum of 1000 feet to the nearest dwelling. No burning shall commence before 9:00 A.M. or after 3:00 P.M. The Contractor shall take special precautionary measures as may be necessary to maintain proper control of such fires. Prevailing winds at the time of the burning shall be away from any city, or town, or built-up area. The Contractor shall also obtain all of the required permits for his burning operations.

E. <u>MEASUREMENT AND PAYMENT</u>

All work required for <u>Site Preparation</u> shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02140

DEWATERING

> Dewatering: Dewatering refers to controlling and disposing of surface and shallow ground water as is necessary for proper excavation, compaction, and other operations requiring dry conditions.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Dewatering in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Excavation	02222
Embankment	02223

B. MATERIALS

Not Used.

C. SUBMITTALS

Procedures for Dewatering proposed by the Contractor shall be submitted to the Engineer for review prior to any Dewatering operations.

D. CONSTRUCTION

1. The Contractor shall do all Dewatering as required for the completion of the work. All surface or ground water removed by Dewatering operations shall be disposed of in accordance with all applicable regulations.

2. The Dewatering system shall be of sufficient size and capacity as required to control ground water or seepage to permit proper excavation operations, embankment construction and reconstruction, subgrade preparation, and to allow concrete to be placed in a dry condition. The system shall include a sump system or other equipment, appurtenances, and other related earthwork necessary for the required control of surface water. The Contractor shall drawdown ground water

to at least 3 feet below the bottom of excavations at all times in order to maintain a dry and undisturbed condition.

3. Prior to the execution of the work, the Contractor, Owner, and Engineer shall jointly survey the condition of adjoining structures. Photographs and records shall be made of any prior settlement or cracking of structures, pavements, and the like, that may become the subject of possible damage claims.

4. The Contractor shall take all the steps that he considers necessary to familiarize himself with the surface and subsurface site conditions, and shall obtain the data that is required to analyze the water and soil environment at the site and to assure that the materials used for the Dewatering systems will not erode, deteriorate, or clog to the extent that the Dewatering systems will not perform properly during the period of Dewatering.

5. The Contractor shall control, by acceptable means, all water regardless of source. Water shall be controlled and its disposal provided for at each berm, structure, etc. when necessary. The entire periphery of the excavation area shall be ditched and diked to prevent surface water from entering the excavation where applicable. The Contractor shall be fully responsible for disposal of the water and shall provide all necessary means at no additional expense to the Owner. The Contractor shall be solely responsible for proper design, installation, proper operation, maintenance, and any failure of any component of the system.

6. The Contractor shall be responsible for and shall repair without cost to the Owner, any damage to work in place and the excavation, including damage to the bottom due to heave and including removal of material and pumping out of the excavated area. The Contractor shall be responsible for damages to any other area or structure caused by his failure to maintain and operate the Dewatering system proposed and installed by the Contractor.

E. MEASUREMENT AND PAYMENT

All work required for Dewatering shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02222

EXCAVATION

Excavation: Excavation includes excavating, sealing, hauling, scraping, undercutting, removal of accumulated surface water or ground water, stockpiling, and all necessary and incidental items as required for bringing the landfill and related structures to the specified lines and grades.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment required to complete Excavation of the landfill containment area and related structures in accordance with the Contract Drawings and these Specifications, except as noted below:

a. Clearing and grubbing and removal of topsoil is addressed in Section 02110, Site Preparation, of these Specifications.

b. Removal of rock is addressed in Section 02229, Rock Removal, of these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Site Preparation	02110
Dewatering	02140
Embankment	02223
Rock Removal	02229
Erosion and Sedimentation Control	02270
CQA Manual	Attached

3. Quality Assurance:

Quality Assurance during Excavation will be provided by the Owner as described in the accompanying Project CQA Manual.

4. Definitions:

   a. Excavation: shall consist of the removal and satisfactory disposal and/or stockpiling of materials located with the limits of construction including widening cuts and shaping of slopes necessary for the preparation of roadbeds, landfill slope areas, cutting of any ditches, channels, waterways, entrances, and other work incidental thereto.

   b. Borrow: shall consist of approved on-site material required for the construction of embankments/fills or for other portions of the work.

   c. Select Borrow: shall consist of approved off-site material required for the construction of embankments/fills, roadway subgrade, backfilling, or for other portions of the work as shown on Contract Drawings or in these Specifications. The Contractor shall make his own arrangements for obtaining select borrow and pay all costs involved.

   d. Unsuitable Material: is any in-place or excavated material which contains undesirable materials, or is in a state which is not appropriate; in the opinion of the CQA Engineer, for the intended use or support of planned structures, embankment, or excavation. This may include but not be limited to organic material, waste/refuse, soft, or wet material not meeting required specifications, etc.

   e. Unsuitable Materials Excavation (Overexcavation): shall consist of the removal and satisfactory disposal of all unsuitable material located within the limits of construction. Where excavation to the finished grade section shown results in a subgrade or slopes of unsuitable material, the Contractor shall overexcavate such material to below the grade shown on the Contract Drawings or as directed by the Engineer and CQA Engineer.

B. MATERIALS

Excavation shall include the removal of all soil, weathered rock, boulders, conduits, pipe, and all other obstacles encountered and shown on the Contract Drawings or specified herein.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer before approval is given to proceed:

1. Plans of open cut excavations showing side slopes and limits of the excavation at grade.

2. List of disposal site(s) for waste and unsuitable materials.

3. Descriptive information on Excavation equipment to be used.

D. CONSTRUCTION

1. The Contractor shall conduct Excavation activities in such a manner that erosion of disturbed areas and off site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. The Contractor shall excavate to the lines and grades shown on the Contract Drawings and stockpile all suitable excavated materials. As the excavation is made, the materials will be examined and identified to the CQA Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Excavation, including pipe excavations, soil overexcavation, and anchor trenches.

3. Stockpiling:

   The Contractor shall stockpile the materials in appropriate stockpiles as approved by the CQA Engineer. The Contractor shall use equipment and methods as necessary to maintain the moisture content of soils stockpiled (excluding topsoil) at or near their optimum moisture content.

   Stockpiles shall be properly sloped and the surfaces sealed by the Contractor at the end of each working day, or during the day in the event of heavy rain, to the satisfaction of the Engineer.

4. The Contractor shall protect all existing facilities and structures including, but not limited to, existing utilities, monitoring wells, signs, grade stakes, etc. during the grading and stockpiling operations.

5. All excavations shall be made in the dry and in such a manner and to such widths as will give ample room for properly constructing and inspecting the structures and/or piping they are to contain and for such sheeting, timbering, pumping, and drainage as may be required.

6. The Contractor shall be responsible for Dewatering as described in Section 02140, Dewatering, of these Specifications, when necessary.

7. Excavation slopes shall be flat enough to avoid sloughs and slides that will cause disturbance of the subgrade or damage of adjacent areas. Slides and overbreaks which occur due to negligence, carelessness, or improper construction techniques

on the part of the Contractor shall be removed and disposed of by the Contractor as directed by the Engineer at no additional cost to the Owner.

8. The intersection of slopes with natural ground surfaces, including the beginning and ending of cut slopes, shall be uniformly rounded. All protruding roots and other vegetation shall be removed from slopes.

9. The bottom of all excavations for structures and pipes shall be examined by the CQA Engineer for bearing value and the presence of unsuitable material. If, in the opinion of the CQA Engineer, additional Excavation is required due to the low bearing value of the subgrade material, or if the in-place materials are soft, yielding, pumping and wet, the Contractor shall remove such material to the required width and depth and replace it with thoroughly compacted structural fill, or material directed by the CQA Engineer. No payment will be made for subgrade disturbance caused by inadequate Dewatering or improper construction methods.

10. Any areas excavated below design subgrade elevations by the Contractor, unless directed by the CQA Engineer, shall be brought back to design elevations at no cost to the Owner. The Contractor shall place and compact such material in accordance with Section 02223, Embankment, of these Specifications.

11. The Contractor shall dispose of excess or unsuitable excavation materials on-site at location(s) approved by the Owner.

12. The Contractor shall properly level-off bottoms of all excavations. Proof-rolling shall be conducted with appropriate equipment.

13. Upon reaching subgrade elevations shown in excavation areas, the Contractor shall scarify subgrade soils to a minimum depth of 6" and obtain the CQA Engineer's approval of quality. If unsuitable materials are encountered at the subgrade elevation, perform additional excavations as approved by the CQA Engineer to remove unsuitable materials.

14. Where subgrade materials are determined to be unsuitable, such materials shall be removed by the Contractor to the lengths, widths and depths approved by the CQA Engineer and backfilled with suitable material unless further excavation or earthwork is required. No additional payment will be made for such excavation and backfill 1 foot or less than the finished subgrade. Unsuitable material excavation greater than 1 foot beneath the finished subgrade shall be made on a unit price basis for excavation and backfill, only as approved by the Engineer and CQA Engineer prior to the work. Unit price for overexcavation and backfill greater than 1 foot in depth shall include disposal of unsuitable materials.

15. All cuts shall be brought to the grade and cross section shown on the Contract Drawings, or established by the Engineer, prior to final inspection.

16. The Contractor shall protect finished lines and grades of completed excavation against excessive erosion, damage from trafficking, or other causes and shall repair any damage at no additional cost to the Owner.

17. Trench Excavation:

a. All pipe Excavation and trenching shall be done in strict accordance with these Specifications, all applicable parts of the OSHA Regulations, 29 CFR 1926, Subpart E, and other applicable regulations. In the event of any conflicts in this information, safe working conditions as established by the appropriate OSHA guidelines shall govern.

b. The minimum trench widths shall be as indicated on the Contract Drawings. Enlargements of the trench shall be made as needed to give ample space for operations at pipe joints. The width of the trench shall be limited to the maximum dimensions shown on the Contract Drawings, except where a wider trench is needed for the installation of and work within sheeting and bracing.

c. Except where otherwise specified, excavation slopes shall be flat enough to avoid slides which will cause disturbance of the subgrade, damage to adjacent areas, or endanger the lives or safety of persons in the vicinity.

d. Hand excavation shall be employed wherever, in the opinion of the Engineer, it is necessary for the protection of existing utilities, poles, trees, pavements, obstructions, or structures.

e. No greater length of trench in any location shall be left open, in advance of pipe laying, than shall be authorized or directed by the Engineer and, in general, such length shall be limited to approximately one hundred (100) feet.

f. Pipe Bedding: All pipe bedding shall be as shown on the Contract Drawings, unless otherwise specified herein.

18. Sheeting and Bracing:

a. The Contractor shall furnish, place, and maintain such sheeting and bracing which may be required to support sides of Excavation or to protect pipes and structures from possible damage and to provide safe working conditions in accordance with current OSHA requirements. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the sole expense of the Contractor. The Contractor shall be responsible for the adequacy of all sheeting and bracing used and for all damage resulting from sheeting and bracing failure or from placing, maintaining, and removing it.

b. The Contractor shall exercise caution in the installation and removal of sheeting to insure that excessive or unusual loadings are not transmitted to any new or existing structure. The Contractor shall promptly repair at his expense any and all damage that can be reasonably attributed to sheeting installation or removal.

c. All sheeting and bracing shall be removed upon completion of the work.

19. If grading operations are suspended for any reason whatsoever, partially completed cut and fill slopes shall be brought to the required slope and the work of seeding and mulching or other required erosion and sedimentation control operations shall be performed at the Contractor's sole expense.

E. MEASUREMENT AND PAYMENT

All work required for Excavation shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02223

EMBANKMENT

Embankment: Embankment is the on-site compacted fill that provides the foundation and the berms for the containment area, the subgrade for some access roadways and structures, and backfill around some structures and piping. Areas defined as Embankment are indicated on the Contract Drawings.

A. DESCRIPTION

1. General:

   The Contractor shall furnish all labor, material, and equipment to complete Embankment including hauling, screening, discing, drying, compaction, control of surface and subsurface water, final grading, sealing, and all necessary and incidental items as detailed or required to complete the Embankment, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

   Related Contract Work is described in the following sections of the Specifications:

Work	Section
Dewatering	02140
Excavation	02222
Rock Removal	02229
Erosion and Sedimentation Control	02270
CQA Manual	Attached

3. Reference Standards:

   The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.
ASTM D 1556	Test for Density of Soil in Place by the Sand-Cone Method.

ASTM D 2167	Test for Density of Soil in Place by the Rubber-Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water Content of Soil and Rock.
ASTM D 2488	Standard Practice for Description and Identification of Soils.
ASTM D 2922	Test for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.

4. Quality Assurance:

Quality Assurance during placement of Embankment will be provided by the Owner as described in the accompanying Project CQA Manual.

5. Definitions:

a Embankment: Shall include construction of all site earthwork including roadways, subgrade, perimeter berm embankments, including preparation of the areas upon which materials are to be placed. Embankment may also be referred to as structural and/or controlled fill. All Embankment materials may be either (off-site) Select Borrow or (on-site) Borrow unless otherwise noted on Contract Drawings or specified by the Engineer.

a. Prepared Subgrade: The ground surface after clearing, grubbing, stripping, excavation, scarification, and/or compaction, and/or proof rolling to the satisfaction of the CQA Engineer.

c. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes. Well-graded does not define any numerical value that must be placed on the coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters. Well-graded is used to define a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

d. Unclassified Fill: The nature of materials to be used is not identified or described herein but must be approved by the Engineer prior to use.

B. MATERIALS

1. The Compacted Embankment shall consist of clean well-graded natural soil classified as SM, SP, SC, ML, MH, CL-ML, CL or CH (ASTM D 2488) containing no topsoil or other deleterious material.

2. Stones or rock fragments shall not exceed one half the maximum lift thickness as compacted in any dimension.

C. SUBMITTALS

The Contractor shall submit the following to the CQA Engineer before approval is given to proceed:

1. Descriptive information on compaction equipment to be used for construction of Embankment and appurtenant structures.

2. Descriptive information on the location and source of off-site borrow material to be used for Embankment, where applicable. Information shall include Standard Proctor curves (ASTM D698) for each borrow material.

D. CONSTRUCTION

1. The Contractor shall conduct Embankment activities in such a manner that erosion of disturbed areas and off-site sedimentation is absolutely minimized as outlined in Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. All placement and compaction of Embankment shall be performed only when the CQA Engineer is informed by the Contractor of intent to perform such work.

3. Embankment shall be placed and compacted to the lines and grades shown on the Contract Drawings. Placement of Embankment outside the construction limits shall occur only as directed and approved by the Engineer.

   The Contractor will perform all surveys necessary to establish and verify lines and grades for all Embankment.

4. The Contractor shall protect all existing facilities including, but not limited to, utilities and monitoring wells.

5. Subgrade Preparation:

   a. The CQA Engineer shall inspect the exposed subgrade prior to placement of Embankment to assure that all rocks, topsoil, vegetation, roots, debris, or other deleterious materials have been removed.

   b. Prior to placement of Embankment, the exposed subgrade shall be proofrolled using a static smooth-drum roller, loaded tandem axle dump truck, or other suitable equipment in the presence of the CQA Engineer. Any soft or unsuitable materials revealed before or during the in-place compaction shall be removed as directed by the CQA Engineer and replaced with suitable Embankment.

6. Surfaces on which Embankment is to be placed, shall be scarified or stepped in a manner which will permit bonding of the Embankment with the existing surface.

7. The Contractor shall be responsible for preparing the materials for the Embankment, including but not limited to, in-place drying or wetting of the soil necessary to achieve the compaction criteria of these Specifications.

8. The Contractor shall be responsible for Dewatering as described in Section 02140, Dewatering, of these Specifications, when necessary.

9. Embankment materials shall be placed in a manner permitting drainage and in continuous, approximately horizontal layers.

10. Compaction Requirements:

    a. The Contractor shall compact Embankment in accordance with the requirements shown in Table 1 of this section. If Embankment does not meet the specified requirements, the Contractor shall rework the material, as may be necessary and continue compaction to achieve these requirements, or remove and replace the material to achieve the specified requirements, at Contractor's expense.

    b. Each lift shall be compacted prior to placement of succeeding lifts. In confined areas, mechanical equipment, suitable for small areas and capable of achieving the density requirements, shall be required.

    c. Lift compaction shall be performed with an appropriately heavy, properly ballasted, penetrating-foot or smooth-drum vibratory compactor depending on soil type. Compaction equipment shall be subject to approval by the CQA Engineer.

11. Embankment that becomes excessively eroded, soft, or otherwise unsuitable shall be removed or repaired by the Contractor as directed by the CQA Engineer, at no cost to the Owner.

12. The exposed surface of Embankment shall be rolled with a smooth-drum roller at the end of each work day to protect from adverse weather conditions.

13. Where Embankment is to be placed and compacted on slopes that are steeper than 3:1, the subgrade shall be benched to a minimum depth of 6 inches and the Embankment shall be placed in horizontal lifts.

14. Backfilling for Structures and Piping:

    a. All structures, including manholes and pipes shall be backfilled with Embankment as shown in the Contract Drawings and as described in these Specifications.

    b. Where sheeting is used, the Contractor shall take all reasonable measures to prevent loss of support beneath and adjacent to pipes and existing structures when sheeting is removed. If significant volumes of soil cannot be prevented from clinging to the extracted sheets, the voids shall be continuously backfilled as rapidly as possible. The Contractor shall thereafter limit the depth below subgrade that sheeting will be driven in similar soil conditions or employ other appropriate means to prevent loss of support.

    c. When backfilling around structures, do not backfill until concrete has sufficiently cured (as determined by the CQA Engineer) and is properly supported. Place backfill in a manner to avoid displacement or damage of structures.

E. MEASUREMENT AND PAYMENT

All work required for Embankment shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

TABLE 1: REQUIRED EMBANKMENT PROPERTIES

ITEM	Required % Standard Proctor (ASTM D698)	Maximum Lift Thickness (Loose) (inches)
Embankment	95	8
Embankment Beneath Structures[1]	98	6
Backfill Around Structures	95	8
Backfill in Pipe Trenches	95	6
Unclassified Fill	N/A	N/A

Notes:

1. Embankment beneath structures shall be considered to include a zone 10 feet out from the foundation of the structure extending down to the natural ground on a 45° slope.

END OF SECTION

SECTION 02229

ROCK REMOVAL

Rock Removal: Rock Removal refers to the removal of rock material of a size which cannot be excavated by traditional means.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Rock Removal which may be necessary during construction, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Excavation	02222
Embankment	02223

B. MATERIALS

For the purposes of this Project, Rock shall refer to any material occupying an original volume of at least one cubic yard which cannot by excavated with a single-tooth ripper drawn by a crawler tractor having a minimum draw bar pull rated at not less than 56,000 pounds (Caterpillar D 8K, D9, or equivalent).

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit Rock Removal procedures for review and approval in advance.

2. When conducting blasting operations within one hundred fifty (150) feet of an uninhabited structure or within three hundred (300) feet of any inhabited structure, copies of a pre-blast survey shall be furnished prior to commencement of work. This survey should include notation and photographs of any existing cracks or other irregularities.

3. Copies of all blasting and seismograph reports, on forms acceptable to the Division of State Fire Marshal, shall be submitted within three working days of each blast.

D. CONSTRUCTION

1. No rock shall be removed prior to authorization by the Engineer.

2. Where rock is encountered above design subgrade elevations, rock shall be removed to approximately 1 foot below the subgrade lines and grades indicated on the Contract Drawings as approved by the Engineer.

   The subgrade will be brought back up to grade by placing suitable Embankment as described in Section 02223, Embankment, of these Specifications.

3. Blasting:

   a. Blasting cannot be performed within the footprint of the liner system.

   b. Blasting shall only be performed when all other reasonable methods fail to remove the rock.

   c. All blasting shall be approved at least two weeks in advance by the Engineer and Owner and shall be conducted in accordance with all applicable ordinances and regulations.

   d. The blasting shall be done by a licensed blaster.

   e. Storage of explosive materials on the site will be prohibited.

   f. All blasts within one hundred fifty (150) feet of an uninhabited structure or within three hundred (300) feet of any inhabited structure shall be monitored with a direct reading velocity seismograph. At the immediate location of an uninhabited structure the maximum peak particle velocity shall not exceed two inches per second. At the immediate location of an inhabited structure the maximum peak particle velocity shall not exceed one inch per second.

   g. The Contractor shall be responsible for any and all damage or injury to persons or property resulting from the use of explosives. Any damage done shall be promptly repaired by the Contractor at his expense.

4. Disposal of excavated rock shall be in accordance with all applicable regulations.

E. MEASUREMENT AND PAYMENT

1. Measurement:

Payment quantities for Rock Removal shall be determined by the Engineer based on the in-place quantity of rock removed.

2. Payment:

All work described in this section and required for Rock Removal shall be included for payment in the Unit Price Bid for Item **X.X**, per cubic yard.

END OF SECTION

SECTION 02240

GEOTEXTILES

Geotextiles: For the proposed construction a Type GT-S (Separator/Filter) Geotextile is specified. The Type GT-S Geotextile will be placed between soil subgrade and aggregate in access roads and in some erosion control and drainage applications.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Geotextiles including all necessary and incidental items as detailed or required for the Contractor to complete the installation in accordance with the Contract Drawings and these Specifications, except as noted below:

a. Geotextiles used as a Silt Fence is covered under Section 02270, Erosion and Sedimentation Control, of these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
Aggregate Surfacing	02505

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO) are hereby made a part of these specifications.

ASTM D 3786	Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics: Diaphragm Bursting Strength Tester Method.
ASTM D 4355	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).

ASTM D 4491	Test Methods for Water Permeability of Geotextiles by Permittivity.
ASTM D 4533	Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
ASTM D 4632	Test Method for Grab Breaking Load and Elongation of Geotextile.
ASTM D 4751	Test Method for Determining Apparent Opening Size of a Geotextile.
ASTM D 4833	Test Methods for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
ASTM D 5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
AASHTO M 288	Standard Specification for Geotextiles.

B. <u>MATERIALS</u>

1. <u>General:</u>

   The materials supplied under these Specifications shall consist of new, first-quality products designed and manufactured specifically for the purpose of this work, which shall have been satisfactorily demonstrated, by prior use, to be suitable and durable for such purposes.

   Labels on each roll of Geotextile shall identify the length, width, lot and roll numbers, and name of Manufacturer.

2. <u>The Type GT-S Geotextile</u> shall be a woven, nonwoven spunbonded, or nonwoven needlepunched synthetic fabric consisting of polyester or polypropylene manufactured in a manner approved by the Engineer and the Owner.

3. All Geotextiles shall conform to the properties listed in Table 1 of this section.

C. <u>SUBMITTALS</u>

The Contractor shall submit the following to the Engineer:

1. <u>Mill Certificate and Sample:</u> Prior to shipping to the site, the Contractor shall submit one copy of a mill certificate or affidavit signed by a legally authorized

official of the Manufacturer for each type of Geotextile attesting that the Geotextiles meet the physical and manufacturing requirements stated in these Specifications. The Contractor shall also submit a sample (4" x 6") of each Geotextile to be used. The samples shall be labeled with the product name and be accompanied by the Manufacturer's specifications.

2. Shipping, Handling, and Storage Instructions: The Manufacturer's plan for shipping, handling, and storage shall be submitted for review.

3. Quality Control Certificates: For Geotextiles delivered to the site, quality control certificates, signed by the Manufacturer's quality assurance manager shall be provided for every roll of each type of Geotextile supplied. Each certificate shall have the roll identification number(s), test methods, frequency, and test results. At a minimum, the test results and frequency of testing shall be as shown in Table 2 of this section.

4. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into the construction.

D. CONSTRUCTION

1. Shipping, Handling, and Storage:

All Geotextiles shall be shipped, handled, and stored in strict accordance with the Manufacturer's recommendations.

2. Installation of Geotextiles:

a. The surface receiving the Geotextiles shall be prepared to a relatively smooth condition, free of obstructions, excessive depressions, debris, and very soft or loose pockets of soil. This surface shall be approved by the Engineer prior to Geotextile placement.

b. Geotextiles shall be placed to the lines and grades shown on the Contract Drawings. At the time of installation, Geotextiles shall be rejected by the Engineer if they have defects, rips, holes, flaws, evidence of deterioration, or other damage.

c. The Geotextiles shall be placed smooth and free of excessive wrinkles.

d. On slopes, Geotextiles shall be anchored at the top and unrolled down the slope. In the presence of wind, all Geotextiles shall be weighted with sandbags or other material as approved by the Engineer. Geotextiles uplifted by wind may be reused upon approval by the Engineer.

4. <u>Seams:</u>

   a. All Geotextile seams shall be sewn. On slopes greater than 10 percent, all seams shall be oriented parallel to (in the direction of) the slope unless otherwise approved by the Engineer.

   b. Seams to be sewn shall be sewn using a Type 401 stitch. One or two rows of stitching may be used. Each row of stitching shall consist of 4 to 7 stitches per inch. The minimum distance from the geotextile edge to the stitch line nearest to that edge (seam allowance) shall be 1.5 inches if a Type SSa (prayer or flat) seam is used. The minimum seam allowance for all other seam types shall be 1.0 inches. All seams must be approved by the Engineer.

   c. Alternately, the Contractor may overlap or heat bond adjacent panels with methods approved by the Engineer.

5. <u>Repair Procedures:</u>

   a. Any Geotextile that is torn or punctured shall be repaired or replaced, as directed by the Engineer, by the Contractor at no additional cost to the Owner. The repair shall consist of a patch of the same type of Geotextile placed over the failed areas and shall overlap the existing Geotextile a minimum of 18 inches from any point of the rupture. Patches shall be spot sewn so as not to shift during cover placement.

   b. <u>Slopes Less Than or Equal to 10 Percent:</u> Damaged areas of a size exceeding 10 percent of the roll width shall be removed and replaced across the entire roll width with new material. Damaged areas of a size less than 10 percent of the roll width may be patched.

   c. <u>Slopes Greater Than 10 Percent:</u> Geotextile panels which require repair shall be removed and replaced with new material. Replacement material shall be sewn as previously described in this specification.

6. <u>Cover Placement:</u>

   Placement of cover over Geotextiles shall be performed in a manner as to ensure that the Geotextiles are not damaged. Cover material shall be placed such that excess tensile stress is not mobilized in the Geotextile.

E. MEASUREMENT AND PAYMENT

All work required for Geotextiles shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

TABLE 1: REQUIRED GEOTEXTILE PROPERTIES

PROPERTY	TEST METHOD	UNITS	VALUE[1]
			TYPE GT-S
Geotextile Construction (NW = Nonwoven) (W = Woven)	----------	----------	NW[2] or W[3]
Mass per Unit Area (Unit Weight)	ASTM D 5261	oz/yd^2	N/A
Ultraviolet Resistance (500 hrs)	ASTM D 4355	%	70
Strength Class[4]	AASHTO M 288	Class	2
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70+
Permittivity	ASTM D 4491	sec^{-1}	1.0

Notes:

1. Minimum Average Roll Value (MARV).
2. Nonwoven geotextiles that have been heat calendered are not acceptable.
3. Woven geotextiles formed exclusively with slit film fibers are not acceptable.
4. AASHTO M 288 includes requirements for the following properties:
   - Grab Tensile Strength (ASTM D 4632),
   - Grab Tensile Elongation (ASTM D 4632),
   - Trapezoidal Tear Strength (ASTM D 4533),
   - Puncture Resistance (ASTM D 4833), and
   - Burst Strength (ASTM D 3786).

TABLE 2: REQUIRED MANUFACTURER'S QUALITY CONTROL TEST DATA

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
Mass per Unit Area (Unit Weight)	ASTM D 5261	100,000 ft^2
Ultraviolet Resistance (500 hrs)	ASTM D 4355	100,000 ft^2
Grab Tensile Strength	ASTM D 4632	100,000 ft^2
Grab Tensile Elongation	ASTM D 4632	100,000 ft^2
Burst Strength (Diaphragm Methods)	ASTM D 3786	100,000 ft^2
Apparent Opening Size (AOS)	ASTM D 4751	100,000 ft^2
Permittivity	ASTM D 4491	100,000 ft^2
Puncture Resistance	ASTM D 4833	100,000 ft^2
Trapezoidal Tear Strength	ASTM D 4533	100,000 ft^2

END OF SECTION

SECTION 02258

VEGETATIVE SOIL LAYER

Vegetative Soil Layer (VSL): The Vegetative Soil Layer (VSL) is placed in the final cover system in order to support permanent vegetative cover. This section includes the topsoil to be placed as the upper 6 inches of the VSL.

A. DESCRIPTION

1. General:

   The Contractor shall furnish all labor, material, and equipment to complete installation of the VSL (including topsoil) for the landfill cover, including hauling, spreading, and final grading and all necessary and incidental items as detailed or required to complete the VSL, all in accordance with the Contract Drawings and these Specifications.

2. Related Work:

   Related Contract Work is described in the following sections of the Specifications:

Work	Section
Revegetation	02930

3. Reference Standards:

   The latest revision of the following standards of the American Society of Testing and Materials (ASTM) are hereby made a part of these Specifications.

ASTM D 2488	Standard Practice for Description and Identification of Soils.

B. MATERIALS

Soil that meets all of the following requirements shall be classified as select soil fill for use in construction of the VSL.

1. Soil shall be classified according to the Unified Soil Classification System (USCS) as SM, SC, ML, MH, CL-ML, or CL (ASTM D 2488).

2. Select soil fill materials shall be reasonably free of gypsum, ferrous, and/or

calcareous concretions and nodules, refuse, roots, or other deleterious substances.

3. Continuous and repeated visual inspection of the materials being used will be performed by the Contractor to ensure proper soils are being used. In addition, the Engineer shall make frequent inspections of the placement operations and materials, and will consult with the Engineer.

4. The VSL shall be uniform, smooth, and free of debris, rock, plant materials, and other foreign material larger than 3 inches in diameter. This material must be capable of supporting growth of vegetative cover.

5. Topsoil: The upper 6 inches of VSL shall contain a minimum of 2% by weight of organics evenly blended into the material in order to support the growth of vegetative cover. Also, the topsoil shall contain 10% by weight gravel size particles (1-½ inch maximum particle size) to aid in the prevention of excess wind erosion.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Before approval is given to proceed, the Contractor shall submit descriptive information on placement equipment to be used in construction of the VSL.

2. Survey Results:

   After completion of a segment of VSL, survey results shall be submitted for review prior to VSL acceptance.

D. CONSTRUCTION

1. All placement of VSL shall be performed only when the Engineer is informed by the Contractor of intent to perform such work.

2. VSL shall be placed as specified below:

   a. The VSL, including topsoil, shall be placed and spread using low ground pressure (less than 6 psi) tracked equipment. The Engineer shall approve the equipment used to place the VSL.

   b. VSL shall be placed to the lines and grades shown on the Contract Drawings with the exception that a 2 inch overbuild at Contractor's expense is allowed. The Contractor will perform all surveys necessary to establish and verify lines and grades for all VSL.

3. After the specified thickness has been achieved and verified, the Contractor shall proceed immediately with seeding.

4. Surveying:

   After completion of a segment of VSL, the VSL shall be surveyed on 100 foot centers and at slope breaks to ensure:

   a. The specified thickness has been achieved.

   b. The top of the VSL slopes at grades specified on the Contract Drawings; and

   c. VSL placed more than 2 inches beyond the limits of the lines and grades as shown on the Contract Drawings will not be accepted and must be removed at the Contractor's sole expense if required by the Engineer.

   This work shall be performed at the Contractor's cost by a surveyor registered in the State of North Carolina.

E. MEASUREMENT AND PAYMENT

All work required for Vegetative Soil Layer shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02270

EROSION AND SEDIMENTATION CONTROL

Erosion and Sedimentation Control: Erosion and Sedimentation Control is a system of construction practices and engineered structures which act to minimize surface water induced erosion of disturbed areas and resulting sedimentation off-site. These Specifications meet or exceed the guidelines of the North Carolina Sediment Control Planning and Design Manual.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of and maintain Erosion and Sedimentation Control facilities and other construction in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
Rip Rap	02271
Revegetation	02930

B. MATERIALS

1. Permanent Sediment Basins:

Permanent sediment basins shall be constructed as shown on the Contract Drawings.

2. Permanent Ditches, Swales, and Drainage Channels:

Permanent ditches, swales, and drainage channels shall be constructed as shown on the Contract Drawings.

3. Silt Fence:

Silt fences shall be constructed as shown on the Contract Drawings and as needed, based on the Contractor's discretion and Engineer's approval. The silt fence is a permeable barrier erected within and downgradient of small disturbed areas to capture sediment from sheet flow. It is made of filter fabric buried at the bottom, stretched, and supported by posts and wire mesh backing. Silt fence shall conform to the following properties:

Posts: Posts shall be 3 feet long "U" or "T"-type steel or wood posts.

Filter Fabric: Filter fabric shall be a woven geotextile made specifically for sediment control. Filter fabric shall have the following minimum properties:

PROPERTY	TEST METHOD	UNITS	MINIMUM VALUE
Grab Tensile Strength	ASTM D 4632	lbs	100
Grab Elongation	ASTM D 4632	%	15
Trapezoidal Tear Strength	ASTM D 4533	lbs	50
Mullen Burst Strength	ASTM D 3786	lbs	265
Puncture Strength	ASTM D 4833	lbs	55
UV Resistance	ASTM D 4355	%	80

4. Geotextiles:

Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

5. Temporary Sediment Traps:

Temporary sediment traps shall be constructed as shown on the Contract Drawings.

6. Filter Berm Basins:

Filter berm basins shall be constructed as shown on the Contract Drawings.

7. Down Chutes:

Down chutes shall be constructed as shown on the Contract Drawings.

8. Rip Rap:

Rip Rap shall conform to the requirements outlined in Section 02271, Rip Rap, of these Specifications.

9. Jute Netting:

Jute netting shall consist of an open weave geotextile made from perpendicular rows of polypropylene photodegradable spun and tape yarns woven into a dimensionally stable matrix. The non-fused, freely opening matrix shall possess strength and elongation properties to limit stretching.

10. Straw With Net Temporary Erosion Control Matting:

The matting shall consist of clean wheat straw from agricultural crops made into a knitted straw mat that is machine assembled. The straw shall be evenly distributed throughout the mat. The mat shall be covered with a photodegradable synthetic mesh attached to the straw with degradable thread.

11. Excelsior Temporary Erosion Control Matting:

The matting shall consist of machine-produced mat of curled wood excelsior with a majority of the fibers 6 inches or longer with consistent thickness and the fibers evenly distributed over the entire area of the mat. The top of the mat shall be covered with a biodegradable synthetic mesh. The mesh shall be attached to the curled wood excelsior with photodegradable synthetic yarn.

12. Turf Reinforcement Matting:

The matting shall consist of entangled nylon, polypropylene, or polyester monofilaments melt bonded at their intersections forming a three dimensional structure. The mat shall be crush-resistant, pliable, water-permeable, and highly resistant to chemical and environmental degradation. The matting shall also meet the following criteria:

Maximum Permissible Velocity $\geq$ 12 ft/sec
Maximum Permissible Shear Stress $\geq$ 6 lbs/ft^2.

13. Other Work:

In addition to the erosion control measures shown on the Contract Drawings, the Contractor shall provide adequate means to prevent any sediment from entering any storm drains, drop inlets, ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of off-site areas. In areas where a natural buffer area exists between the work area and the closest stream or water course, this area shall not be disturbed. All paved areas shall be scraped and swept as necessary to prevent the accumulation of dirt and debris. Work associated with this provision shall be considered incidental to the project and no separate payment will be made.

14. Temporary Ground Cover:

The Contractor shall provide temporary or permanent ground cover adequate to restrain erosion on erodible slopes or other areas that will be left unworked for periods exceeding 30 calendar days.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Erosion and Sedimentation Control materials manufactured for the project have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Establishment of Erosion Control Devices:

   a. All erosion control structures will be constructed according to the Contract Drawings and these Specifications.

   b. Due to the nature of the work required by this Contract, it is anticipated that the location and nature of the erosion control devices may need to be adjusted on several occasions to reflect the current phase of construction.

   c. Erosion control devices shall be established prior to the work in a given area. Where such practice is not feasible, the erosion control device(s) shall be established immediately following completion of the clearing operation.

d. The construction schedule adopted by the Contractor will impact the placement and need for specific devices required for the control of erosion. The Contractor shall develop and implement such additional techniques as may be required to minimize erosion and off-site sedimentation.

e. The location and extent of erosion control devices shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from construction areas. All deviations from the control provisions shown on the Contract Drawings shall have the prior approval of the Engineer.

2. Maintenance of Erosion Control Devices:

a. The Contractor shall furnish the labor, material, and equipment required for maintenance of all erosion control devices. Maintenance shall be scheduled as required for a particular device to maintain the removal efficiency and intent of the device.

b. All erosion control devices shall be inspected immediately after each significant rainfall event, and appropriate maintenance conducted.

c. Maintenance shall include, but not be limited to:

(1) The removal and satisfactory disposal of trapped sediments from basins or silt barriers;

(2) Replacement of filter fabrics used for silt fences upon loss of specified efficiency; and

(3) Replacement of any other components which are damaged or cannot serve the intended use.

d. Sediments removed from erosion control devices shall be disposed of in locations that will not result in off-site sedimentation as approved by the Engineer.

e. All erosion control structures shall be maintained to the satisfaction of the Engineer until the site has been stabilized.

3. Finish Grading:

All disturbed areas outside of the disposal area shall be uniformly graded to the lines, grades, and elevations shown on the Contract Drawings. Finished surfaces shall be reasonably smooth, compacted, and free from irregular surface changes. Unless otherwise specified, the degree of finish shall be that ordinarily obtainable from either blade or scraper operations. Areas shall be finished to a smoothness suitable for application of topsoil.

4. Seeding:

Seeding shall conform to the requirements of Section 02930, Revegetation, of these Specifications.

5. Cleanup:

a. The Contractor shall remove from the site all subsoil excavated from his work and all other debris including, but not limited to, branches, paper, and rubbish in all landscape areas, and remove temporary barricades as the work proceeds.

b. All areas shall be kept in a neat, orderly condition at all times. Prior to final acceptance, the Contractor shall clean up the entire landscaped area to the satisfaction of the Engineer.

E. MEASUREMENT AND PAYMENT

All work required for Erosion and Sedimentation Control shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02271

RIP RAP

Rip Rap: This section includes all rip rap aprons and channel protection.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of Rip Rap for protection of earthen slopes against erosion as indicated, including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Geotextiles	02240
Erosion and Sedimentation Control	02270

3. Reference Standards:

The latest revision of the following standards of the North Carolina Department of Transportation (NCDOT) are hereby made a part of these Specifications.

NCDOT Standard Specifications for Roads and Structures.

B. MATERIALS

1. Rip Rap: Rip Rap shall be of the size indicated on the Contract Drawings and shall conform to NCDOT Section 1042, Rip Rap Materials.

2. Geotextiles: Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results prior to installation, that all Rip Rap has been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Surface Preparation:

a. Trim and dress all areas to conform to the Contract Drawings as indicated with tolerance of 2 inches from theoretical slope lines and grades.

b. Bring areas that are below allowable minimum tolerance limit to grade by filling with compacted Embankment material similar to adjacent material.

c. Geotextiles shall be placed as shown on the Contract Drawings and in accordance with Section 02240, Geotextiles, of these Specifications.

d. Do not place any stone material on the prepared surface prior to inspection and approval to proceed from the Engineer.

2. Placing Rip Rap:

Rip Rap shall be placed in accordance with NCDOT Section 868, Rip Rap.

E. MEASUREMENT AND PAYMENT

All work required for Rip Rap shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02505

AGGREGATE SURFACING

Aggregate Surfacing: Aggregate Surfacing will include wearing surface placement for vehicular traffic on final graded perimeter areas and access ramps/roads.

A. DESCRIPTION

1. General:

   The Contractor shall furnish all labor, material, and equipment to complete installation of Aggregate Surfacing including crushed stone placement and grading in accordance with the Contract Drawings and these Specifications.

2. Related Work:

   Related Contract Work is described in the following sections of the Specifications:

Work	Section
Embankment	02223
Geotextiles	02240

3. Reference Standards:

   The latest revision of the following standards of the North Carolina Department of Transportation (NCDOT) are hereby made a part of these Specifications.

   NCDOT Standard Specifications for Roads and Structures.

B. MATERIALS

1. Aggregate Base Course (ABC): ABC materials shall be in accordance with NCDOT Section 520, Aggregate Base Course. Type "A" or "B" aggregate will be acceptable for this project.

2. Geotextiles: Geotextiles shall conform to the requirements outlined in Section 02240, Geotextiles, of these Specifications.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results prior to installation, that all materials required for Aggregate Surfacing have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. Existing subgrade upon which ABC is to be placed shall be prepared in accordance with Section 02223, Embankment, of these Specifications.

2. Geotextiles shall be placed as shown on the Contract Drawings and in accordance with Section 02240, Geotextiles, of these Specifications.

3. Construct ABC to the grade, thickness, and typical section as indicated on the Contract Drawings.

4. ABC shall be constructed in accordance with NCDOT Section 520, Aggregate Base Course, except that mixing, moisture addition, and compaction testing may be omitted.

3. Compaction:

   a. Compact by vibrating or other methods approved by the Engineer.

   b. Any irregularities in the surface shall be corrected by scarifying, remixing, reshaping and recompacting until a smooth surface is secure.

   c. The Engineer may approve other stone surfacing materials and testing requirements (if any).

E. MEASUREMENT AND PAYMENT

All work required for Aggregate Surfacing shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02720

STORM WATER SYSTEMS

Storm Water Systems: Storm Water Systems shall include all piping, pipe fittings, headwalls, flared end sections, drop inlets, and other appurtenances designated to convey stormwater.

A. DESCRIPTION

1. General:

The contractor shall furnish all labor, material, and equipment to complete installation of Storm Water Systems in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Excavation	02222
Embankment	02223

3. Reference Standards:

The latest revision of the following standards of the American Society of Testing and Materials (ASTM) and the American Association of State Highway and Transportation Officials (AASHTO) are hereby made a part of these specifications.

ASTM C 76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
ASTM C 150	Specification for Portland Cement.
ASTM D 1248	Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.
ASTM D 2321	Standard Specification for Underground Installation of Flexible Thermoplastic Sewer Pipe.

ASTM D 3350	Standard Specification for Polyethylene Plastics Pipe and Fitting Materials.
AASHTO M 36	Specification for Corrugated Steel Pipe.
AASHTO M 252	Specification for Corrugated Polyethylene Drainage Tubing, 3 to 10 Inch Diameter.
AASHTO M 294	Specification for Corrugated Polyethylene Pipe, 12 to 36 Inch Diameter.

B. MATERIALS

1. Concrete Culvert and Drain Pipe:

   a. All reinforced concrete culvert and drain pipe shall be manufactured in accordance with ASTM C 76, Wall Type B or C, and shall be of the class that equals or exceeds the pipe class as shown on the Contract Drawings. All pipe shall be aged at the manufacturing plant for at least fourteen (14) days before delivery to the job site.

   b. Minimum pipe laying lengths shall be four (4) feet.

   c. Joints for the reinforced concrete culvert and drain pipe shall have bell and spigot ends with flexible preformed plastic gaskets.

2. Corrugated Metal Pipe (CMP):

   a. Corrugated metal pipe and fittings shall be of the sizes shown or specified and shall conform to every aspect of AASHTO M 36.

   b. Corrugated metal pipe shall be fabricated from galvanized steel sheets. Corrugation profile shall be 2-2/3 inch crest to crest and ½ inch crest to valley, and sheet thickness shall be 16 gage/.064 inch minimum.

   c. Pipe sections shall be helically corrugated with each pipe end rerolled to obtain no less than two (2) annular corrugations.

   d. Coupling Bands: CMP shall be firmly joined by coupling bands in accordance with the manufacturer's recommendations. These bands shall be not more than two nominal sheet thicknesses lighter than the thickness of the pipe to be connected and in no case lighter than 0.052 inches.

   e. All CMP utilized for permanent installation shall have gasketed joints.

f. Asphaltic or bituminous coatings shall be applied in conformance with the manufacturer's requirements, as applicable.

3. Corrugated Polyethylene (CPE) Pipe:

CPE Pipe and fittings shall be of the sizes and type shown on the Contract Drawings and shall conform to every aspect of AASHTO M 252 (3 to 10 inch diameters) or AASHTO M 294 (12 to 36 inch diameters).

4. Drop Inlets, Headwalls, and Flared End Sections:

Drop inlets, headwalls, and flared end sections shall be as described in the Contract Drawings.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Submit a certification and summary of all required test results, prior to installation, that all Storm Water Systems have been produced in accordance with these Specifications.

2. Furnish copies of the delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction.

D. CONSTRUCTION

1. All piping shall be installed by skilled workmen and in accordance with the best standards for piping installation. Proper tools and appliances for the safe and convenient handling and installation of the pipe and fittings shall be used.

2. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced at the Contractor's expense.

3. Excavation and backfilling of pipe trenches shall be as described in Section 02222, Excavation and Section 02223, Embankment, respectively, of these Specifications.

4. Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. No materials shall be dropped or dumped into the trench.

5. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fittings, or valves. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored as required.

6. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade.

7. The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings. Before joints are made, each pipe shall be well bedded on a solid foundation. No pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place. Pipe that has the grade or joint disturbed after laying shall be taken up and relaid by the Contractor at his own expense.

8. The laying of reinforced concrete pipe shall conform to the applicable sections of the Concrete Pipe Handbook as published by the American Concrete Pipe Association.

E. MEASUREMENT AND PAYMENT

All work required for Storm Water Systems shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

SECTION 02930

REVEGETATION

Revegetation: Revegetation includes permanent Revegetation of disturbed site areas as indicated on the Contract Drawings. Note that the seeding schedule provided in this section is based on Table 6.11p of the North Carolina Erosion and Sediment Control Planning and Design Manual.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete Revegetation in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Embankment	02223
Vegetative Soil Layer	02258
Erosion and Sedimentation Control	02270

B. MATERIALS

1. Limestone: Unless otherwise defined by specific soil tests, supply agricultural grade ground limestone conforming to the current "Rules, Regulations, and Standards of the Fertilizer Board of Control."

2. Fertilizer: Unless otherwise defined by specific soil tests, supply commercial fertilizer of 10-10-10 analysis, meeting applicable requirements of State and Federal law. Do not use cyanamic compounds of hydrated lime. Deliver fertilizer in original containers labeled with content analysis.

3. Grass Seed: Supply fresh, clean, new-crop seed as specified in Table 1 of this section. Do not use seed which is wet, moldy, or otherwise damaged. Deliver seed in standard sealed containers labeled with producer's name and seed analysis, and in accord with US Department of Agriculture Rules and Regulations under Federal Seed Act.

4. Mulch: Supply clean, seed-free, threshed straw of oats, wheat, barley, rye, beans, or other locally available mulch material.

   a. Do not use mulch containing a quantity of matured, noxious weed seeds or other species that will be detrimental to seeding, or provide a menace to surrounding land.

   b. Do not use mulch material which is fresh or excessively brittle, or which is decomposed and will smother or retard growth of grass.

5. Binder: Supply emulsified asphalt or synthetic binder.

6. Water: Supply potable, free of substances harmful to growth.

C. SUBMITTALS

The Contractor shall submit the following to the Engineer:

1. Certificates for each grass seed mixture, stating botanical and common name, percentage by weight, and percentages of purity, germination, and weed seed. Certify that each container of seed delivered is fully labeled in accordance with Federal Seed Act and equals or exceeds specification requirements.

2. Copies of invoices for fertilizer, showing grade furnished and total quantity applied.

D. CONSTRUCTION

1. The Contractor shall establish a smooth, healthy, uniform, close stand of grass from the specified seed. The Engineer will perform the observations to determine when successful Revegetation is achieved.

2. Soil Preparation:

   a. Limit preparation to areas which will be planted soon after preparation.

   b. Loosen surface to minimum depth of four (4) inches.

   c. Remove stones, sticks, roots, rubbish and other extraneous matter over three (3) inches in any dimension.

   d. Spread lime uniformly over designated areas at the rate specified in Table 1 of this section.

e. After application of lime, prior to applying fertilizer, loosen areas to be seeded with double disc or other suitable device if soil has become hard or compacted. Correct any surface irregularities in order to prevent pocket or low areas which will allow water to stand.

f. Distribute fertilizer uniformly over areas to be seeded at the rate specified in Table 1 of this section.

(1) Use suitable distributor.

(2) Incorporate fertilizer into soil to depth of a least two (2) inches.

(3) Remove stones or other substances which will interfere with turf development or subsequent mowing.

g. Grade seeded areas to smooth, even surface with loose, uniformly fine texture.

(1) Roll and rake, remove ridges and fill depressions, as required to meet finish grades.

(2) Fine grade just prior to planting.

5. <u>Seeding:</u>

a. Use approved mechanical power driven drills or seeders, mechanical hand seeders, or other approved equipment.

b. Distribute seed evenly over entire area at the rate specified in Table 1 of this section.

c. Stop work when work extends beyond most favorable planting season for species designated, or when satisfactory results cannot be obtained because of drought, high winds, excessive moisture, or other factors.

d. Resume work only when favorable condition develops, or as directed by the Engineer.

e. Lightly rake seed into soil followed by light rolling or cultipacking.

f. Immediately protect seeded areas against erosion by mulching or placing erosion control matting or netting, where applicable.

(1) Spread mulch in a continuous blanket at the rate specified in Table 1 of this section.

(2) Immediately following spreading mulch, secure with evenly distributed binder at the rate specified in Table 1 of this section.

6. <u>Maintenance:</u>

a. Regrade and revegetate all eroded areas until stabilized by grass.

b. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose. Anchor as required to prevent displacement.

c. Replant bare areas using same materials specified.

E. <u>MEASUREMENT AND PAYMENT</u>

All work required for <u>Revegetation</u> shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

TABLE 1: SEEDING SCHEDULE

MATERIAL	SEED TYPE	MINIMUM SEED PURITY (%)	APPLICATION RATE[1]
Lime	-----	-----	4000 lbs/acre
Fertilizer	-----	-----	1000 lbs/acre
Seed	Kentucky 31 Tall Fescue Pensacola Bahiagrass Sericea Lespedeza[3] Kobe Lespedeza Seasonal Nurse Crop[2]	97 97 97 97 97	80 lbs/acre 50 lbs/acre 30 lbs/acre 10 lbs/acre See Note 2
Mulch	-----	-----	1500 lbs/acre
Binder	-----	-----	150 gallons/acre

Notes:

1. Application rates and/or chemical analysis shall be confirmed or established by a soil test.

2. Use seasonal nurse crop in accordance with seeding dates as stated below:

April 15 - August 15	10 lbs/acre German Millet or 15 lbs/acre Sudangrass
August 15 - April 15	25 lbs/acre Rye (grain).

3. From September 1 - March 1, use unscarified sericea seed.

END OF SECTION

SECTION 03310

CONCRETE WORK

Concrete Work: Concrete will be placed around sediment basin risers to anchor these structures against hydrostatic uplift.

A. DESCRIPTION

1. General:

The Contractor shall furnish all labor, material, and equipment to complete installation of all concrete including all necessary and incidental items, in accordance with the Contract Drawings and these Specifications.

2. Related Work:

Related Contract Work is described in the following sections of the Specifications:

Work	Section
Erosion and Sedimentation Control	02270
Storm Water Systems	02720

3. Reference Standards:

The latest revision of the following standards of the American Concrete Institute (ACI) are hereby made a part of these specifications:

ACI 301 Specifications for Structural Concrete for Buildings.

B. MATERIALS

1. Portland Cement:

Cement shall be Portland cement Type II conforming to ASTM C 150, unless otherwise acceptable to the Engineer. Cement shall be proportioned in the mix for the specified class of concrete in conformity with the applicable provisions of ACI 301.

2. Water: Potable.

3. Class B Concrete:

Nonstructural concrete (Class B) may be used for fill concrete, thrust blocks, etc. Class B concrete shall conform to the following requirements:

Compressive Strength (28 day):	2500 psi
Minimum Cement Content:	545 lbs/cy
Maximum Slump:	4 inches

4. Quality Control:

The Contractor will perform Quality Control testing on Concrete Work as described in this section.

C. SUBMITTALS

The Contractor shall submit concrete mix designs to the Engineer for approval at least 15 days prior to the first concrete placement.

D. CONSTRUCTION

1. Concrete shall be placed per the procedures specified in ACI 301.

2. Inserted and Embedded Items:

   Pipes, anchor bolts, steps, and other inserts, as indicated on the Contract Drawings or as required, shall be encased in concrete.

3. Concrete thrust blocks and valve footings shall be poured in-place and shall satisfy the minimum bearing surface requirements as shown on the Contract Drawings.

4. Structures shall be formed, chamfered, and finished in a workman-like manner.

5. Curing:

   Curing shall be with curing compound conforming to ASTM C309, Type 2, Class A in two uniform thoroughly covering coats applied at right angles to each other.

6. Quality Control Testing During Construction:

   The Contractor will employ a testing laboratory to perform tests and to submit test reports. Sampling and testing for quality control during placement of concrete may include the following, as directed by the Engineer:

a. Sampling Fresh Concrete: Follow ASTM C172, except modified for slump to comply with ASTM C94.

(1) Slump: ASTM C143; one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.

(2) Compression Test Specimen: ASTM C31; one set of 3 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required. A minimum of one set shall be made for any pours.

(3) Compressive Strength Tests: ASTM C39; one set for each day's pour exceeding 5 cu. yds. plus additional sets for each 50 cu. yds. over and above the first 25 cu. yds. of each concrete class placed in any one day; one specimen tested at 7 days, one specimen tested at 28 days, and one specimen retained in reserve for later testing if required.

b. Test results will be reported in writing to the Engineer and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7 day tests and 28 day tests.

c. Additional Tests: The testing laboratory will make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, as directed by the Engineer. The testing service, may conduct tests to determine the adequacy of concrete by cored cylinders complying with ASTM C42, or by other methods as directed. The Contractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.

E. MEASUREMENT AND PAYMENT

All work required for Concrete Work shall be included for payment in the Contractor's Lump Sum Price for Item **X.X**, wherein no measurement will be made.

END OF SECTION

Appendix I

Construction Quality Assurance Manual

Halifax County
Construction & Demolition Debris Landfill

Prepared for:

Halifax County Solid Waste Department

Halifax, North Carolina

August 1997

PERMIT ISSUE DOCUMENTS

G.N. Richardson & Associates, Inc.
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HALIFAX COUNTY
CONSTRUCTION AND DEMOLITION DEBRIS LANDFILL

CONSTRUCTION QUALITY ASSURANCE MANUAL

TABLE OF CONTENTS

Table of Contents (Continued)

SECTION 1.0
GENERAL

1.1 INTRODUCTION

This Construction Quality Assurance (CQA) Manual has been prepared to provide the Owner, Engineer, and CQA Engineer the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations.

More specifically, this CQA Manual addresses the earthwork component of the landfill.

The CQA Manual is divided into the following sections:

- Section 1.0 General
- Section 2.0 CQA Documentation
- Section 3.0 Earthwork CQA

1.2 DEFINITIONS RELATING TO CONSTRUCTION QUALITY

1.2.1 Construction Quality Assurance (CQA)

In the context of this Manual, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the earthwork with the project drawings and the project specifications. CQA is provided by the CQA Engineer as a representative of the Owner and is independent from the Contractor and all manufacturers. The CQA program is designed to provide adequate confidence that items or services meet contractual and regulatory requirements and will perform satisfactorily in service.

1.2.2 Construction Quality Control (CQC)

Construction Quality Control refers to actions taken by the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only.

1.2.3 CQA Certification Document

At the completion of construction, a certification document will be prepared by the CQA Engineer and submitted to State Solid Waste Regulators. The certification report will include all CQA testing performed by the CQA Engineer.

1.2.4 Discrepancies Between Documents

The CQA Manual is intended to be a supporting document to improve the overall documentation of the work. The CQA Manual is less specific than the project specifications, and conflicts may exist between the documents. The Contractor is instructed to bring discrepancies to the attention of the CQA Engineer for resolution who shall then notify the Engineer. The Engineer has the sole authority to determine resolution of discrepancies existing within the Contract Documents. Unless otherwise determined by the Engineer, the more stringent requirement shall be the controlling resolution.

1.3 PARTIES TO CONSTRUCTION QUALITY ASSURANCE

1.3.1 Description of the Parties

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, CQA Engineer, and Soils CQA Laboratory.

1.3.1.1 <u>Owner</u>

The Owner is Halifax County, who owns and/or is responsible for the facility.

1.3.1.2 <u>Engineer</u>

The Engineer is responsible for the engineering design, drawings, and project specifications for the earthwork. The Engineer is an official representative of the Owner. The Engineer serves as communications coordinator for the project, initiating the meetings outlined in Section 1.7. The Engineer shall also be responsible for proper resolution of all quality issues that arise during construction. The Engineer is G.N. Richardson & Associates, Inc.

1.3.1.3 <u>Contractor</u>

The Contractor is responsible for the construction of the subgrade and the construction of soil berms. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the CQA Engineer. Additional responsibilities of the Contractor are defined by the project specifications.

1.3.1.4 <u>CQA Engineer</u>

The CQA Engineer is a representative of the Owner, is independent from the Contractor, and is responsible for observing, testing, and documenting activities related to the CQA of the earthworks at the site. The CQA Engineer may make field observations and review submittals for the Engineer and is responsible for notifying the Owner and Engineer of all quality issues that arise during construction.

The CQA Engineer is also responsible for issuing a facility certification report, sealed by a Professional Engineer registered in The State of North Carolina.

1.3.1.5 Soils CQA Laboratory

The Soils CQA Laboratory is a party, independent from the Owner, that is responsible for conducting geotechnical tests on conformance samples of soils used in structural fills.

1.3.2 Qualifications of the Parties

The following qualifications are required of all parties involved with the installation and CQA of all materials for the earthwork. Where applicable, these qualifications must be submitted by the Contractor to the Owner and Engineer for review and approval.

1.3.2.1 Contractor

Qualifications of the Contractor are specific to the construction contract and independent of this CQA Manual.

1.3.2.2 CQA Engineer

The CQA Engineer will act as the Owner's and Engineer's CQA Representative. The CQA Engineer will perform CQA testing to satisfy the requirements of this CQA Plan and will prepare the CQA certification document. The CQA Engineer will have experience in the CQA aspects of soils testing, and be familiar with ASTM and other related industry standards. The activities of the CQA Engineer will be performed under the supervision of a Registered Professional Engineer.

1.3.2.3 Soils CQA Laboratory

The Soils CQA Laboratory will have experience in testing structural fills and be familiar with ASTM and other applicable test standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after, as agreed to at the outset of the project, receipt of samples, and will maintain that standard throughout the installation.

1.4 SCOPE OF CONSTRUCTION QUALITY ASSURANCE MANUAL

The scope of this CQA Manual includes the CQA of the earthwork for the subject facility. The CQA for the selection, evaluation, and placement of the soils is included in the scope.

1.5 UNITS

In this CQA Manual, all properties and dimensions are expressed in U.S. units.

1.6 REFERENCES

The CQA Manual includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM).

1.7 SITE AND PROJECT CONTROL

To facilitate the specified degree of quality during installation, clear, open channels of communication are essential. To that end, meetings are critical.

1.7.1 Weekly CQA Progress Meetings

A weekly progress meeting will be held between the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. This meeting will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The CQA Engineer will log any problems, decisions, or questions arising at this meeting in his daily report. Any matter requiring action which is raised in this meeting will be reported to the appropriate parties.

1.7.2 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the meeting will be attended by the Engineer, the CQA Engineer, the Contractor, and representatives from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- define and discuss the problem or deficiency;
- review alternative solutions; and
- implement an action plan to resolve the problem or deficiency.

The meeting will be documented by the Engineer and minutes will be transmitted to affected parties.

1.8 CONTROL VERSES RECORD TESTING

1.8.1 Control Testing

In the context of this CQA Manual, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

1.8.2 Record Testing

Record Tests are those tests performed during the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications.

SECTION 2.0
CQA DOCUMENTATION

2.1 DOCUMENTATION

An effective CQA plan depends largely on recognition of construction activities that should be monitored and on assigning responsibilities for the monitoring of each activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Engineer will document that quality assurance requirements have been addressed and satisfied.

The CQA Engineer will provide the Owner and Engineer with his daily progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports shall also identify potential quality assurance problems.

2.2 DAILY CQA REPORT

The CQA Engineer's reporting procedures will include preparation of a daily report which, at a minimum, will include the following information, where applicable:

- an identifying sheet number for cross referencing and document control;
- date, project name, location, and other identification;
- data on weather conditions;
- a reduced-scale Site Plan showing all proposed work areas and test locations;
- descriptions and locations of ongoing construction;
- descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- locations where tests and samples were taken;
- a summary of test results;
- calibrations or recalibrations of test equipment, and actions taken as a result of recalibration;
- decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;
- summaries of pertinent discussions with the Contractor; and

- the CQA Engineer's signature.

The daily report must be completed at the end of each CQA Engineer's shift, prior to leaving the site. This information will be submitted weekly to and reviewed by the Owner and Engineer.

2.3 CQA PHOTOGRAPHIC REPORTING DATA SHEETS

Photographic reporting data sheets, where used, will be cross-referenced with CQA observation logs and testing data sheets and/or CQA construction problem and solution data sheets. Photographs shall be taken at regular intervals during the construction process and in all areas deemed critical by the CQA Engineer.

These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. The basic file will contain color prints; negatives will also be stored in a separate file in chronological order. These records will be presented to the Engineer upon completion of the project.

In lieu of photographic documentation, videotaping may be used to record work progress, problems, and mitigation activities. The Engineer may require that a portion of the documentation be recorded by photographic means in conjunction with video taping.

2.4 DEFICIENCIES

The Owner and Engineer will be made aware of any significant recurring non-conformance with the project specifications. The Engineer will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and any revision to procedures or project specifications will be approved by the Owner and Engineer.

2.5 DESIGN AND/OR PROJECT TECHNICAL SPECIFICATION CHANGES

Design and/or project specification changes may be required during construction. In such cases, the CQA Engineer will notify the Engineer. The Engineer will then notify the appropriate agency, if necessary.

Design and/or project specification changes will be made only with the written agreement of the Engineer, and will take the form of an addendum to the project specifications. All design changes shall include a detail (if necessary) and state which detail it replaces in the plans.

2.6 FINAL CQA REPORT

At the completion of each major construction activity at the landfill unit, the CQA

Engineer will certify all required forms, observation logs, field and laboratory testing data sheets including sample location plans, construction problem and solution data sheets. The CQA Engineer will also provide a final report which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The CQA Engineer will also provide summaries of all the data listed above with the report. The Record Drawings will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All surveying and base maps required for development of the Record Drawings will be done by the Contractor's Construction Surveyor. These documents will be certified by the Contractor and delivered to the CQA Engineer and included as part of the CQA documentation (Certification) report.

It may be necessary to prepare interim certifications, as allowed by the regulatory agency to expedite completion and review.

SECTION 3.0
EARTHWORK CQA

3.1 INTRODUCTION

This section of the CQA Manual addresses earthwork (excavation and embankment) and outlines the soils CQA program to be implemented with regard to material approval, subgrade approval, field control and record tests, and resolution of problems.

3.2 EMBANKMENT MATERIAL APPROVAL

All material to be used as compacted embankment shall be approved in advance by the CQA Engineer. Approval is based upon successful completion of CQA control testing outlined below. Such testing can be performed either during excavation and stockpiling or from existing stockpiles prior to use.

3.2.1 Control Tests

The procedure for CQA testing during excavation and stockpiling (including existing stockpiles) is outlined below.

Each load of soil will be examined either at the borrow source or the stockpile area. Any unsuitable material will be rejected or routed to separate stockpiles consistent with its end use. Appropriate entries shall be made in the daily log.

During stockpiling operations, control tests, as shown on Table 1, will be performed prior to placement of any compacted embankment.

3.3 SUBGRADE APPROVAL

The CQA Engineer shall verify that the compacted embankment subgrade is constructed in accordance with the project specifications.

3.4 EARTHWORK CONSTRUCTION

3.4.1 Construction Monitoring

A. Earthwork shall be performed as described in the project specifications.

B. Only soil previously approved by the CQA Engineer (see Section 3.2) shall be used in construction of the compacted embankment. Unsuitable material will be removed prior to acceptance by the CQA Engineer.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed. The surface preparation (e.g.

wetting, drying, scarification, etc.) shall be completed before the CQA Engineer will allow placement of subsequent lifts.

D. The CQA Engineer shall monitor protection of the earthwork during and after construction.

3.4.2 Control Tests

The control tests, as shown on Table 2, will be performed prior to compaction of embankment.

3.4.3 Record Tests

The record tests, as shown on Table 2, will be performed during placement of compacted embankment.

3.4.3.1 Record Test Failure

Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

3.4.4 Judgmental Testing

During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Engineer when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- the rollers slip during rolling operation;
- the lift thickness is greater than specified;
- the fill material is at an improper moisture content;
- fewer than the specified number of roller passes are made;
- dirt-clogged rollers are used to compact the material;
- the rollers may not have used optimum ballast;
- the fill materials differ substantially from those specified; or
- the degree of compaction is doubtful.

3.5 DEFICIENCIES

The CQA Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. All defects and deficiencies shall be properly documented by the CQA Engineer. The Contractor will correct defects and deficiencies to the satisfaction of the CQA Engineer. The CQA Engineer shall observe all retests on repaired defects.

TABLE 1: CQA TESTING PROGRAM FOR MATERIAL APPROVAL

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS:		
Visual Classification	ASTM D 2488	Each Soil
Moisture-Density Relationship	ASTM D 698	5,000 CY per Each Soil

TABLE 2: CQA TESTING PROGRAM FOR COMPACTED EMBANKMENT

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS: (See Table 1)		
RECORD TESTS:		
Loose Lift Thickness	-----	Each Lift
Moisture Content	ASTM D 2216	80,000 ft^2 per lift
In-Place Density	ASTM D 2922[1]	80,000 ft^2 per lift

Notes:

1. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device.

Appendix J

Operations Manual

Halifax County
Construction & Demolition Debris Landfill

Prepared for:

Halifax County Solid Waste Department

Halifax, North Carolina

August 1997

PERMIT ISSUE DOCUMENTS

G.N. Richardson & Associates, Inc.

Engineering and Geological Services

417 N. Boylan Avenue

Raleigh, North Carolina 27603

HALIFAX COUNTY
CONSTRUCTION AND DEMOLITION DEBRIS LANDFILL

OPERATIONS MANUAL

TABLE OF CONTENTS

SECTION 1.0 GENERAL FACILITY OPERATIONS

This operations manual was prepared for the Halifax County Construction and Demolition Debris (C&D) Landfill. The information contained herein was prepared to provide the County landfill personnel with a clear understanding of how the Design Engineer assumed that the facility would be operated. While deviations from the operations outlined here may be acceptable, they should be reviewed and approved by the Design Engineer.

Responsible Persons:

In an emergency, the following persons are to be contacted:

Solid Waste Director:	Richard Garner	919-586-4748
County Manager:	Charles Archer	919-583-1131
Fire, Police, Rescue:		911

1.1 Access Control

Access to active areas of the landfill will be controlled by a combination of fences and natural barriers, such as the creeks, and strictly enforced operating hours. A landfill attendant will be on duty at all times when the facility is open for public use to enforce access restrictions.

1.1.1 Physical Restraints

The site will be accessed by the existing entrance along State Road 1417. Scales, a scale house, an administration building, a waste inspection area, and a public convenience/recycling area will all be located near the entrance. All waste trucks entering the facility will be weighed upon entering and exiting. The entrance has a gate which will be securely locked during non-operating hours.

1.1.2 Security

Frequent inspections of gates and fences will be performed by landfill personnel. The County Solid Waste Director will arrange for a random security patrol of the main gate to further discourage trespassing. Evidence of trespassing, vandalism or illegal operation will be reported to the Halifax County Solid Waste Director.

1.2 Signage

A prominent sign containing the information required by NCDEHNR will be placed just inside the main gate. This sign will provide information on operating hours, operating procedures, and acceptable wastes. Additional signage will be provided within the landfill complex to distinctly distinguish the roadway to the C&D landfill active cell. Service and maintenance roads for use by operations personnel will be clearly marked and barriers (e.g., traffic cones, barrels, etc.) will be provided as required.

1.3 Communications

Two way radio communication will be maintained between the C&D landfill and the landfill scale house. The scale house has telephones in case of emergency and for the conduct of day-to-day business. Emergency telephone numbers are displayed in the scale house.

1.4 Fire and Safety

1.4.1 Fire Control

The possibility of fire within the landfill or a piece of equipment must be anticipated in the daily operation of the landfill. A combination of factory installed fire suppression systems and/or portable fire extinguishers will be operational on all heavy pieces of equipment at all times. For larger or more serious outbreaks, the Halifax County Fire Department will respond.

Fires within the landfill will be limited by the use of periodic cover soil and control of "hot" loads entering the landfill. Landfill personnel at the scale house will turn away all trucks containing waste that is suspected to be hot. If a hot load is placed on the working face, then daily cover soil will be immediately placed on the waste to extinguish the fire. The use of a periodic cover soil will limit the amount of MSW available to the fire.

1.4.2 Safety

All aspects of the Halifax County Landfill operation were developed with the health and safety of the landfill's operating staff, customers, and neighbors in mind. Prior to commencement of operations in the new landfill, a member of the landfill operating staff will be designated site safety officer. This individual, together with the facility's management will modify the site safety and emergency response program to remain consistent with National Solid Waste Management Association and OSHA guidance.

Safety equipment provided includes equipment rollover protective cabs, seat belts, audible reverse warning devices, hard hats, safety shoes, and first aid kits. Landfill personnel will be encouraged to complete the American Red Cross Basic First Aid Course. Other safety requirements as designated by the County will also be implemented.

1.5 Equipment Requirements

The Halifax County Landfill will maintain on-site equipment required to perform the necessary landfill activities. Periodic maintenance of all landfilling equipment, and minor and major repair work will be performed at the maintenance building away from the landfill area.

1.6 Utilities

Electrical power, water, telephone, and restrooms will be provided at the existing administration building adjacent to the scale area.

SECTION 2.0 LANDFILL OPERATIONS

Halifax County will operate this facility in accordance with applicable sections of the North Carolina Solid Waste Management Rules, this Operations Manual (as revised), and the Permit to Operate.

2.1 Acceptable Wastes

The Halifax County C&D Landfill will only accept for disposal the following wastes generated within approved areas of service:

- Construction and Demolition Debris Waste: (Waste or debris from construction, remodeling, repair, or demolition operations on pavement or other structures)
- Land Clearing and Inert Debris Waste: (Waste from land clearing, concrete, brick, concrete block, uncontaminated soils and rock, untreated and unpainted wood, and yard trash)
- Other Wastes as Approved by the Solid Waste Section of the Division of Waste Management

In addition, the special wastes described in Section 2.3 may also be accepted at this facility.

2.2 Unacceptable Wastes

No municipal solid (MSW), hazardous (as defined by 15A NCAC 13A including hazardous waste from conditionally exempt small quantity generators), or liquid waste will be accepted at this facility. In addition, no polychlorinated biphenyl (PCB) waste will be accepted. The County will implement a waste screening program, described in Section 2.4, to control this type of waste.

2.3 Special Wastes

2.3.1 Animal Carcasses

Any animal carcasses will be disposed of in special trenches outside of the C&D landfill and immediately covered with soil. Animal carcasses will only be accepted after advance notification by the generator.

2.3.2 Asbestos

Halifax County may accept asbestos materials through the life of this facility. Asbestos will only be accepted if it has been processed and packaged in accordance with State and Federal (40 CFR 61) regulations. Asbestos will arrive at the site in vehicles that contain only the asbestos waste and only after advance notification by the generator.

Once the hauler brings the asbestos to the landfill, the hauler will be directed to the active face by operations personnel. A designated disposal area will be prepared at the toe of the active face by will be notified verbally within 24 hours and in writing within 30 days of the attempt. All documentation will be incorporated in the Operating Record.

2.5 Record Keeping

The Halifax County Solid Waste Director will keep an Operating Record on file at the landfill. A copy of the Operating Record will be kept at the Halifax County offices in Halifax. This copy will be updated quarterly. A list of items to be incorporated into the Operating Record includes:

1. Landfill Personnel Training Procedures and Records of Training Completed,

2. A record of all waste received by weight and source of generation,

3. Quantity, location of disposal, generator, and special handling procedures for all special wastes disposed of at the site.

4. All groundwater and surface water quality information including:

    a. Monitoring well construction records,
    b. Semi-annual sampling dates and results,
    c. Statistical analyses, and
    d. Results of inspections, repairs, etc.

5. Annual Landfill Report for the last three calendar years.

6. A list of generators and haulers that have attempted to dispose of restricted wastes.

7. All closure information where applicable including:

    a. Testing and
    b. Certification.

8. All cost estimates.

9. All Financial Assurance documentation.

This Operating Record will be kept up to date by the Solid Waste Director or his assistant. It will be present upon request to the Solid Waste Section for inspection. A copy of this Operations Manual will be kept at the landfill and available for use at all times.

SECTION 3.0 WASTE HANDLING OPERATIONS

Waste handling operations at the Halifax County C&D Landfill will be modified to reflect operational criteria promulgated in the NCDEHNR regulations.

3.1 Waste Placement

Waste will be placed in such a manner that the active face is minimized. An active face width of no more than 75 feet is recommended, with a target of 50 feet desirable. The waste lift should be relatively thick in order to minimize the active face and the distance waste is spread by the compactor.

C&D waste will be unloaded at the upper limit of the working face and inspected (according to Section 2.4.2) prior to being spread on the face and compacted.

3.1.1 Access Ramp

The location of the access ramp during waste placement will be determined by operations personnel in order to reflect waste placement strategy.

Traffic will be clearly directed to the ramp and all vehicles entering the cell will use the active ramp. Traffic speed on the ramp should be less than 10 MPH. Rutting of the gravel roadway surface must be repaired by placement of additional gravel on the roadway and not solely by grading the rut.

3.1.2 Limits of Waste

The active working face for each day shall be less than 1/4 acre in size and have a slope flatter than 4H:1V. The surface of the active area must be graded to drain.

3.1.3 Waste Compaction

Waste spread over the working face will be placed in lifts at least 5-ft thick and will receive a minimum of five passes of the compaction equipment over each lift. The 5 foot thick lift layer will be placed over the entire active area to be used that day. Once the area has received a full lift layer, subsequent lift layers that day will be placed above the previous lift. Each lift layer will be no more than 3 feet thick in compacted thickness. The entire day's lift should be approximately 8-10 feet thick at the end of a given working day. The maximum slope of the working face will be flatter than 4H:1V to ensure proper compaction and stability of the waste.

3.2 Periodic Cover

At the completion of waste placement each week or sooner if the area of exposed waste exceeds one acre in size, a 6-inch layer of earthen material will be placed over the exposed waste. This periodic cover is intended to control vectors, fire, odors, and blowing debris.

SECTION 4.0 ENVIRONMENTAL MANAGEMENT

This section reviews the overall environmental management tasks required for the successful operation of the landfill. Surface waters as described herein are waters resulting from precipitation or site run-on that have not contacted the waste.

4.1 Erosion and Sediment Control

The erosion and sediment control system consists of five major components:

1. Benches
2. Ditches
3. Down Pipes
4. Sediment Basin.

The landfill side slopes are designed with 4H:1V slopes and swales every 20 vertical feet. These slopes and swales are designed to keep water volumes and velocities low enough to minimize erosion of the landfill cover. Maintenance of the swales will involve periodic mowing and repair of any erosion problems and bare spots. These items will be inspected at least once a month and after any significant rainfall events.

The down pipes are designed to carry concentrated flows of surface water off of the landfill. Slopes will vary from 25 percent on the slopes to a minimum of 2 percent on the swales. The down pipes will be anchored at 10 foot intervals along the side slopes. The down pipes will be inspected at least once a month and after any significant rainfall event.

Stormwater run-off from the landfill is conveyed to the sedimentation basin located on the north side of the landfill. The basin should be inspected regularly for sediment build-up or erosion damage. The basin should be cleaned out when sediments fill the lower half of the basin.

Additional erosion control measures have been taken at points of stormwater discharge. All final cover should be inspected quarterly for erosion damage and promptly repaired.

4.2 Landfill Gas Control

Due to the nature of the waste disposed in this landfill, gas control will not be of concern.

4.3 Vector Control

Due to the nature of the waste disposed in this landfill, vector control will not be of concern. Note that the use of periodic cover will discourage animals from nesting in the waste.

4.4 Odor Control

Due to the nature of the waste disposed in this landfill, odor control will not be of concern.

SECTION 5.0 CLOSURE PLAN

A closure plan is provided in the Design Drawings. The closure plan incorporates 4H:1V slopes and swales every 20 vertical feet to limit long-term erosion of the cover and minimize annual maintenance. A system of down pipes is used to drain each swale. In this manner, the volume of run-off carried by the swales is not accumulative going top to bottom.

This section is intended to serve as a guide for the proposed closure. A formalized Closure Plan for the landfill unit will be submitted for NCDEHNR approval prior to beginning closure construction.

5.1 Final Cover and Vegetation

The final cover over the waste will consist of a 24 inch thick vegetative soil layer. This final cover profile is shown on Drawing FC2 of the Design Drawings. The final cover surface must be vegetated immediately after completion according to the project seeding specifications.

5.2 Surface Water Run-Off System

Precipitation falling on the cover will infiltrate into the cover or run off the cover. The run-off is collected in swales built into the side slopes. Swales are provided at the upper edge of the slope and at 20-foot vertical increments. Water captured in a swale is carried to the base of the landfill in a down pipe.

5.2.1 Required Maintenance

The stormwater run-off system must be inspected annually and immediately after every major storm. Sediment build-up in the swales must be cleaned out on a regular basis to promote run-off.

5.3 Closure Verification

The following procedures will be implemented following closure:

- A signed certification from a registered Professional Engineer verifying that closure has been completed in accordance with the closure plan will be submitted to the NCDEHNR Division of Solid Waste Management.

- At least one sign notifying all persons of the closing of the phase and that wastes are no longer accepted will be posted. Suitable barriers will be installed as necessary at former access points to prevent new waste from being deposited.

- Within 90 days, a survey plat, prepared by a registered Professional Land Surveyor, indicating the location and dimensions of landfill disposal areas, will be prepared.

- A notation shall be recorded on the deed notifying any potential purchaser of the property that the land has been used as a landfill facility and that future use is restricted under the approved closure plan. A copy of the deed notation as recorded shall be filed with the operating record.

SECTION 6.0 POST-CLOSURE PLAN

This Post-Closure Plan has been developed to outline steps to be taken to ensure the integrity of the landfill during its post-closure care period. The post-closure care period will last at least 30 years after final closure and, at a minimum, will consist of the following:

- Maintaining integrity and effectiveness of final cover system,
- Performing groundwater and surface water monitoring, and
- Maintaining run-on/run-off controls.

No wastes will remain exposed after closure of the unit. Access to the closed site by the public will not pose a health hazard.

6.1 Post-Closure Contact

All correspondence and questions concerning the post-closure care of the unit should be directed to:

Mr. Charles Archer
Halifax County Manager
P.O. Box 327
Halifax, NC 27839
(919) 583-1131.

6.2 Description of Use

After filling operations cease at the landfill and the unit is officially closed in accordance with the Closure Plan, the area will be allowed to return to its natural vegetative state. Halifax County will maintain control of the property and prevent public access to it during the post-closure period.

There will be an access road on the cap to allow proper maintenance during post-closure. Precise location of the access will be determined as a part of operations. Low ground pressure and rubber tire vehicles will be used for maintenance.

6.3 Maintenance

6.3.1 Repair of Security Control Devices

All security control devices will be inspected and maintained as necessary to ensure access to the site is controlled. Locks, vehicular gates, and fencing will be replaced if functioning improperly. Warning signs will be kept legible at all times and will be replaced if damaged by inclement weather or vandalism.

TABLE 6.4.1 Post-Closure Inspection Frequencies

INSPECTION ACTIVITY	YEAR 1	YEARS 2-30
Security Control Devices	Quarterly	Quarterly
Cover Drainage System	Quarterly*	Semi-Annually
Groundwater Monitoring System	Semi-Annually	Semi-Annually**
Erosion Damage	Quarterly*	Quarterly
Cover Settlement, Subsidence, and Displacement	Quarterly*	Semi-Annually
Vegetative Cover Condition	Quarterly*	Quarterly
Stormwater Control System	Quarterly*	Quarterly
Benchmark Integrity	Annually	Annually

* These items will be inspected after each major storm event (i.e. $\geq$ 1 inch in any 24 hours).
** Or in accordance with groundwater monitoring schedule described in current SAP.

6.4.2 Quarterly Inspections

Quarterly inspections of the closed site will be conducted by the County. These inspections will include examination of the security control devices for signs of deterioration or vandalism to ensure access to the site is limited to authorized persons. The disposal area will be checked to ensure the integrity of the final cover system is maintained, erosion damage is repaired, vegetative cover persists, and that cover settlement, subsidence, and displacement are minimal. Drainage ditches will be cleared of litter and debris and benchmark integrity will be noted and maintained.

6.4.3 Semi-Annual Inspections

Semi-annual inspections of the site during the post-closure period will be conducted by the County with attention paid to integrity and drainage of the final cover system and condition of the groundwater monitoring system. A report of findings will be made to the responsible party, including recommendations for actions deemed necessary to ensure the site continues to meet the closure performance standard.

6.5 Engineering Certification

Based on the County's monitoring reports, annual certifications by a registered engineer will be placed in the operating record. They will certify that the closure plan has been followed, noting discrepancies along with the corrective actions undertaken. At the end of the post closure period, the individual certifications will be compiled into a final document and forwarded to the Solid Waste Section.

Appendix K

HALIFAX COUNTY
CONSTRUCTION & DEMOLITION DEBRIS LANDFILL

APPENDIX K: CALCULATIONS

TABLE OF CONTENTS

Objective To determine the expected life of the landfill given the proposed contours and the current loading rate.

Assumptions
1. Density of Waste.
2. Waste to Periodic Cover (i.e. daily and intermediate) Ratio.

Analysis The volume will be calculated by taking cross sections of the landfill, using a planimeter to measure the area of the cross sections, and using the average end area method. Alternatively, AutoCAD will be used to generate volumes.

G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: Z 16
JOB #: HALIFAX-11
DATE: 8/21/97
BY: PKS
CHKD BY:

Halifax County - C & D Landfill
Analysis of Life Expectancy

Waste Parameters:

Unit Weight (pcy) =	1720
Unit Weight (tcy) =	0.86
Percentage of Periodic Cover =	10
Area of Final Cover (Ac.) =	5.1

Waste Loading Parameters:

Daily Tonnage =	30
Daily Waste Volume (cy) =	34.883721
Days of Operation per Year =	280

Volume Calculations:

Volume From AutoCAD = 229191 cy

Adjustment For Other Layers:

2 feet (Avg.) of Final Cover =		16456 cy
	Sum =	16456 cy

Volume of Waste and Periodic Cover (cy) =	212735
Volume of Periodic Cover (cy) =	21274
Volume of Waste (cy) =	191462
Landfill Life Expectancy (years) =	$\boxed{19.6}$

LIFE.WB3

3/6

User Name: ANTHONY
Project: HALIFAX COUNTY LANDFILL
FILE NAME: d:\-cad\halfax-3\topo.DWG

Date: 08-21-97
Time: 13:28:50
Page: 1

S I T E   D E S I G N - VOLUME CALCULATIONS

PRISMOIDAL METHOD

ORIGINAL SURFACE	PROP C&D SITE REV
FINAL SURFACE	PROP C&DD SITE FILL REV
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	0.00 CY
RAW FILL VOLUME	229191.36 CY

G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

Halifax County - C & D Landfill
Analysis of Life Expectancy - Cell 1

SHEET: 4/6
JOB #: HALIFAX-11
DATE: 8/26/97
BY: PKS
CHKD BY:

Waste Parameters:

Unit Weight (pcy) =	1720
Unit Weight (tcy) =	0.86
Percentage of Periodic Cover =	10
Area of Final Cover (Ac.) =	0

Waste Loading Parameters:

Daily Tonnage =	30
Daily Waste Volume (cy) =	34.883721
Days of Operation per Year =	280

Volume Calculations:

Volume From AutoCAD = 51230 cy

{Phase 1 on Drawing P1}

Adjustment For Other Layers:

2 feet (Avg.) of Final Cover = 0 cy

Sum = 0 cy

Volume of Waste and Periodic Cover (cy) = 51230

Volume of Periodic Cover (cy) = 5123

Volume of Waste (cy) = 46107

Landfill Life Expectancy (years) = $\boxed{4.7}$ ≈ 5 yrs.

5/6

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S I T E   D E S I G N - VOLUME CALCULATIONS

PRISMOIDAL METHOD

ORIGINAL SURFACE	PROP C&D SITE REV
FINAL SURFACE	PROP-CDD-PH1-FILL
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	0.00 CY
RAW FILL VOLUME	52239.51 CY

52239.51
− 1009.74 (Berm)
PHASE 1 FILL → 51,229.77 C.Y.

2.5 yrs ✓

6/6

User Name: ANTHONY
Project: HALIFAX COUNTY LANDFILL
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S I T E   D E S I G N - VOLUME CALCULATIONS

PRISMOIDAL METHOD

ORIGINAL SURFACE	PROP C&D SITE REV
FINAL SURFACE	PROP CDD PH1 DIVIDER BERM
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	0.00 CY
RAW FILL VOLUME	1009.74 CY

— OVERALL EARTHWORK VOLUMES —

1/1

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Project: HALIFAX COUNTY LANDFILL
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Page: 1

S I T E D E S I G N - VOLUME CALCULATIONS

PRISMOIDAL METHOD

ORIGINAL SURFACE	EXIST SURFACE
FINAL SURFACE	PROP C&D SITE REV
CUT COMPACTION FACTOR	0.00 %
FILL COMPACTION FACTOR	0.00 %
RAW CUT VOLUME	43319.39 CY
RAW FILL VOLUME	19220.45 CY

Erosion And Sedimentation Control Plan

Halifax County
Construction & Demolition Debris Landfill

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

August 1997

PERMIT ISSUE DOCUMENTS

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

Erosion And Sedimentation Control Plan

Halifax County
Construction & Demolition Debris Landfill

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

To the Attention of:
Mr. Richard Garner, Director

GNRA Project No. HALIFAX-11

NORTH CAROLINA PROFESSIONAL SEAL 021698 ENGINEER PIETER K. SCHEER 8/27/97

Pieter K. Scheer, P.E.
Project Engineer

NORTH CAROLINA PROFESSIONAL SEAL 8895 ENGINEER GREGORY N. RICHARDSON 8/27/97

Gregory N. Richardson, Ph.D., P.E.
President

August 1997

PERMIT ISSUE DOCUMENTS

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

HALIFAX COUNTY
CONSTRUCTION & DEMOLITION DEBRIS LANDFILL

EROSION AND SEDIMENTATION CONTROL PLAN

TABLE OF CONTENTS

HALIFAX COUNTY
CONSTRUCTION & DEMOLITION DEBRIS LANDFILL

EROSION AND SEDIMENTATION CONTROL PLAN

1.0 NARRATIVE

1.1 Project Description

Halifax County plans to construct a construction and demolition debris (C&D) landfill at their existing landfill facility near Aurelian Springs. The construction and operation of the C&D landfill will require the disturbance of approximately 8.0 acres which will create the potential for erosion and the transportation of sediment. This plan discusses the erosion and sedimentation control measures used on this project to counter this threat of erosion.

1.2 Contact Information

1.2.1 Engineer: For questions regarding this erosion and sedimentation control plan, please contact the following:

G.N. Richardson & Associates, Inc.
Attn.: Pieter K. Scheer, P.E.
417 N. Boylan Ave.
Raleigh, NC 27607
(919) 828-0577
FAX: 828-3899.

1.2.2 Owner: The owner of the site and the person to contact should sediment control issues arise during the land-disturbing activity is as follows:

Halifax County Solid Waste Department
Attn.: Richard Garner, Director
P.O. Box 327
Halifax, NC 27839
(919) 586-4748
FAX: 586-2184.

1.3 Existing Site Conditions

The proposed site occupies a shallow swale, which slopes gently toward a perennial stream (unnamed tributary), situated along the north side of a east-west trending ridge. Existing ground surface elevations vary from El. 322 (feet) along the ridge at the south end of the site, decreasing to El. 260 along the tributary. Currently, the site is vegetated with pine scrub and brush.

1.4 Adjacent Areas

The proposed site borders County landfill property to the north, south, and west. To the east, and upstream of the proposed landfill, lies an undeveloped, wooded tract. The runoff from this property will be diverted to the unnamed tributary to the south in a stabilized channel.

1.5 Site Soils Information

The soils within the upper 10 feet of the surface are generally classified as low to medium plasticity clayey and/or sandy silt (ML) and high plasticity silt (MH) with occasional silty sand (SM). The deeper soils are more granular and exhibit a relic rock-like texture, generally classified as coarse silty sand (SM).

2.0 DESIGN GUIDELINES AND PROCEDURES

The erosion and sediment control design for the landfill was conducted based on guidelines and procedures as set forth in the North Carolina Erosion and Sediment Control Planning and Design Manual (E&SCP&DM) and "Elements of Urban Stormwater Design" (EOUSD), by H. Rooney Malcom, P.E. Design calculations are provided as an attachment to this plan.

All stormwater flow volumes were calculated using the Rational Method based on the maximum rate of runoff from a 10-year storm event. Note that the maximum rate of runoff from a 10-year storm exceeds the rate of runoff from a 25-year, 24-hour storm. Runoff coefficients for various ground cover conditions are referenced to Table 8.03a in the E&SCP&DM. Rainfall intensities used in the Rational Method were derived from an analysis of design storms for the site. Times of concentration were calculated with the Kirpich Equation. Drainage areas were determined using a planimeter and/or AutoCAD on topographic sheets of the project area.

3.0 EROSION AND SEDIMENTATION CONTROL MEASURES

The following erosion and sedimentation control measures are to be used in construction of the landfill. Attachments A, B, and C to this plan include technical specifications, calculations, and plans and details for each of these measures, respectively.

3.1 Sediment Basin

There is one permanent sediment basin which will serve the site. Sediment basin design is subject to several requirements. The sediment basin must provide a basin volume of 1800 ft^3/acre of disturbed area. Other E&SCP&DM requirements for permanent basins include riser/barrel principal spillways and emergency weir-type spillways. The principal spillway must have a capacity of 0.2 ft^3 /second/acre of drainage area. This flow must be met with one foot of driving head. The crest of the emergency spillway is set one foot above the invert of the riser and must pass the peak run-off from the 10-year storm event with one foot of freeboard to crest of berm. The principal and emergency spillways were designed using a spreadsheet based on methods provided in EOUSD. These methods provide a more detailed design than provided in

E&SCP&DM while meeting the above requirements. The riser/barrel assembly must be provided with an anchor displacing a buoyant weight of at least 1.1 times the weight of water displaced by the riser. The riser must also be provided with a method of dewatering the basin. This design was carried out in accordance with criteria from E&SCP&DM.

3.2 Drainage Channels

Drainage channel calculations were conducted using a reformulation of Manning's Equation to calculate normal depth of flow, as set forth in EOUSD, for given conditions to establish ditch capacity and velocity of flow. For conservatism, the channel calculations assume peak flow over maximum slope of channel reach in determining velocity. Channels were first checked assuming just constructed, bare earth, conditions. The maximum allowable velocity for bare earth was assumed to be 2.5 feet per second (Table 8.05d E&SCP&DM). If velocity exceeded this value, a temporary liner was chosen if appropriate. Normal depth and velocity was then calculated assuming grass lining as a minimum constructed condition. The allowable velocity for grass lining was assumed to be 4.5 feet per second (Table 8.05a, E&SCP&DM). If velocity exceeded this, a permanent liner was designed. Both temporary and permanent channel linings were designed using the Tractive Force Procedure as outlined in E&SCP&DM.

3.3 Vegetative Stabilization

Vegetative stabilization will be in accordance with the seeding schedule in the project specifications (provided as an attachment to this plan). The seeding schedule was based on Table 6.11p of E&SCP&DM which is applicable to this site.

3.4 Final Cover Drainage Structures

Upon reaching final design grades in the landfill, drainage structures including diversion berms, side slope swales, and down pipes will be installed. Diversion berms and side slope swales will be designed using the same guidelines described above for drainage channels. Down pipes were sized based on the orifice equation which governs the amount of flow carried by each pipe. Down pipes will be adequately anchored to the landfill side slopes and each will be outlet to the stabilized perimeter channels.

4.0 SCHEDULE FOR IMPLEMENTATION

All erosion control measures will be placed before any land disturbance or waste placement may begin in that portion of the site which drains to the erosion control measures. All areas reaching final elevations will be vegetated.

5.0 MAINTENANCE AND SEDIMENT DISPOSAL

All erosion and sedimentation control devices will be inspected at regular intervals and immediately following any significant rainfall event. Repairs will then be made as needed and accumulated sediment removed if necessary. In the case of the permanent sediment basin, sediments will be removed when one half of the basin volume is filled with sediment.

All sediments which are removed from erosion and sedimentation control measures will be disposed of in an approved manner at a location to be designated by the Engineer in such a manner that further erosion and sedimentation will not occur.

Objective

To design ditches, sedimentation basins, and other structures to remove and contain storm water flow from the 10 year storm at the proposed facility.

Calculations will be based on:

- Rational Method
- Manning's Equation
- Tractive Force Procedure
- Rainfall Frequencies for the Site

Analysis

The main design criteria will be to ensure that all storm water conveyance and retention structures will be able to accommodate the peak rate of run off from the 10 year storm without erosion.

The erosion control measures will be designed to control sedimentation from time of construction until the site is stabilized.

References

North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Malcom, H. Rooney, Elements of Urban Stormwater Design, NC State Univ., Raleigh, NC, 1989.

Calculations

- Rational Method (Flow Rate, Q):

$Q = CIA$ (cfs) (Malcom Eq. I -1)

where:
- C = Rational Runoff Coefficient
- I = Applicable Rainfall Intensity (in/hr) of storm event (Based on Time of Concentration)
- A = Drainage Area (Acres)

- Time of Concentration (t_c) (Kirpich Equation):

$$t_c = \frac{\left(\frac{L^3}{H}\right)^{0.385}}{128}$$ (minutes) (Malcom Eq. I-2)

where: L = Hydraulic Length of Watershed to Point of Interest (ft)
H = Fall Along L (ft)

Note: I is found by calculating t_c and using a rainfall intensity - duration - frequency graph or table suitable to the site. t_c (minimum) = 5 minutes.

- Manning's Equation:

$$Q = \frac{1.49\,AR^{2/3}S^{1/2}}{n} = AV$$ (Malcom Eq. I-8)

where: Q = Discharge/Flow Rate (cfs)
n = Manning's Roughness Coefficient
A = Cross Sectional Area of Flow (ft^2)
R = Hydraulic Radius (ft) = A/Wetted Perimeter
S = Slope of Channel (ft/ft)
V = Average Channel Velocity (ft/sec)

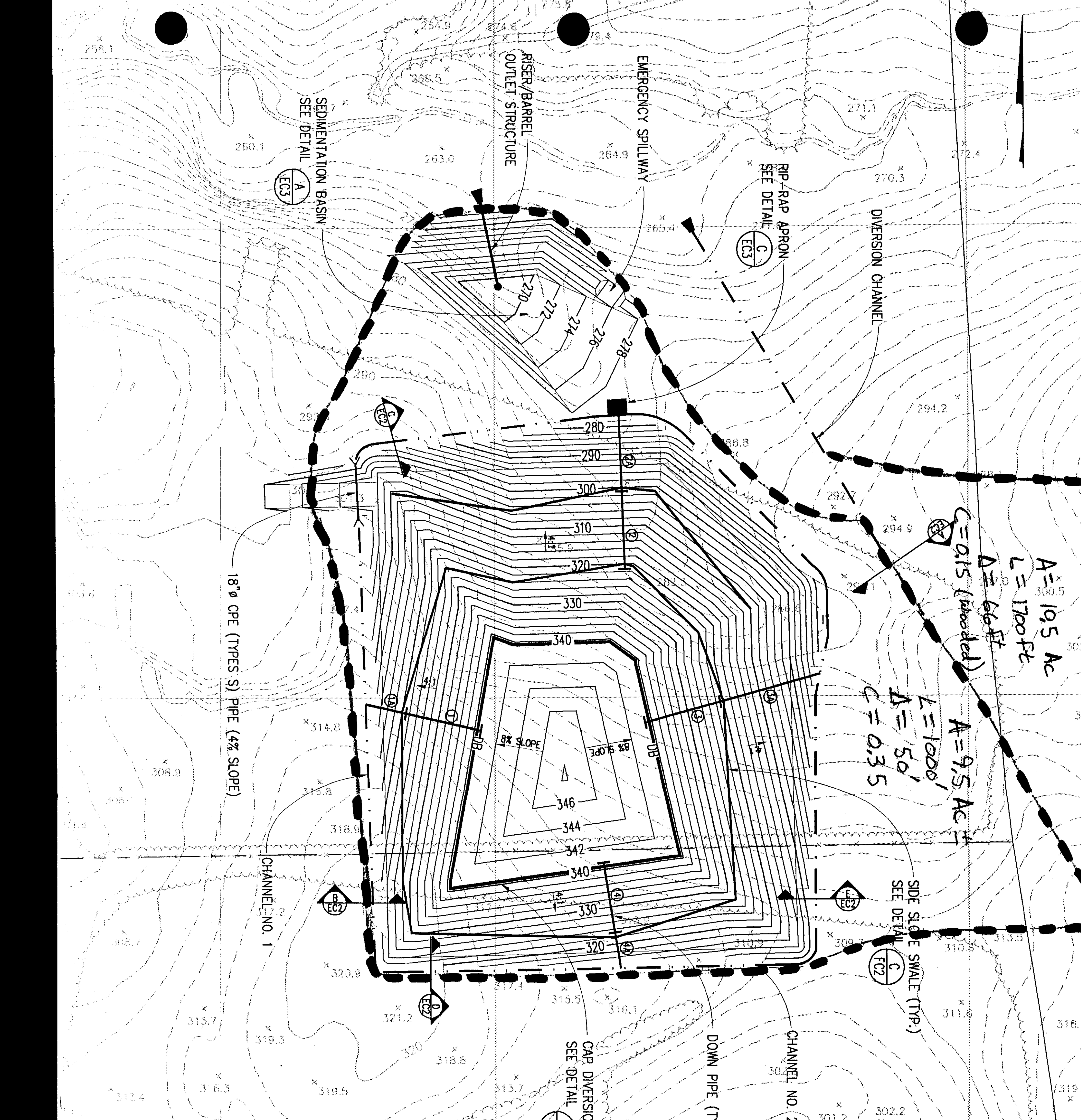
- Tractive Force Procedure:

T = yds

where: T = Shear Stress on Channel Lining (lb/ft^2)
y = Unit Weight of Water (62.4 lb/ft^3)
d = Depth of Flow (ft)
s = Channel slope (ft/ft)

Attachments
- Drainage Area Determination
- Down Pipe Analysis
- Culvert Analysis
- Analysis of Design Storms
- Normal Depth Analyses
- Sedimentation Basin Analysis

G.N. RICHARDSON & ASSOCIATES
Engineering and Geological Services
417 N. Boylan Avenue, Raleigh, NC 27603
Telephone: (919) 828-0577



DOWN PIPE SCHEDULE	
DOWN PIPE	DIA. (INCHES)
1	12
1A	12
2	12
2A	12
3	12
3A	12
4	12
4A	12

DRAINAGE AREAS

DRAWING TITLE:	PROJECT TITLE:	SEAL	SEAL	
EROSION CONTROL PLAN	HALIFAX COUNTY C & D LANDFILL	NORTH CAROLINA PROFESSIONAL SEAL 8895 ENGINEER GREGORY N. RICHARDSON	NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PETER K. SCHEER	G.N. RICHARDSON & ASSOCIATES, INC. Engineering and Geological Services 417 N. BOYLAN AVENUE RALEIGH, N.C. 27603 PHONE-919-828-0577 FAX-919-828-3899 WWW.GNRA.COM

Objective To compile the expected design storm depths and intensities over various return periods. These design storm values will be used in various calculations.

References Rainfall data was obtained from the following references:

Frederick, R.H., V.A. Myers, and E.P. Anciello, "Five to 60-Minute Precipitation Frequency for the Eastern and Central United States," NOAA Technical Memo. NWS HYDRO-35, National Weather Service, NOAA, U.S. Dept. Of Commerce, Silver Spring, MD, 1977.

U.S. Weather Bureau, "Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years," U.S. Weather Bureau Technical Paper 40, 1961.

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2/2
JOB #: Halifax-11
DATE: 8/21/97
BY: PKS
CHKD BY: GNR

Halifax County
Analysis of Design Storms

INPUT DATA:
LOCATION: Aurelian Springs, NC

DURATION	2-YR P (in)	100-YR P (in)	SOURCE
5 min	0.48	0.81	NOAA HYDRO-35
15 min	1.02	1.81	NOAA HYDRO-35
60 min	1.70	3.50	NOAA HYDRO-35
2 hr to 24 hr Rainfall Events		**USER INPUT**	USWB TP-40

DEPTH-DURATION-FREQUENCY TABLE
LOCATION: Aurelian Springs, NC

RETURN PERIOD

DURATION	2-YR (in)	5-YR (in)	10-YR (in)	25-YR (in)	50-YR (in)	100-YR (in)	
5 min	0.48	0.55	0.60	0.68	0.75	0.81	
10 min	0.80	0.93	1.02	1.17	1.29	1.40	
15 min	1.02	1.19	1.32	1.51	1.66	1.81	
30 min	1.35	1.65	1.86	2.16	2.40	2.64	
60 min	1.70	2.12	2.41	2.84	3.17	3.50	
2 hr	2.15	2.75	3.20	3.70	4.20	4.70	**USER INPUT**
3 hr	2.40	3.05	3.55	4.05	4.55	5.05	**USER INPUT**
6 hr	2.80	3.60	4.10	4.90	5.50	6.10	**USER INPUT**
12 hr	3.40	4.20	4.95	5.90	6.50	7.30	**USER INPUT**
24 hr	3.60	4.90	5.80	6.50	7.40	8.20	**USER INPUT**

INTENSITY-DURATION-FREQUENCY TABLE
LOCATION: Aurelian Springs, NC

RETURN PERIOD

DURATION	2-YR (in/hr)	5-YR (in/hr)	10-YR (in/hr)	25-YR (in/hr)	50-YR (in/hr)	100-YR (in/hr)
5 min	5.76	6.58	7.22	8.19	8.96	9.72
10 min	4.79	5.56	6.15	7.02	7.71	8.40
15 min	4.08	4.76	5.27	6.04	6.64	7.24
30 min	2.71	3.29	3.71	4.32	4.80	5.28
60 min	1.70	2.12	2.41	2.84	3.17	3.50
2 hr	1.08	1.38	1.60	1.85	2.10	2.35
3 hr	0.80	1.02	1.18	1.35	1.52	1.68
6 hr	0.47	0.60	0.68	0.82	0.92	1.02
12 hr	0.28	0.35	0.41	0.49	0.54	0.61
24 hr	0.15	0.20	0.24	0.27	0.31	0.34

PROJECT	Halifax County - C&D Landfill	SHEET	1 OF ~~2~~ 3
		JOB NO.	HALIFAX-11
		DATE	8/22/97
SUBJECT	Down Pipe Sizing	COMPUTED BY	PKS
		CHECKED BY	GWR

Objective Evaluate the required size of down pipes based on the peak flow from a 10 year storm.

Assumptions
1. Allow no overtopping of berms.
2. The minimum time of concentration is 5 minutes.

Analysis Use the Rational Method to determine the peak flow which needs to be handled by each pipe. Pipe flow will be governed by the orifice equation.

Equations:

Rational Method:

$$Q_p = CIA$$

where:
- Q_p = Peak Flow (cfs)
- C = Runoff Coef.
- I* = Rainfall Intensity (in/hr)
- A = Contributing Area (Ac)

*I is based on time of concentration (t_c)

Orifice Equation:

$$Q = C_d A \sqrt{2gh}$$

where:
- Q = Pipe Discharge (cfs)
- C_d = Coefficient of Discharge (0.6 = Typical Value)
- A = Area of Pipe at Inlet (ft^2)
- g = Acceleration of Gravity (32.2 ft/s^2)
- h = Driving Head (ft) to Centroid of A

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SHEET: 2/3
JOB #: HALIFAX-11
DATE: 8/22/97
BY: PKS
CHKD BY: GNR

Halifax County - C&D Landfill
Stormwater Down Pipe Sizing

10 Year, 5 Min Design Storm Intensity = **7.22** in/hr ✓ (From NOAA HYDRO-35)

Flow Parameters (Orifice Eqn.)

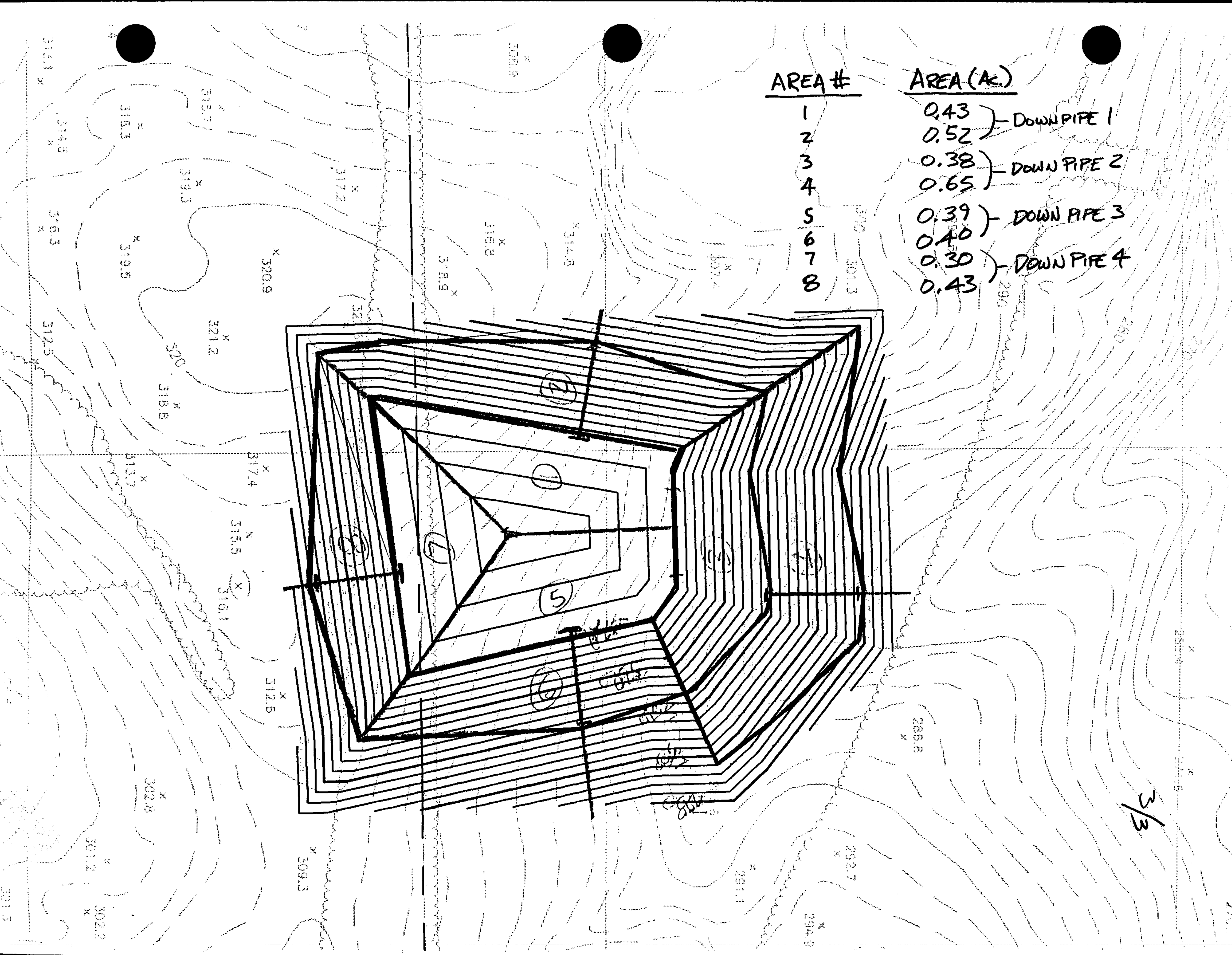
Coef. of Discharge = 0.6
Height of Water Above Top of Pipe = 6 in

Pipe Section	Drainage Areas Served*	Total Drainage Area (Ac.)	Runoff Coef. (c)	Qreq (cfs)	Select D (in)	Qallow (cfs)	Comment
1	1	0.43	0.35	1.1	12.0	3.8	O.K.
1A	1,2	0.95	0.35	2.4	12.0	3.8	O.K.
2	3	0.38	0.35	1.0	12.0	3.8	O.K.
2A	3,4	1.03	0.35	2.6	12.0	3.8	O.K.
3	5	0.39	0.35	1.0	12.0	3.8	O.K.
3A	5,6	0.79	0.35	2.0	12.0	3.8	O.K.
4	7	0.30	0.35	0.8	12.0	3.8	O.K.
4A	7,8	0.73	0.35	1.8	12.0	3.8	O.K.

*Note: See Attached Drainage Areas.

DOWNPIP.WB3

AREA #	AREA (Ac.)	
1	0.43	DOWNPIPE 1
2	0.52	
3	0.38	DOWN PIPE 2
4	0.65	
5	0.39	DOWN PIPE 3
6	0.40	
7	0.30	DOWN PIPE 4
8	0.43	



3/3

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SHEET: 1 / 1
JOB #: HALIFAX-11
DATE: 8/19/97
BY: PKS
CHKD BY: GNR

Halifax County - C&D Landfill
Normal Depth Analysis - Diversion Channel

Ditch/Swale Parameters: (User Entry)

Drainage Area (Ac.) =	10.5	
Hydraulic Length (ft) =	1700	
Fall Along Length (ft) =	66	
Lining:	6" RipRap	
Maximum Slope (ft/ft) =	0.1	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	**(EOUSD - Exhibit 8)**
B (ft) =	3	
M =	2	

Flow Volume:

Time of Conc. (min.) =	8.4	
Intensity (in/hr) =	6.49	**(User Entry) (10 Year Storm)**
Runoff Coefficient =	0.15	**(User Entry) (EOUSD - Exhibit 1 - Avg. Wooded Conditions)**
Q (cfs) =	10.2	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.65081903	
y (ft) =	0.4	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.70726917	
Normal Depth (ft) =	0.4	

Velocity:

V (ft/s) = 7.31

Liner Shear Stress:

T (lb/ft^2) = 2.50

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	1.45527559	
y (ft) =	0.6	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	1.46532739	
Normal Depth (ft) =	0.6	

Velocity:

V (ft/s) = 4.08

Liner Shear Stress:

T (lb/ft^2) = 0.75

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SHEET: 1 / 1
JOB #: HALIFAX-11
DATE: 8/21/97
BY: PKS
CHKD BY: GNR

Halifax County - C&D Landfill
Normal Depth Analysis - Channel 1A

Ditch/Swale Parameters: (User Entry)

Drainage Area (Ac.) =	1.7	
Hydraulic Length (ft) =	500	
Fall Along Length (ft) =	44	
Lining:	6" RipRap	
Maximum Slope (ft/ft) =	0.1	
Minimum Slope (ft/ft) =	0.04	
n =	0.03	**(EOUSD - Exhibit 8)**
B (ft) =	1	
M =	2	

Flow Volume:

Time of Conc. (min.) =	2.4	
Intensity (in/hr) =	7.22	**(User Entry) (10 Year Storm)**
Runoff Coefficient =	0.35	**(User Entry) (EOUSD - Exhibit 1 - Unimproved Cleared Area)**
Q (cfs) =	4.3	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.27352004	
y (ft) =	0.39	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.27767538	
Normal Depth (ft) =	0.39	

Velocity:

V (ft/s) = 6.28

Liner Shear Stress:

T (lb/ft^2) = 2.43

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.43247315	
y (ft) =	0.49	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.43865117	
Normal Depth (ft) =	0.49	

Velocity:

V (ft/s) = 4.49

Liner Shear Stress:

T (lb/ft^2) = 1.22

NDEPTH.WB3(2)

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Halifax County - C&D Landfill
Normal Depth Analysis - Channel 1B

SHEET: 1 / 1
JOB #: HALIFAX-11
DATE: 8/21/97
BY: PKS
CHKD BY: GNR

Ditch/Swale Parameters: (User Entry)

Drainage Area (Ac.) =	2.9	
Hydraulic Length (ft) =	750	
Fall Along Length (ft) =	70	
Lining:	6" RipRap	
Maximum Slope (ft/ft) =	0.1	
Minimum Slope (ft/ft) =	0.04	
n =	0.03	**(EOUSD - Exhibit 8)**
B (ft) =	2	
M =	2	

Flow Volume:

Time of Conc. (min.) =	3.2	
Intensity (in/hr) =	7.22	**(User Entry) (10 Year Storm)**
Runoff Coefficient =	0.35	**(User Entry) (EOUSD - Exhibit 1 - Unimproved Cleared Area)**
Q (cfs) =	7.3	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.46659301	
y (ft) =	0.39	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.47454927	
Normal Depth (ft) =	0.39	

Velocity:

V (ft/s) = 6.87

Liner Shear Stress:

T (lb/ft^2) = 2.43

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.73774832	
y (ft) =	0.49	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.72296627	
Normal Depth (ft) =	0.49	

Velocity:

V (ft/s) = 4.92

Liner Shear Stress:

T (lb/ft^2) = 1.22

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SHEET: 1 / 1
JOB #: HALIFAX-11
DATE: 8/21/97
BY: PKS
CHKD BY: gnr

Halifax County - C&D Landfill
Normal Depth Analysis - Channel 2A

Ditch/Swale Parameters: (User Entry)

Drainage Area (Ac.) =	1.1	
Hydraulic Length (ft) =	450	
Fall Along Length (ft) =	38	
Lining:	6" RipRap	
Maximum Slope (ft/ft) =	0.06	
Minimum Slope (ft/ft) =	0.015	
n =	0.03	**(EOUSD - Exhibit 8)**
B (ft) =	0	
M =	2	

Flow Volume:

Time of Conc. (min.) =	2.2	
Intensity (in/hr) =	7.22	**(User Entry) (10 Year Storm)**
Runoff Coefficient =	0.35	**(User Entry) (EOUSD - Exhibit 1 - Unimproved Cleared Area)**
Q (cfs) =	2.8	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.22848479	
y (ft) =	0.54	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.22616383	
Normal Depth (ft) =	0.54	

Velocity:

V (ft/s) = 4.72

Liner Shear Stress:

T (lb/ft^2) = 2.02

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.45696957	
y (ft) =	0.7	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.45182258	
Normal Depth (ft) =	0.7	

Velocity:

V (ft/s) = 2.80

Liner Shear Stress:

T (lb/ft^2) = 0.66

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SHEET: 1 / 1
JOB #: HALIFAX-11
DATE: 8/21/97
BY: PKS
CHKD BY: GNR

Halifax County - C&D Landfill
Normal Depth Analysis - Channel 2B

Ditch/Swale Parameters: (User Entry)

Drainage Area (Ac.) =	5.19
Hydraulic Length (ft) =	1150
Fall Along Length (ft) =	70
Lining:	6" RipRap
Maximum Slope (ft/ft) =	0.1
Minimum Slope (ft/ft) =	0.02
n =	0.03 **(EOUSD - Exhibit 8)**
B (ft) =	4
M =	2

Flow Volume:

Time of Conc. (min.) =	5.2
Intensity (in/hr) =	7.18 **(User Entry) (10 Year Storm)**
Runoff Coefficient =	0.35 **(User Entry) (EOUSD - Exhibit 1 - Unimproved Cleared Area)**
Q (cfs) =	13.0

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.83041433
y (ft) =	0.38 **(Iterate)**
accuracy =	0.1
f(M,y,B) =	0.84158386
Normal Depth (ft) =	0.38

Velocity:

V (ft/s) = 7.31

Liner Shear Stress:

T (lb/ft^2) = 2.37

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	1.85686288
y (ft) =	0.6 **(Iterate)**
accuracy =	0.1
f(M,y,B) =	1.87757679
Normal Depth (ft) =	0.6

Velocity:

V (ft/s) = 4.23

Liner Shear Stress:

T (lb/ft^2) = 0.75

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SHEET: 1 / 1
JOB #: HALIFAX-11
DATE: 8/22/97
BY: PKS
CHKD BY: GNR

Halifax County - C&D Landfill
Normal Depth Analysis - Side Slope Swale

Ditch/Swale Parameters: (User Entry)

Drainage Area (Ac.) =	0.65	
Hydraulic Length (ft) =	220	
Fall Along Length (ft) =	10	
Lining:	EC Mat	
Maximum Slope (ft/ft) =	0.04	
Minimum Slope (ft/ft) =	0.02	
n =	0.03	**(EOUSD - Exhibit 8)**
B (ft) =	0	
M =	2.75	

Flow Volume:

Time of Conc. (min.) =	1.6	
Intensity (in/hr) =	7.22	**(User Entry) (10 Year Storm)**
Runoff Coefficient =	0.35	**(User Entry) (EOUSD - Exhibit 1 - Unimproved Cleared Area)**
Q (cfs) =	1.6	

MAXIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.16535738	
y (ft) =	0.42	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.16443673	
Normal Depth (ft) =	0.42	

Velocity:

V (ft/s) = 3.37

Liner Shear Stress:

T (lb/ft^2) = 1.05

MINIMUM SLOPE

Normal Depth Calculations:

nQ/(1.49s^0.5) =	0.23385065	
y (ft) =	0.48	**(Iterate)**
accuracy =	0.1	
f(M,y,B) =	0.23477078	
Normal Depth (ft) =	0.48	

Velocity:

V (ft/s) = 2.60

Liner Shear Stress:

T (lb/ft^2) = 0.60

Objective To analyze culverts for inlet and outlet control. Verify that the allowable headwater depth is not exceeded.

Reference Debo, T.N., and Reese, A.J., Municipal Storm Water Management, Lewis Publishers, Boca Raton, FL, 1995, pp.438-442.

Analysis

① Determine Input Parameters:

- HW_{ALLOW} = Allowable Headwater Depth (ft)
- Q_{Total} = Total Discharge From Design Storm (cfs)
- N = Number of Pipes Used
- $Q_{PIPE} = Q_{TOTAL}/N$ (cfs)
- D = Culvert Diameter (in)
- Type of Culvert (i.e., Concrete, CMP, etc.)
- L = Culvert Length (ft)
- s = Culvert Slope (ft/ft)
- n = Manning's Number
- k_e = Entrance Loss Coefficient
- d_c = Critical Depth (Use Critical Depth Figures) (ft)

② Find actual HW for the culvert for both inlet & outlet control. The condition with the greatest HW governs.

- For Inlet Control:

- Enter Inlet Control Nomograph with D & Q_{PIPE} and find HW/D for the proper entrance type.
- Compute HW. If HW exceeds HW_{ALLOW}, try larger culvert.

-For Outlet Control:

- Enter Outlet Control Nomograph with L, K_e, & D.
- To compute HW, connect the length scale for the type of entrance condition and culvert diameter scale with a straight line, pivot on the turning line, and draw a straight line from

the design discharge through the turning point to the head loss scale H. Compute HW from the following equation:

$$HW = H + h_o - LS$$

where: $h_o = \left(\frac{d_c + D}{2}\right)$ or tailwater depth, whichever is greater.

- If HW exceeds HW_{ALLOW}, try larger culvert.

Table 3-6.1L 3/7

ENTRANCE LOSS COEFFICIENTS

Outlet Control, Full or Partly Full Entrance Loss

$$H_e = k_e \frac{V^2}{2g}$$

Type of Structure and Design of Entrance	Coefficient k_e	Standard Plan
Pipe, Concrete		
Projecting from fill (no headwalls)		
Socket end (groove end)	0.2	
Square cut end	0.5	
Beveled end section (mitered to conform to fill slope)	0.7	B-7a
Mitered concrete headwall to conform to fill slope	0.7	B-9
Flared metal end sections (or concrete)	0.5	B-7 Design B
Vertical headwall with wingwalls		B-6 Series (Modified for Round Pipe)
Rounded edge or socket end	0.2	
Square edge	0.5	
Rounded (radius = 1/12 D)	0.2*	
Pipe or Pipe Arch, Corrugated Metal		
Projecting from fill (no headwalls)	0.9	
Beveled end section (mitered to conform to fill slope, no headwall)	0.7	B-7a
Mitered concrete headwall to conform to fill slope	0.7	B-9
Flared metal end sections	0.5	B-7 Design A
Vertical headwall with wingwalls	0.5	B-6 Series (Modified for Round Pipe)
Box, Reinforced Concrete		
Mitered concrete headwall to conform to fill slope		
Square-edged on 3 edges	0.5	
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2*	
Wingwalls at 30 degrees to 75 degrees to barrel		
Square-edged at crown	0.4	
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2*	
Wingwall at 10 degrees to 25 degrees to barrel		
Square-edged at crown	0.5	B-6 Series
Wingwalls parallel (extension of sides)		
Square-edged at crown	0.7	
Side- or slope-tapered inlet	0.2*	

* Note: Reference Section 3-7.6 for the design of special improved inlets with very low entrance coefficients.

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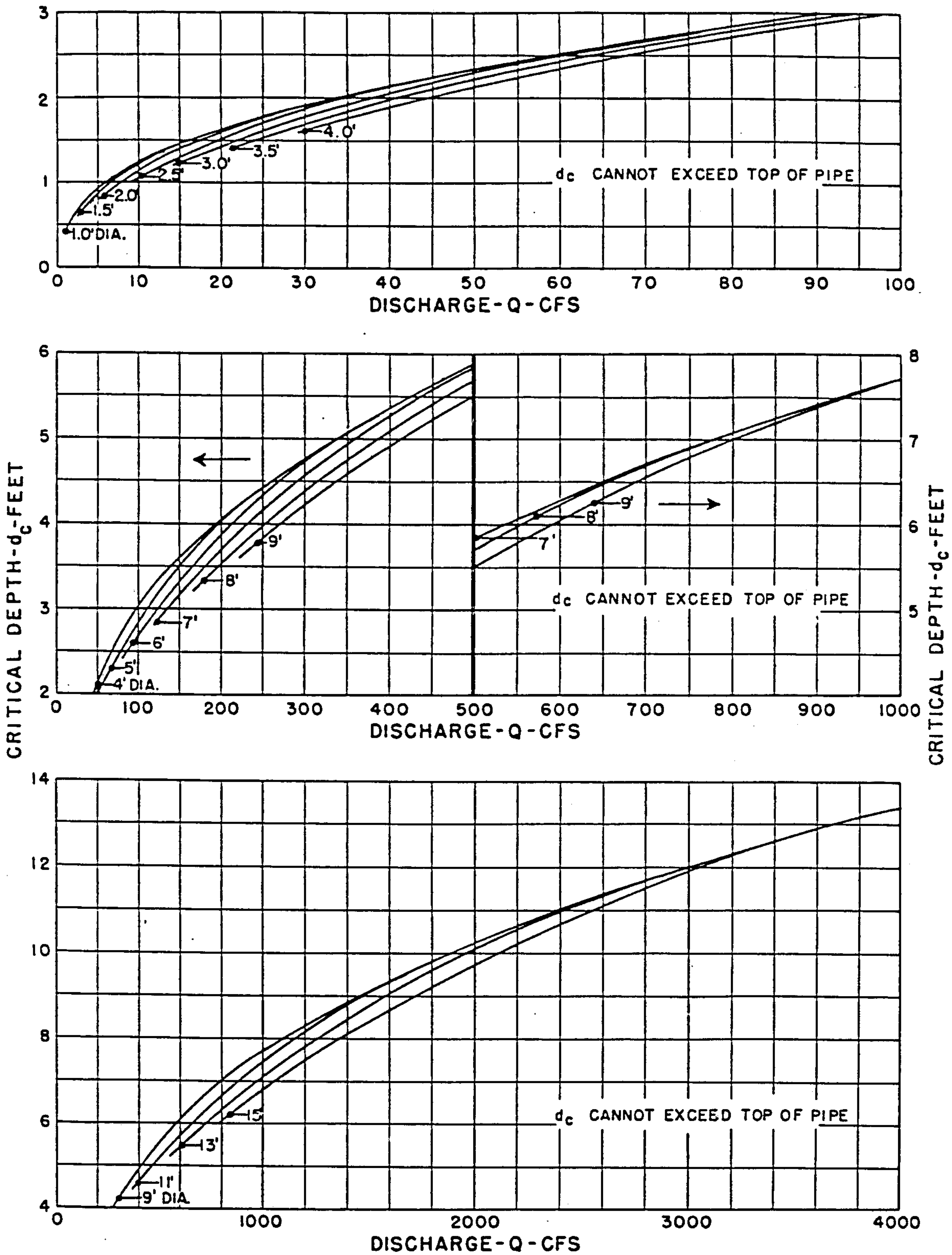

BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

FIGURE 3-6.1M(1)

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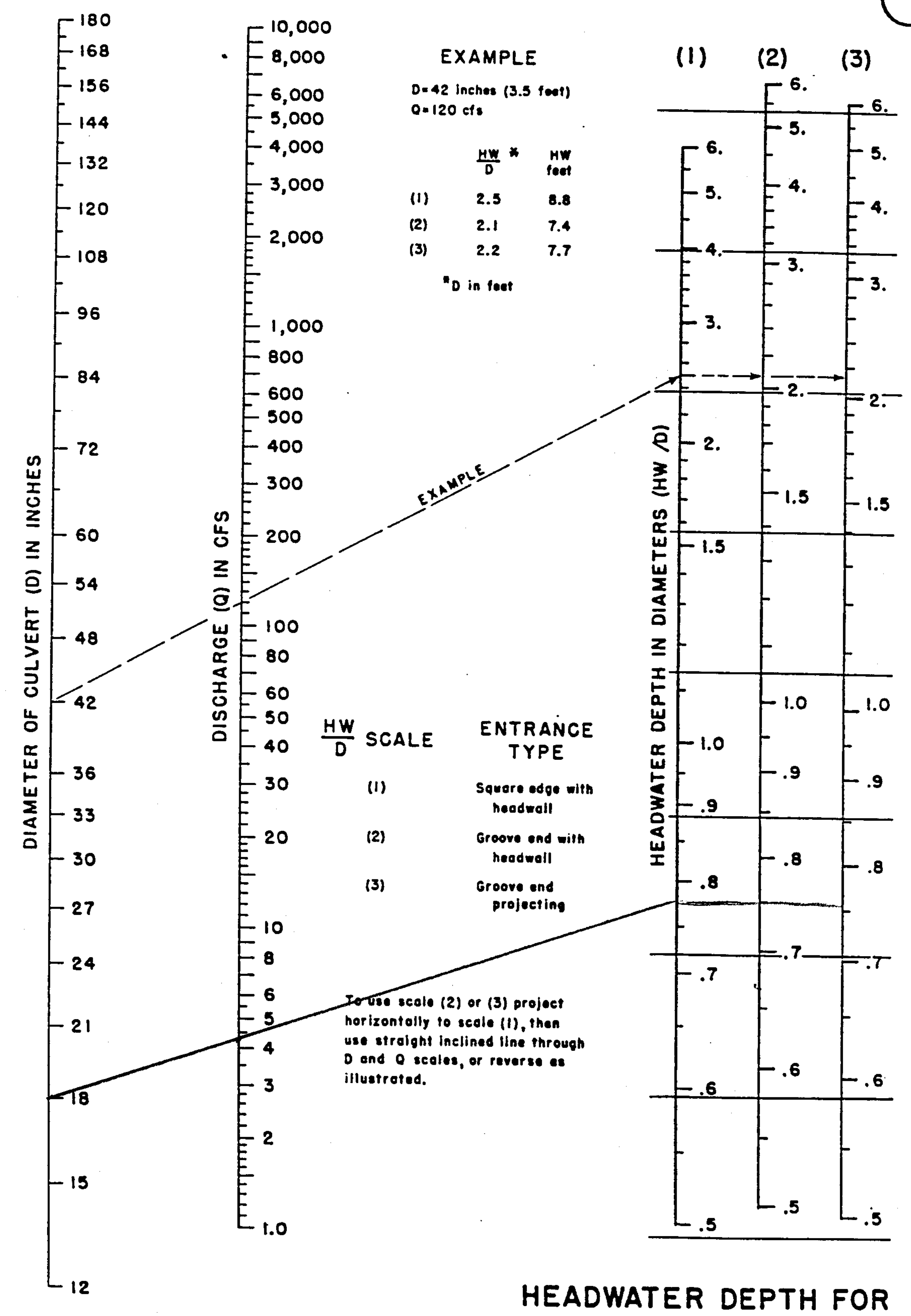
3-4.1 Concrete Pipe (Inlet Control Nomograph)

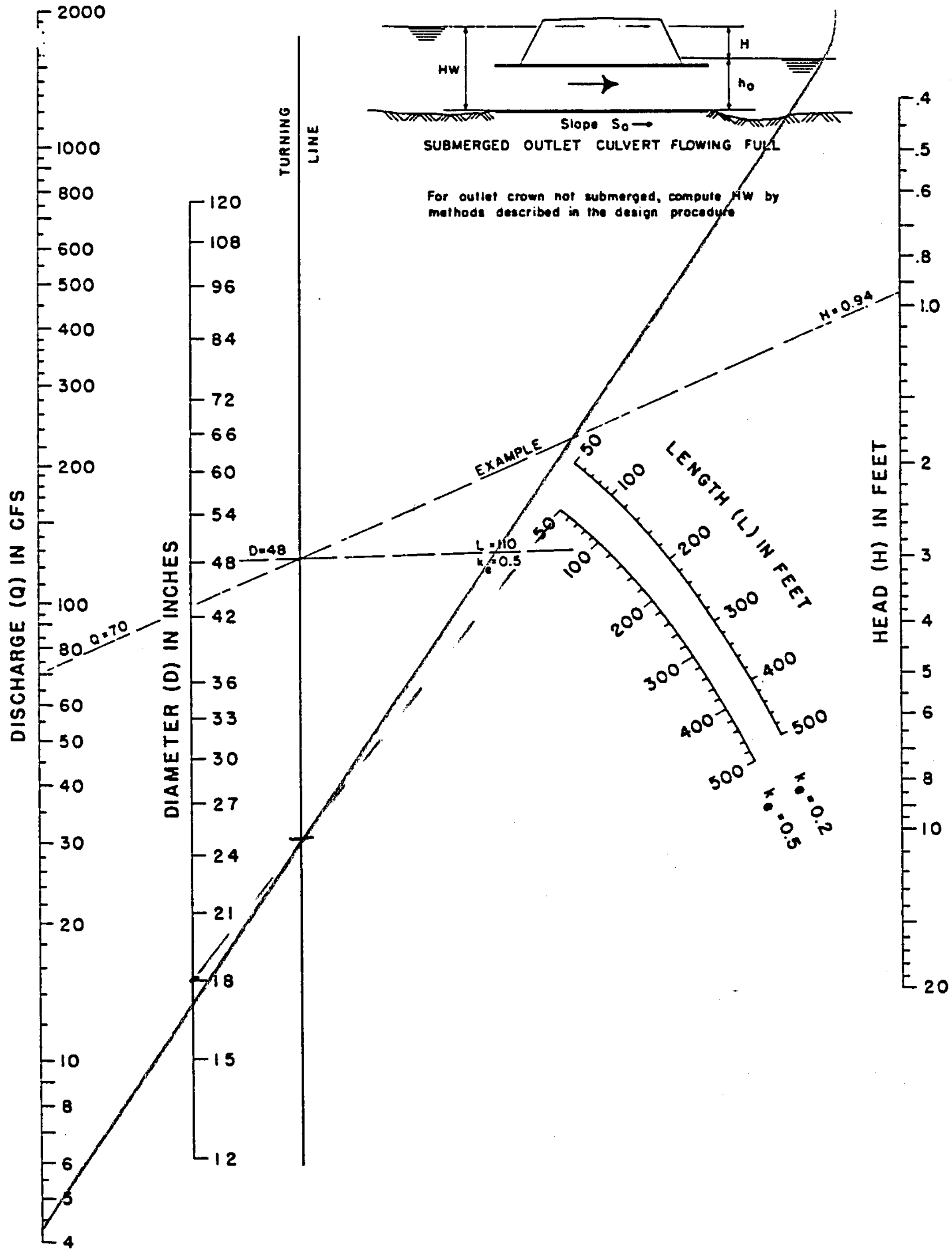


HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

6/7



HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

SHEET:	7 / 7
JOB #:	HALIFAX-11
DATE:	8/22/97
BY:	PKS
CHKD BY:	GNR

Halifax County - C&D Landfill
Culvert Analysis

Input Parameters:

Allowable HW Depth (ft) =	3	Culvert Length, L (ft) =	50
Qtotal (cfs) =	4.3	Culvert Slope, S (ft/ft) =	0.04
Number of Pipes, N =	1	Manning's Number, n =	0.012
Qpipe (cfs) =	4.3	Entrance Loss Coef., ke =	0.5
Culvert Diameter, D (in) =	18	Critical Depth (ft) =	0.8
Type of Culvert =	N-12		

Case 1: Inlet Control

HW/D = 0.76 **(USER INPUT - FROM INLET CONTROL NOMOGRAPH)**
HW (ft) = 1.1

INLET CONTROL GOVERNS!

Case 2: Outlet Control

ho (ft) = 1.2
H (ft) = 0.4 **(USER INPUT - FROM OUTLET CONTROL NOMOGRAPH)**
HW (ft) = -0.5

CULVERT.WB3

Objective To design a sediment basin to handle the maximum flow from the design storm.

References North Carolina Erosion & Sediment Control Planning & Design Manual, North Carolina Division of Land Resources, 1988.

Malcom, H. Rooney, Elements of Urban Stormwater Design, N. C. State University, Raleigh, NC, 1989.

Analysis The following approach is used to properly size and evaluate the sediment basin:

1. Determine Flow into Basin
2. Formulate Design Hydrograph.
3. Size Basin & Determine Stage-Storage Function.
4. Preliminarily Design Riser/Barrel.
5. Route for Flow Check.
6. Refine Design for Desired Settling Efficiency.
7. Determine Cleanout Level, Design Basin Dewatering Method, Calculate Anchorage Requirements, & Design Emergency Spillway.
8. Design Rip-Rap Outlet Protection.

Calculations

- Determine Flow Into Basin:

Use Rational Method (Q_P=CIA)

- Formulate Design Hydrograph:

Estimate Volume of Runoff from 6 hour storm for the design return period (i.e. 6 hr. 10 yr., or 6 hr. 25 yr. storm). The six hour storm for the return period of interest is typically included in the design hydrograph (Malcom).

$$Q^* = \frac{(P-0.2S)^2}{(P+0.8S)}$$ (Malcom Equation III-6)

Where: Q^* = Volume of Runoff from 6 hr, x year storm (in.)

$S = \frac{1000}{CN} - 10$

CN = Runoff Curve Number

P = 6 hr, x year Storm Depth (in.)

Set Time to Peak Using Step Function as Pattern Hydrograph

$$Tp = \frac{Q^*A}{1.39Qp}$$ (Malcom Eq. III-4)

Where: T_p = Time to Peak (min)

Q^* = Volume of Runoff (in.)

A = Area Flowing to Basin (Ac)

Qp = Peak Flow into Basin (cfs)

Design Hydrograph

$$Q = \frac{Qp}{2}\left|1 - COS\left(\frac{\pi t}{Tp}\right)\right|$$ (Malcom Eq. III-1)

for $0 \le t \le 1.25$ Tp

$$Q = 4.34\,Qp\exp\left|-1.30\left(\frac{t}{Tp}\right)\right|$$ (Malcom Eq. III-2)

for $t > 1.25$ Tp

Where: Q = Flow into Basin at Time t (cfs)

- Size Basin & Determine Stage-Storage Function:

Size Basin based on required minimum storage volume and surface areas.

Determine Stage-Storage Function

$S = K_S Z^b$ (Malcom Eq. III-7)

Where:

Where:	S	=	Storage Volume (ft^3)
	K_S&b	=	Linear Regression Constants Describing the Stage-Storage Relationship
	Z	=	Stage Referenced to the Bottom of the Basin (ft)

- Preliminarily Design Riser/ Barrel:

Select riser/barrel parameters such that the minimum flow capacity for this structure is met.

- Route for Flow Check:

Route design hydrograph through the sediment basin to determine peak stage and outflow.

- Refine for Desired Settling Efficiency:

Settling Velocity of Design Particle

$$V_o = \frac{g}{18}\left[(S_s - 1)/\upsilon\right] d^2$$ (Malcom Eq. IV-3)

Where:	V_o	=	Settling Velocity (ft/s) - convert from (m/s)
	g	=	Gravitational Acceleration (m/s^2)
	S_s	=	Specific Gravity of Design Particle
	υ	=	Kinematic Viscosity of the Fluid (m^2/s)
			(= 1.14×10^{-6} m^2/s @ 15°C Rf. Streeter, 1975)
	d	=	Diameter of Design Particle (m)

Settling Constant

$$C_s = \frac{bK_s(V_o)}{N\left[(1-E)^{-1/N}-1\right]}$$ (Malcom Eq. IV-10)

Where: N = Number of Effective Cells (N=Z=>Conservative)

E = Settling Efficiency (Decimal Fraction)

Settling Envelope

$$Q = C_S Z^{(b-1)}$$ (Malcom Eq. IV-9)

Where: Q = Discharge Limit at Given Stage Z (ft)

Surface Area

$$A_s = bK_s Z^{(b-1)}$$ (Malcom Eq. IV-7)

Settling Efficiency

$$E = 1 - \left[1 + \frac{V_o A_s}{NQ}\right]^{-N}$$ (Malcom Eq. IV-1)

- Basin Dewatering (Riser/ Barrel System Only):

Design dewatering system for riser. Use ½ inch ϕ holes. Perforate riser below sediment cleanout level and cover with NCDOT No. 57 stone.

Find Total Area of Holes Required

$$A_o = \frac{A_s\sqrt{(2h)}}{T\,C_d\,(20428)}$$

$$\left[\#\ of\ ½\ inch\ \phi\ Holes = \frac{A_o}{A_{½}}\right]$$

Where:

A_o	=	Surface Area of Dewatering Hole (ft^2)
A_s	=	Surface Area of Basin (ft^2)
h	=	Head of Water Above Hole (ft)
C_d	=	Coefficient of Contraction (=0.60)
T	=	Detention Time (hrs.) (10 hrs. recommended)

Note:
- Assume h = Crest of Riser to Cleanout Elevation.
- Cleanout Elevation is at ½ Basin Volume.

- Anchorage Requirements (Riser/Barrel System Only):

Design anchor for riser with buoyant weight greater than 1.1 times the water displaced by the riser.

Design Uplift Force (↑F)

$$\uparrow F = 1.1\ (\text{Volume of Riser})\ (\rho H_2O = 62.4\ lb/ft^3) \qquad \text{(lbs)}$$

Volume of Concrete Ballast

$$Volume = \frac{\uparrow F}{P_{concrete,\ buoyant}} = \frac{\uparrow F}{(150\,pcf - 62.4\,pcf)} \qquad (ft^3)$$

- Design Emergency Spillway:

Allow 1 foot of driving head and determine spillway length based on the weir equation:

$$L = \frac{Q_p}{C_w H^{3/2}} \qquad \text{(Malcom Eq. III-11)}$$

Where:

L	=	Length of Spillway Crest (ft)
C_w	=	Weir Coefficient (= 3.0 for Broad Crest)
H	=	Driving Head (ft)

Check Crest Velocity: (Assume Flow Depth at Crest = 2/3 H)

$$V = \frac{Q_p}{A}$$

Where: V = Velocity at Crest (ft/s)

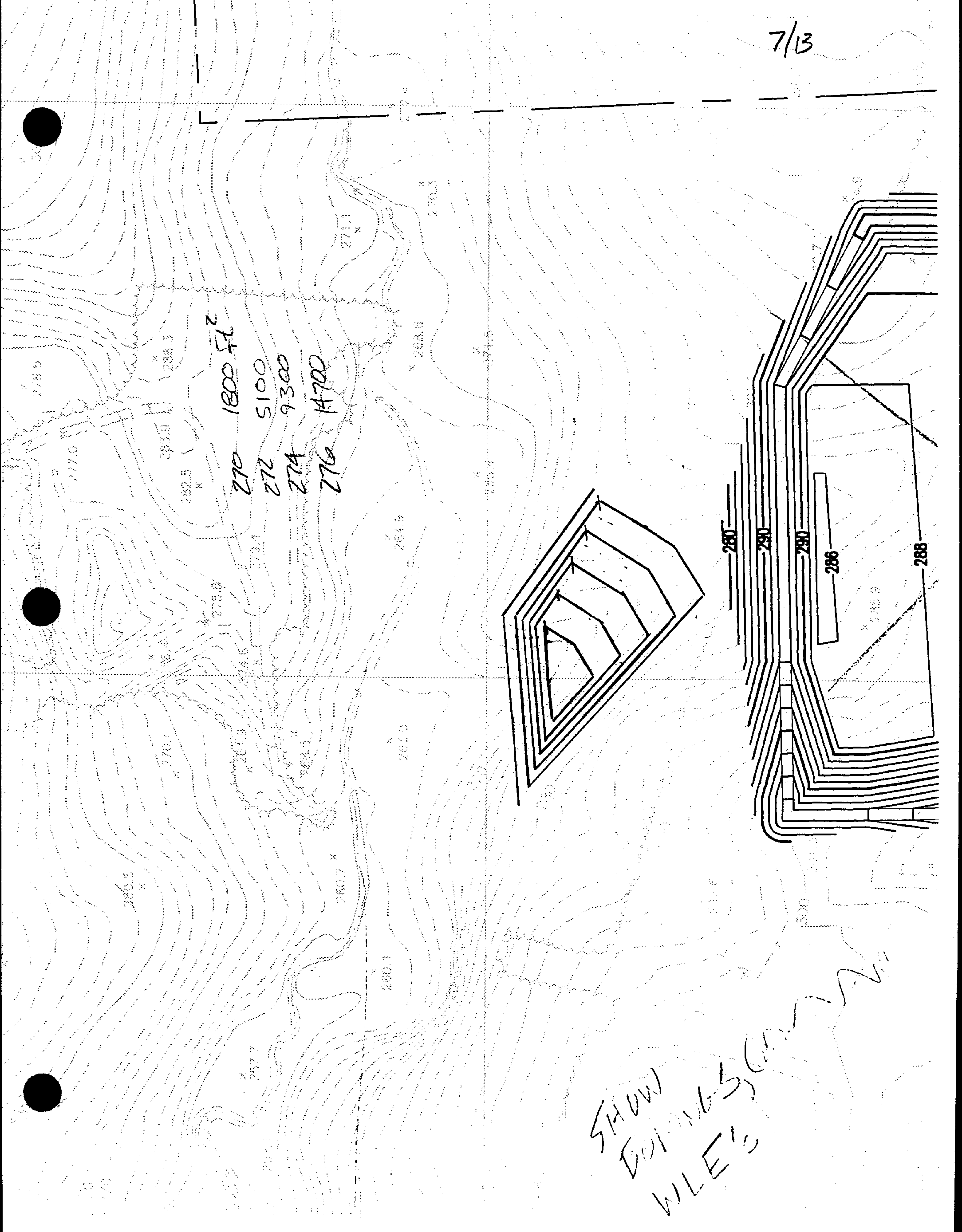
A = Area of Flow = 2/3 HL (ft^2)

- <u>Design Rip-Rap Outlet Protection</u>:

Follow the procedure outlined in Section 8.06 of the NC Erosion & Sediment Control Planning and Design Manual:

1. Determine the tailwater condition and select the appropriate design chart.
2. Using the appropriate design chart, determine the d_{50} rip-rap size and minimum apron length (La).
3. Using the same chart, determine apron dimensions.
4. Determine the maximum stone diameter: $d_{max} = 1.5 \times d_{50}$
5. Determine the apron thickness: Thickness = 1.5 x d_{max} (No Filter Geotextile)
   Thickness = 1.5 x d_{50} (With Filter Geotextile)

7/13


270 1800 ft²
272 5100
274 9300
276 14700
280
290
290
286
288
SHOW
WLE's

G.N. Richardson & Associates
ENGINEERING AND GEOLOGICAL SERVICES

Halifax County - C&D Landfill
Sedimentation Basin Analysis

SHEET: 8/13
JOB #: HALIFAX-11
DATE: 8/20/97
BY: PKS
CHKD BY: GNR

AREAS DRAINING INTO BASIN:

Hydraulic Length (ft) = 1000 **(User Input)**
Fall Along Length (ft) = 50 **(User Input)**

Drainage Area	Area (Ac.)	C	
C&D Landfill Area	9.5	0.35	**(User Input)**

Total = 9.5 Acres

Avg. C = 0.35

PEAK FLOW VOLUME:

Time of Conc. = 5.1
Intensity (in/hr) = 7.2 **(User Input)(10 yr Storm)**
Qp (cfs) = 23.9

ESTIMATE VOLUME OF RUNOFF:

P6,10 (in) = 4.1 **(User Input)(6 hr, 10 yr Storm)**

Runoff Curve # (CN) = 79 **(User Input)(NC Sed. & Erosion Control Man., Fair Condition Soil Type C)**

Q* (in) = 2.04

SET TIME TO PEAK:

Tp (min) = 35.3

SEDBSNDT.WB3(1)

BASIN REQUIREMENTS:

SHEET:	9 / 13
JOB #:	HALIFAX-11
DATE:	8/20/97
BY:	PKS
CHKD BY:	GWZ

Required Storage Capacity (ft^3) = 17100 Minimum
Required Surface Area (Ac) = 0.24 Minimum

DETERMINE STAGE-STORAGE FUNCTION:

Contour	Area (sq ft)	Incr Vol (cu ft)	Accum Vol (cu ft)	Stage (ft)	ln S	ln Z	Z est
270	1800		0	0			
272	5100	6900	6900	2	8.84	0.69	2.00
274	9300	14400	21300	4	9.97	1.39	4.00
276	14700	24000	45300	6	10.72	1.79	6.00

***REGRESSION ANALYSIS IS NOT RUN AUTOMATICALLY!**

Regression Output:		
Constant		7.644018
Std Err of Y Est		0.0485111
R Squared		0.998688
No. of Observations		3
Degrees of Freedom		1
X Coefficient(s)	1.703540141	
Std Err of Coef.	0.061745337	

Ks = 2088
b = 1.70

PRINCIPAL SPILLWAY - PRELIMINARY DESIGN:

Estimate Height of Principal Spillway:

Min. Height of Principal Spillway (ft) = 3.4 (Based on Storage)
4.6 (Based on Surface Area)

Check Capacity:

Minimum Capacity (cfs) = 1.9

Riser/Barrel Parameters:

Riser Diam. (in) =	36.00	**(User Input)**
Riser Height (ft) =	4.00	**(User Input)**
Barrel Diam. (in) =	18.00	**(User Input)**
Riser Driving Head (ft) =	1.00	**(User Input)**
Barrel Driving Head (ft) =	4.25	
Weir Coefficient =	3.30	**(User Input)**
Discharge Coef. =	0.59	**(User Input)**

Analyze Capacity of Riser Acting as a Weir:

Q (cfs) = 31.1 **OK**

Analyze Capacity of Riser as an Orifice:

Q (cfs) = 33.5 **OK**

Analyze Capacity of Barrel as an Orifice:

Q (cfs) = 17.2 **OK**

SHEET: 10/13
JOB #: HALIFAX-11
DATE: 8/20/97
BY: PKS
CHKD BY: GNR

RISER BARREL ROUTING - PRELIMINARY DESIGN:

Input Data:

	Qp (cfs) =	23.9	
	Tp (min) =	35.3	
	dT (min) =	2	**(user input)**
	Ks =	2088	
	b =	1.70	
	Zo (ft) =	270	**(user input)**
	Zinitial (ft) =	270	**(user input)**
Riser:	Dr (in) =	36	**(user input)**
	Cw =	3.3	**(user input)**
	Zcr (ft) =	274	**(user input)**
Barrel:	Db (in) =	18	**(user input)**
	Zi (ft) =	270	**(user input)**
	Cd =	0.59	**(user input)**

Spreadsheet Assumes Riser Acts As A Weir.

Normal Surface Area = 0.22 ac

Peak Outflow = 16.94 cfs
Peak Stage = 274.86 ft

TIME (min)	INFLOW (cfs)	STORAGE (cu ft)	STAGE (ft)	OUTFLOW (cfs)	RISER (cfs)	BARREL (cfs)
0	0.0	0	270.00	0.00	na	na
2	0.2	0	270.00	0.00	0.00	0.00
4	0.7	23	270.07	0.00	0.00	0.07
6	1.7	113	270.18	0.00	0.00	0.30
8	2.9	312	270.33	0.00	0.00	0.74
10	4.4	661	270.51	0.00	0.00	1.43
12	6.2	1193	270.72	0.00	0.00	2.41
14	8.1	1936	270.96	0.00	0.00	3.70
16	10.2	2913	271.22	0.00	0.00	5.30
18	12.3	4138	271.49	0.00	0.00	7.21
20	14.4	5618	271.79	0.00	0.00	8.51
22	16.5	7351	272.09	0.00	0.00	9.68
24	18.4	9328	272.41	0.00	0.00	10.76
26	20.1	11532	272.73	0.00	0.00	11.75
28	21.5	13939	273.05	0.00	0.00	12.66
30	22.6	16518	273.37	0.00	0.00	13.51
32	23.4	19233	273.68	0.00	0.00	14.30
34	23.9	22044	273.99	0.00	0.00	15.03
36	23.9	24907	274.29	4.73	4.73	15.71
38	23.6	27209	274.51	11.44	11.44	16.21
40	22.9	28669	274.65	16.45	16.45	16.51
42	21.9	29445	274.73	16.66	19.30	16.66
44	20.5	30073	274.79	16.78	21.69	16.78
46	19.1	30524	274.83	16.87	23.45	16.87
48	17.8	30793	274.85	16.92	24.52	16.92
50	16.5	30894	274.86	16.94	24.92	16.94
52	15.3	30840	274.86	16.93	24.71	16.93
54	14.2	30648	274.84	16.89	23.94	16.89
56	13.2	30329	274.81	16.83	22.68	16.83
58	12.3	29896	274.77	16.75	21.01	16.75
60	11.4	29361	274.72	16.64	18.98	16.64
62	10.6	28734	274.66	16.52	16.68	16.52
64	9.9	28024	274.59	14.17	14.17	16.37
66	9.2	27506	274.54	12.42	12.42	16.27
68	8.5	27115	274.50	11.13	11.13	16.19
70	7.9	26799	274.47	10.13	10.13	16.12
72	7.3	26532	274.45	9.30	9.30	16.06
74	6.8	26297	274.42	8.58	8.58	16.01
76	6.3	26086	274.40	7.96	7.96	15.97
78	5.9	25891	274.38	7.39	7.39	15.92
80	5.5	25711	274.37	6.88	6.88	15.88

SHEET:	11 / 13
JOB #:	HALIFAX-11
DATE:	8/20/97
BY:	PKS
CHKD BY:	GWR

RISER BARREL ROUTING - REFINED DESIGN:

Input Data:

Particle Data:

Diam. (microns) = 40 **(user input)**
Specific Gravity = 2.65 **(user input)**

Settling Veloc. (ft/s) = 0.004139705
Reynolds No. (<0.5) = 0.044284395

Efficiency Data:

Desired Efficiency (%) = 70 **(user input)**
No. of Effective Cells = 2 **(user input)**

Cs = 8.9167

TIME (min)	INFLOW (cfs)	STORAGE (cu ft)	STAGE (ft)	OUTFLOW (cfs)	SURF. AREA (ft^2)	SET ENV. (cfs)	SET EFF. (%)
0	0.0	0	270.00	0.00	0	na	na
2	0.2	0	270.00	0.00	0	0	ERR
4	0.7	23	270.07	0.00	549	1	ERR
6	1.7	113	270.18	0.00	1065	3	ERR
8	2.9	312	270.33	0.00	1623	4	ERR
10	4.4	661	270.51	0.00	2212	6	ERR
12	6.2	1193	270.72	0.00	2823	7	ERR
14	8.1	1936	270.96	0.00	3448	9	ERR
16	10.2	2913	271.22	0.00	4082	10	ERR
18	12.3	4138	271.49	0.00	4718	12	ERR
20	14.4	5618	271.79	0.00	5353	13	ERR
22	16.5	7351	272.09	0.00	5982	15	ERR
24	18.4	9328	272.41	0.00	6600	17	ERR
26	20.1	11532	272.73	0.00	7205	18	ERR
28	21.5	13939	273.05	0.00	7791	20	ERR
30	22.6	16518	273.37	0.00	8357	21	ERR
32	23.4	19233	273.68	0.00	8899	22	ERR
34	23.9	22044	273.99	0.00	9415	24	ERR
36	23.9	24907	274.29	4.73	9902	25	96.5
38	23.6	27209	274.51	11.44	10270	26	87.8
40	22.9	28669	274.65	16.45	10494	26	81.4
42	21.9	29445	274.73	16.66	10611	27	81.4
44	20.5	30073	274.79	16.78	10703	27	81.4
46	19.1	30524	274.83	16.87	10769	27	81.4
48	17.8	30793	274.85	16.92	10809	27	81.5
50	16.5	30894	274.86	16.94	10823	27	81.5
52	15.3	30840	274.86	16.93	10815	27	81.5
54	14.2	30648	274.84	16.89	10787	27	81.4
56	13.2	30329	274.81	16.83	10741	27	81.4
58	12.3	29896	274.77	16.75	10677	27	81.4
60	11.4	29361	274.72	16.64	10598	27	81.4
62	10.6	28734	274.66	16.52	10504	26	81.4
64	9.9	28024	274.59	14.17	10396	26	84.2
66	9.2	27506	274.54	12.42	10316	26	86.5
68	8.5	27115	274.50	11.13	10255	26	88.2
70	7.9	26799	274.47	10.13	10206	26	89.5
72	7.3	26532	274.45	9.30	10164	25	90.6
74	6.8	26297	274.42	8.58	10126	25	91.6
76	6.3	26086	274.40	7.96	10093	25	92.4
78	5.9	25891	274.38	7.39	10062	25	93.1
80	5.5	25711	274.37	6.88	10033	25	93.8

SHEET:	12/13
JOB #:	HALIFAX-11
DATE:	8/20/97
BY:	PKS
CHKD BY:	GWR

BASIN DEWATERING:

Determine Cleanout Level:

Ks =	2088	Basin Vol. (ft^3) =	22150.746
b =	1.70	1/2 Basin Vol. (ft^3) =	11075.373
Zcr (ft) =	274		
Zo (ft) =	270	Cleanout Level (ft) =	272.66

h (ft) =	1.34	(crest of riser to cleanout level)
Area of Basin (ft^2) =	7085	(at cleanout level)
Coef. of Contraction =	0.6	**(User Input)**
Detention Time (hrs.) =	10	**(User Input)**
Tot. Area of Holes(ft^2) =	0.0945	
Number of 1/2" Holes =	68	

ANCHORAGE REQUIREMENTS:

Design Uplift Force:

F (lbs) = 1941

Concrete Ballast Required:

Volume (ft^3) = 22.2

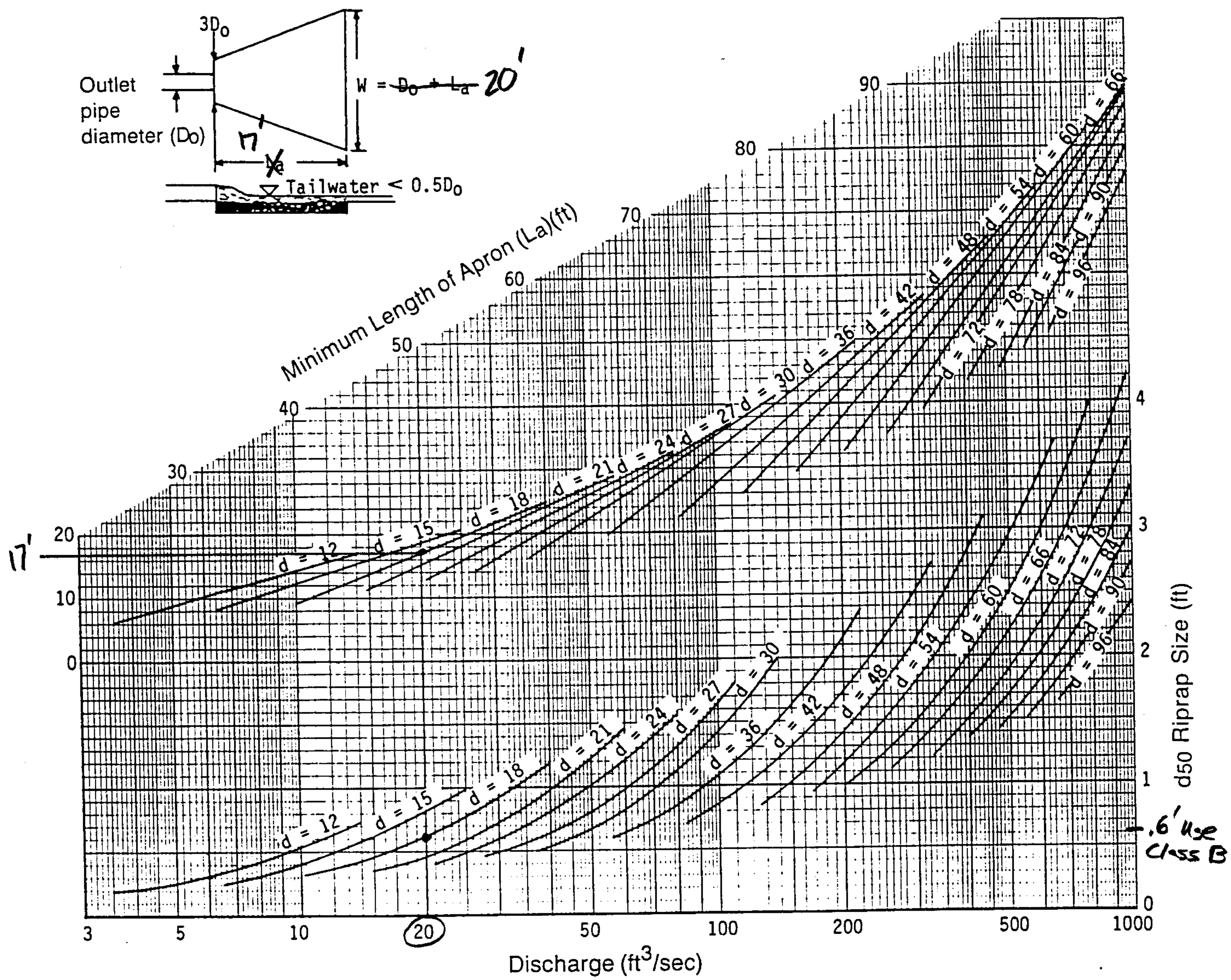
4'x4'x2' O.K.

EMERGENCY SPILLWAY DESIGN:

Required Capacity (cfs) =	23.9	
Driving Head (ft) =	1	**(User Input)**
Weir Coefficient =	3	**(User Input)**
Length of Crest (ft) =	8.0	(Determine by Weir Equation)*
Design Crest Length (ft) =	20	**(User Input)**

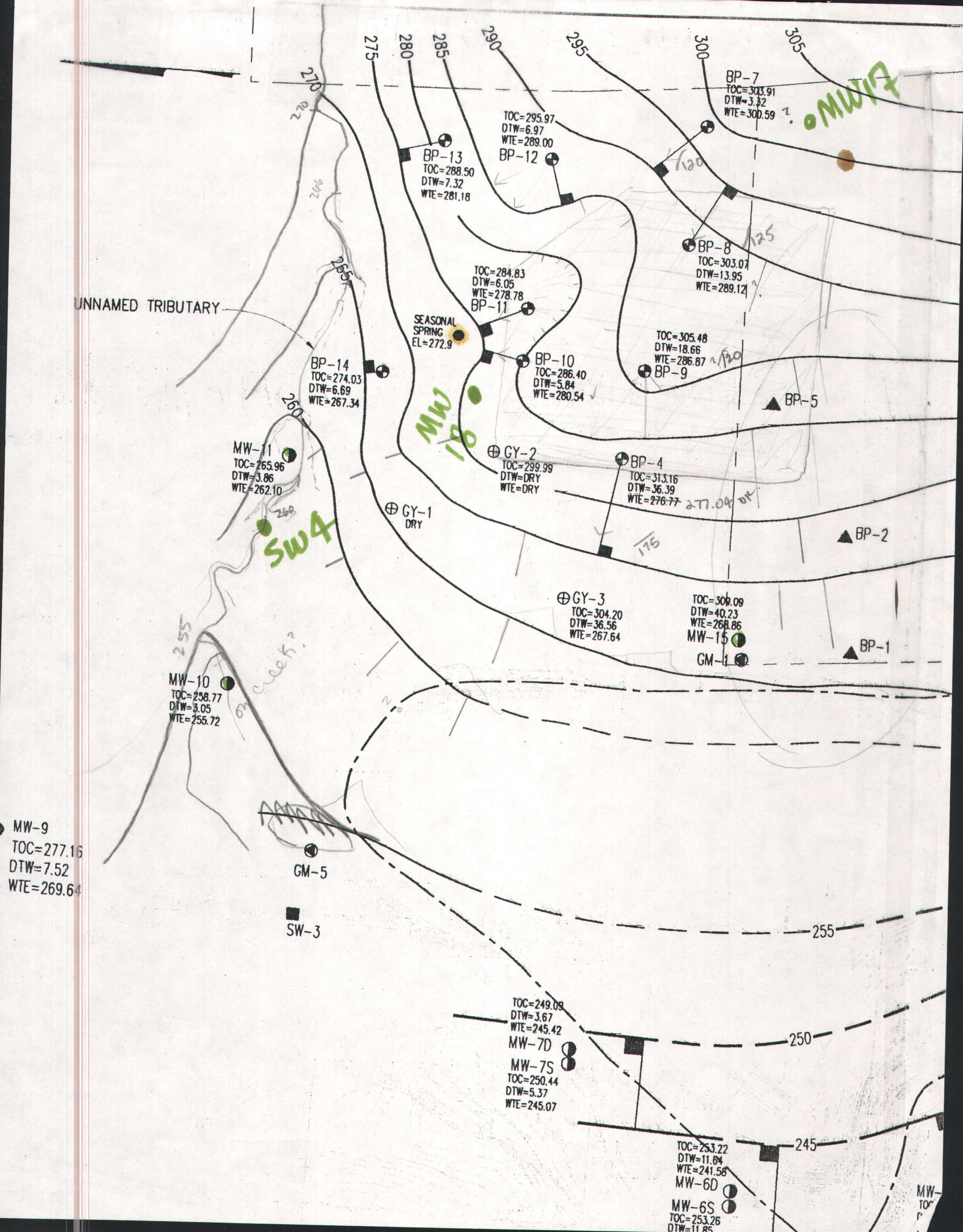
*** Length = 20 ft minimum.**

Velocity (ft/s) =	1.8	**Grass OK**



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).



270
275
280
285
290
295
300
305
BP-7
TOC=303.91
DTW=3.32
WTE=300.59
MW17
TOC=295.97
DTW=6.97
WTE=289.00
BP-12
BP-13
TOC=288.50
DTW=7.32
WTE=281.18
120
125
BP-8
TOC=303.07
DTW=13.95
WTE=289.12
UNNAMED TRIBUTARY
265
TOC=284.83
DTW=6.05
WTE=278.78
BP-11
SEASONAL SPRING
EL=272.9
BP-14
TOC=274.03
DTW=6.69
WTE=267.34
BP-10
TOC=286.40
DTW=5.84
WTE=280.54
TOC=305.48
DTW=18.66
WTE=286.87
BP-9
BP-5
MW 18
260
MW-11
TOC=265.96
DTW=3.86
WTE=262.10
GY-2
TOC=299.99
DTW=DRY
WTE=DRY
BP-4
TOC=313.16
DTW=36.39
WTE=276.77
277.09 ok
GY-1
DRY
SW4
175
BP-2
GY-3
TOC=304.20
DTW=36.56
WTE=267.64
TOC=309.09
DTW=40.23
WTE=268.86
MW-15
GM-1
BP-1
255
MW-10
TOC=258.77
DTW=3.05
WTE=255.72
on creek?
MW-9
TOC=277.16
DTW=7.52
WTE=269.64
GM-5
SW-3
255
TOC=249.09
DTW=3.67
WTE=245.42
MW-7D
MW-7S
TOC=250.44
DTW=5.37
WTE=245.07
250
245
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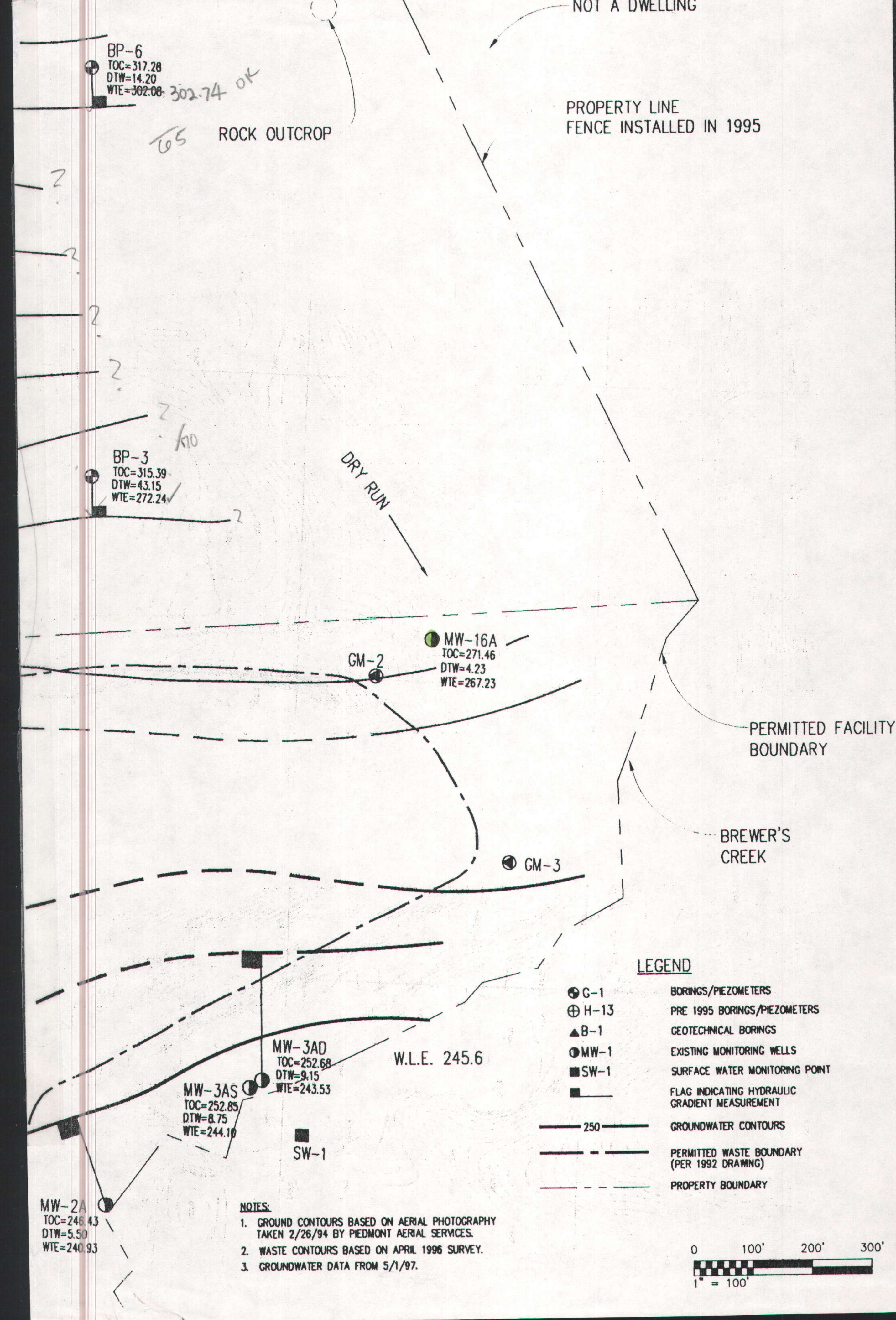
WTE=241.58
MW-6D
MW-6S
TOC=253.26
DTW=11.85



NOTES:
1. GROUND CONTOURS BASED ON AERIAL PHOTOGRAPHY TAKEN 2/26/94 BY PIEDMONT AERIAL SERVICES.
2. WASTE CONTOURS BASED ON APRIL 1996 SURVEY.
3. GROUNDWATER DATA FROM 5/1/97.

G.N. RICHARDSON & ASSOCIATES, Engineering and Geological Ser...
417 N. BOYLAN AVENUE RALEIGH, N.C. 2...
PHONE-919-828-0577 FAX-919-828-3899 WWW.G...

SEAL: NORTH CAROLINA PROFESSIONAL SEAL 021666 ENGINEER PIETER K. SCHEER

SEAL: NORTH CAROLINA LICENSED SEAL 983 GEOLOGIST C. DAVID GARRETT

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: GROUND WATER POTENTIOMETRIC SURFACE AS OF 5/1/97

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO. HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO 6	DRAWING NO S1A

Table 2
Geotechnical Laboratory Data

Sample Number	Sample Depth, ft.	Sample Type	Grain Size Distributuion and Soil Classification % >3" >75 mm	% Gravel 75 mm>	% Sand 4.5 mm>	% Silt 0.075 mm>	% Clay 0.005 mm>	Liquid Limit	Plasticity Index	USCS Class.	Natural Moisture %
BP-1	0-1.5 sdc	Jar	0	0	29	18	53	59	27	MH	--
BP-3	0-1.5 cl	Jar	0	0	30	20	50	57	29	CH	--
BP-3	3.0 - 5.0 sdcsi	Bulk	0	0	59	40*	-- #100	37	10	SM	13.8
BP-6 (1)	0-1.5 sdsicl	Jar	0	0	20	35	45	58	12	MH	--
BP-6 (2)	3.5-5.0 sdclsi	Jar	0	0	47	32	21	59	7	MH	--
BP-6	15-20	Bulk	0	0	48	52*	--	49	15	ML	34.2
BP-7	1.0-10.0	~~Jar~~ Bulk	0	0	39	39	22	43	15	ML	36.7
BP-8	1.0-10.0	Bulk	0	0	37	10	53	49	15	ML	25.1
BP-9	15 - 20	Bulk	0	0	48	34	18	45	6	ML	31.8
BP-12	0-1.5	Jar	0	0	18	65	17	72	13	MH	72.0
BP-13	0-1.5	Jar	0	0	20	62	18	70	16	MH	57.8
BP-2	0-1.5				30	18	52	57	29	CH	

Representative nat mois

Sample Number	Sample Depth, ft.	Sample Type	Remolded Moisture-Density Data: Max. Dry Density, pcf	Optimum Moisture, %	Natural Moisture, %	Total** Porosity, %	Hydraulic Conductivity Data: Rem. Dry Density, pcf	Remolded Moisture, %	Ksat @ 5 psi cm/sec
BP-3 (sdclsi)	3.0 - 5.0	Bulk	107.5	19.0	13.8 ?	40.3	102.5	22.0	3.97E-08
BP-6 (sdclsi / sdsi (fill))	15.0 - 20.0	Bulk	102.6	21.5	34.2 ?	43.2	97.6	24.5	1.45E-07
BP-8 (s,sdcl)	1.0-10.0	Bulk	98.1	24.0	25.1	45.9	92.9	24.4	2.96E-07 only sample in footpt.

The following Undisturbed Samples were collected during Nov-Dec 1995 for MSW permiting report and considered representative: ← of what?

Test Notes?

Sample Number	Sample Depth, ft.	Sample Type	In-Situ Moisture-Density and Hydraulic Conductivity Data: Dry Density, pcf	Wet Density, pcf	Natural Moisture, %	Total Porosity,%	Ksat @ 5 psi cm/sec**
B-4	1.0 - 3.0	Tube	110.6	129.8	17.3	35.6	4.66E-06
B-8	5.0 - 7.0	Tube	99.5	123.2	23.8	42.0	1.62E-05

← Test value should be closer to 3.20 see ASTM D5084 8.5.3 1 more test should have been run. (9.08 does not fall w/in 25% of mean value of K).

Note to Above:

Moisture Contents are Dry Unit Weight Based

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

** Total Porosity values are backcalculated from Void Ratios

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

Samples tested by Geotechnologies, Inc.

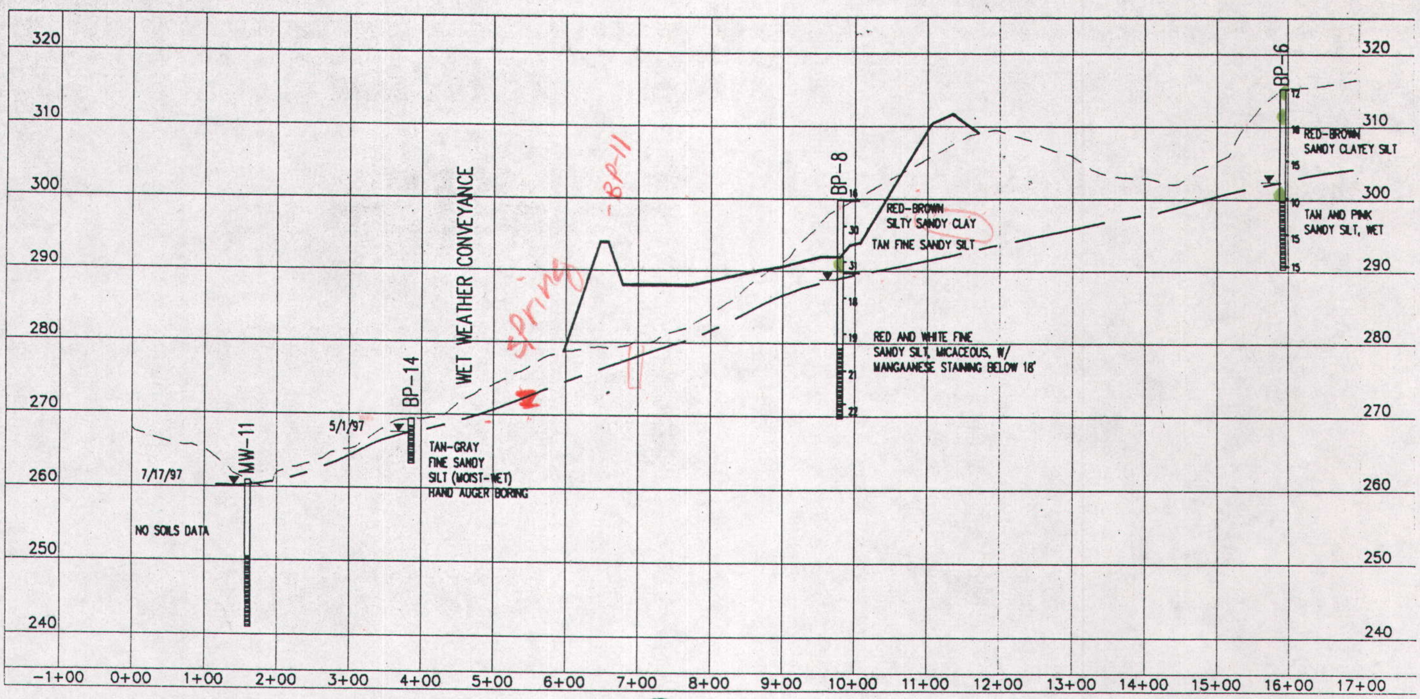
C	S	S	G
22	40		
52	~~64~~ ~~52~~ 12		~~100~~ ~~64~~ 36

50-96

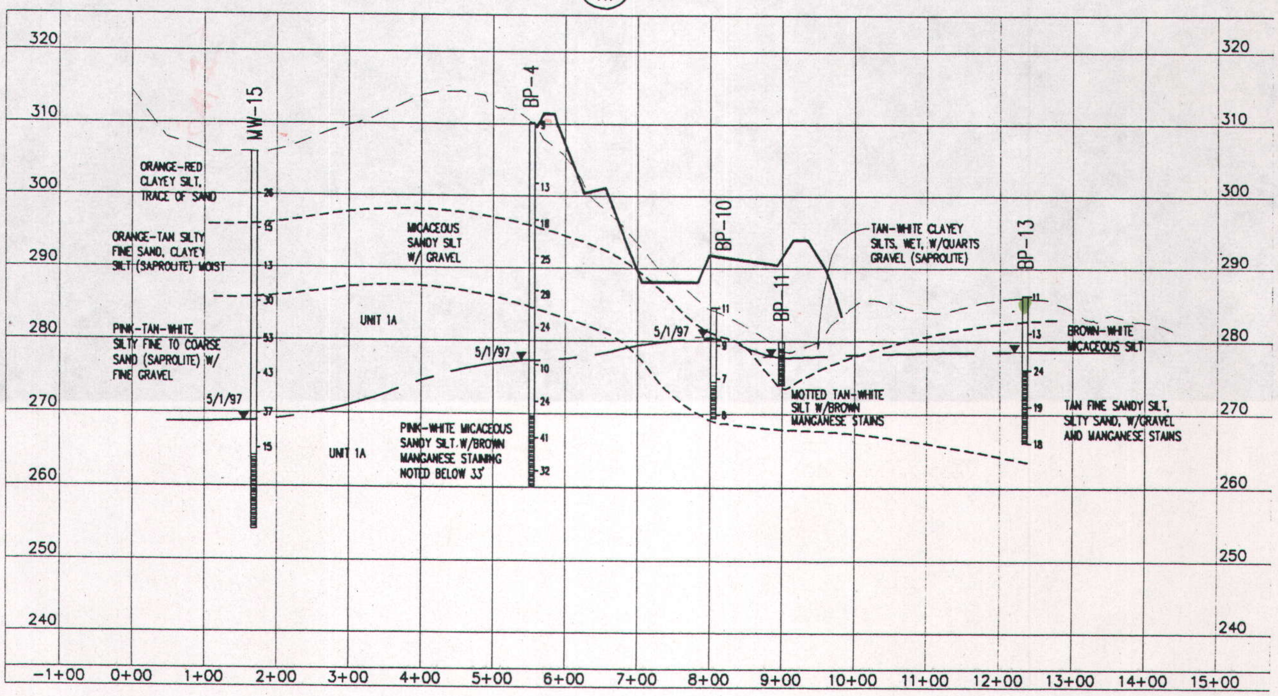
600

62

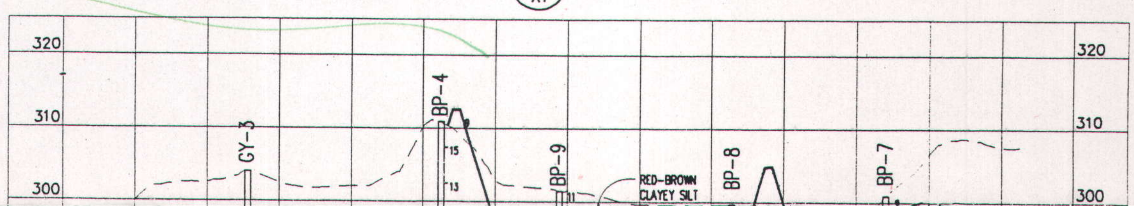
D:\-CAD\HALFAX-11\S-X1.dwg DATE: AUG 28, 1997 TIME: 3:35 PM



CD-1 / X1 CROSS SECTION



CD-2 / X1 CROSS SECTION



LEGEND

BP-1 36 29' 36'
BP-2 30 40

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

BP-5 40

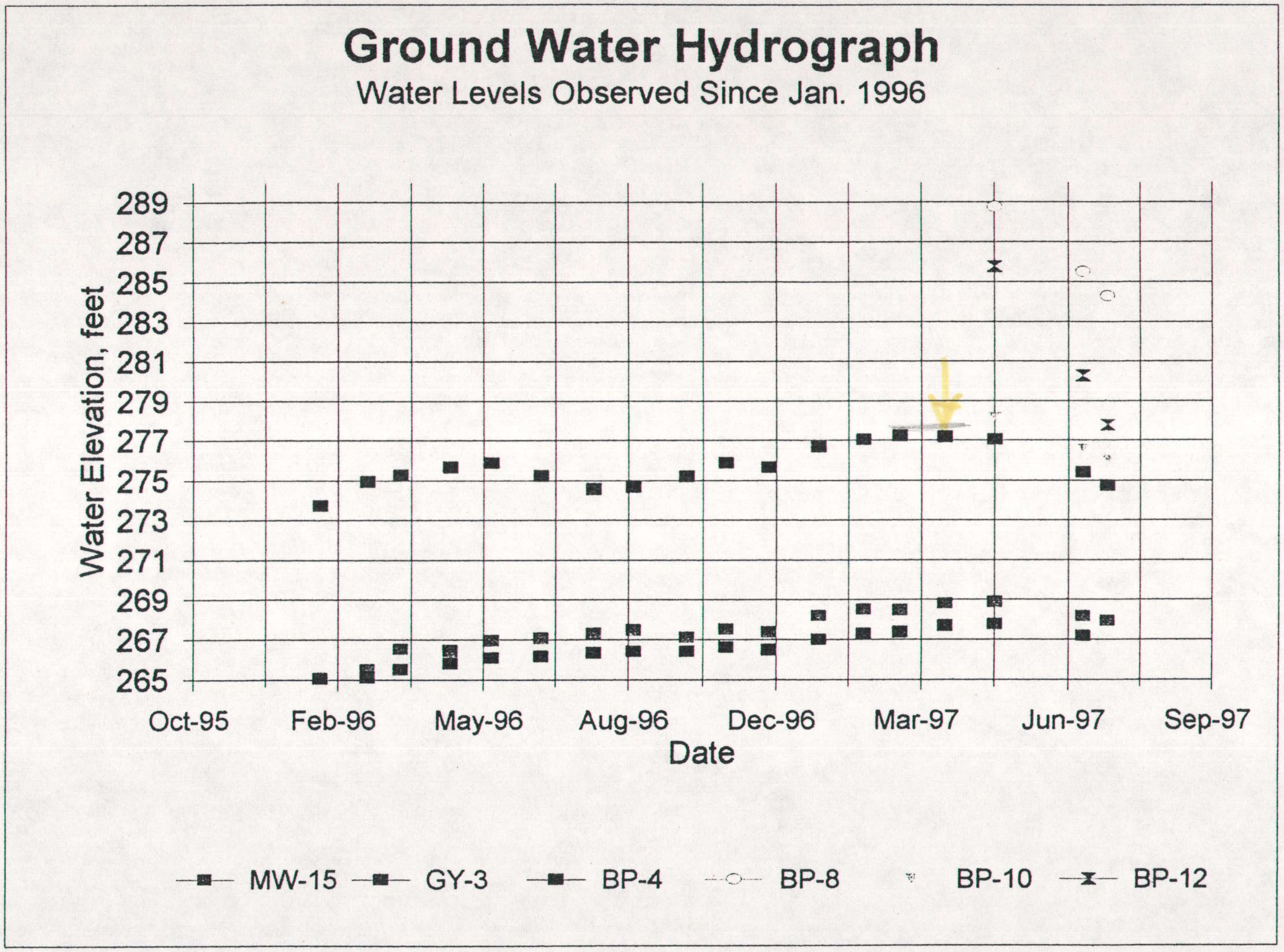
Elevation Data				Geotechnical Data					Piezometer Construction Data				
Boring Number	Boring Date	Ground Elev.	PVC Pipe Elev.	Boring Depth, ft.	PWR Depth, ft.	PWR Elev.	Refusal Depth, ft.	Refusal Elev.	Top of Piez. Screen Depth, ft.	Top of Piez. Screen Elev.	Bot. of Piez. Screen Depth, ft.	Bot. of Piez. Screen Elev.	Stickup ft.
BP-3	12/06/95	313.7	315.39	50	--	--	--	--	38	275.7	48	265.7	1.69
BP-4	12/06/95	310.8	313.16	48	--	--	--	--	38	272.8	48	262.8	2.36
BP-6	12/05/95	315.0	317.28	25	--	--	--	--	15	300.0	25	290.0	2.28
BP-7	04/29/97	301.1	303.91	20	--	--	--	--	15	286.1	20	281.1	2.81
BP-8	04/29/97	299.8	303.07	30	--	--	--	--	23.5 24	276.3	28.5	271.3	3.27
BP-9	04/28/97	302.1	303.48	36?	--	--	--	--	26	276.1	36	266.1	1.38
BP-10	04/30/97	284.4	286.40	15	--	--	--	--	10	274.4	15	269.4	2.00
BP-11	05/01/97	280.0	284.83	6	--	--	--	--	1	279.0	6	274.0	4.83
BP-12	04/30/97	294.4	295.97	26?	--	--	--	--	21	273.4	26	268.4	1.57
BP-13	04/30/97	286.1	288.50	20	--	--	--	--	15	271.1	20	266.1	2.40
BP-14	05/01/97	269.7	274.03	6	--	--	--	--	1	268.7	6	263.7	4.33
GY-1		291.2	292.51	30	--	--	--	--					1.31
GY-2		297.9	299.99	20	--	--	--	--					2.09
GY-3		304.2	304.20	50	--	--	--	--					0.00
MW-11			265.96		--	--	--	--					
MW-15	09/21/94	307.1	309.09	~~20~~ 50	--	--	--	--	35	272.6	49	258.1	1.99

missing borelogs

BP1 Dry
2 27
5 27

Ground Water Observations				
Boring Number	Time of Boring Depth, ft.	Time of Boring Elev.	24-hour readings Depth, ft.	24-hour readings Elev.
BP-3	45.51	268.19	45.22	268.48
BP-4	38.3	272.50	36.25	274.55
BP-6	16.64	298.36	15.94	299.06
BP-7	1	300.10	3.26	297.84
BP-8	21.7	278.10	14.43	285.37
BP-9	18.4	283.70	18.88	283.22
BP-10	4.8	279.60	5.86	278.54
BP-11	0.5	279.50	2.05	277.95
BP-12	21.3	273.10	6.97	287.43
BP-13	15.8	270.30	7.32	278.78
BP-14	2.5	267.20	2.6	267.10
GY-1				
GY-2				
GY-3				
MW-11				
MW-15	41.5	265.60	42.15	264.95

Notes:
1. Ground water and piezometer elevations are based on topographic surveys performed 2/25/96 and 5/15/97
2. No data exists for GY series brings, performed by others ca. 1994
3. Boring record not located for MW-11, performed by others ca. 1994
4. No 7-day ground water levels were obtained - see Table 1 C



Ground Water Hydrograph
Water Levels Observed Since Jan. 1996
Water Elevation, feet
289
287
285
283
281
279
277
275
273
271
269
267
265
Oct-95
Feb-96
May-96
Aug-96
Dec-96
Mar-97
Jun-97
Sep-97
Date
MW-15
GY-3
BP-4
BP-8
BP-10
BP-12

Table 3
Ground Water Hydrograph

	01/24/96	02/26/96	03/20/96	04/23/96	05/22/96	06/25/96	07/31/96	08/27/96	10/02/96	10/29/96	11/27/96	12/31/96	01/31/97	02/25/97	03/28/97	05/15/97	06/30/97	07/17/97
MW-15		265.51	266.53	266.46	266.95	267.06	267.32	267.47	267.13	267.53	267.39	268.19	268.52	268.48	268.79	268.86	268.16	267.92
GY-2	278.36	278.35	278.35	278.34	278.32	--	278.32	278.33	278.32	278.27	278.25	278.24	278.28	--	--	--	--	--
GY-3	265.07	265.10	265.52	265.81	266.10	266.18	266.33	266.40	266.40	266.61	266.48	267.00	267.29	267.35	267.68	267.76	267.17	--
BP-3	268.44	269.28	269.94	270.14	270.48	270.41	270.51	270.55	270.50	270.89	270.79	271.10	272.02	271.93	272.26	272.00	271.48	271.12
BP-4	273.72	274.93	275.26	275.67	275.88	275.21	274.55	274.68	275.18	275.87	275.64	276.66	277.05	277.23	277.19	277.04	275.39	274.71
BP-6	300.98	303.97	303.48	303.67	302.89	298.93	298.80	298.92	298.86	302.03	301.34	301.50	299.79	304.80	304.21	302.72	298.26	296.40
BP-7																298.29	294.61	293.27
BP-8																288.76	285.49	284.25
BP-9																284.32	281.93	280.92
BP-10																278.17	276.58	276.03
BP-11																278.01	275.62	--
BP-12																285.75	280.26	277.77
BP-13																278.59	274.94	273.26
BP-14																266.91	265.86	264.97

Summary of Highest Water Elevations Observed Since January 1996

Boring	H.W.E.	Date	Comment
MW-15	268.86	05/01/97	Well has been in service since Sept. 1994
GY-2	278.36	01/24/96	Recurred 1/31/97, went dry the next month
GY-3	267.76	05/01/97	
BP-3	272.26	03/28/97	
BP-4	277.23	02/25/97	
BP-6	304.21	03/28/97	
BP-7	298.29	05/01/97	24-hour stabilized reading
BP-8	288.76	05/01/97	
BP-9	284.60	04/29/97	24-hour stabilized reading
BP-10	280.54	05/01/97	24-hour stabilized reading
BP-11	278.01	05/02/97	24-hour stabilized reading
BP-12	289.00	05/01/97	24-hour stabilized reading
BP-13	281.18	05/01/97	24-hour stabilized reading
BP-14	267.10	05/02/97	24-hour stabilized reading

Table 1

Ground Water and Surface Water Monitoring Plan
Monitoring Well and Stream Sampling Locations

Halifax County Landfill

October, 1996

Monitoring Wells	Well Location	Monitoring Schedule
MW-1	Background well	Semi-annually
MW-2a	Down gradient well	Semi-annually
MW-3ad	Down gradient well	Semi-annually
MW-6s	Down gradient well	Semi-annually
MW-6d	Down gradient deep well	Bi-annually
MW-7s	Down gradient well	Semi-annually
MW-7d	Down gradient deep well	Bi-annually
MW-15	Up gradient well	Semi-annually
MW-16a	Up gradient well	Semi-annually
MW-17*	Up gradient of new C&D landfill	Semi-annually
MW-18*	Down gradient of new C&D landfill	Semi-annually
Stream Sampling Point	**Location of Sampling Point**	**Proposed Placement**
SW-1	Up gradient of Unlined MSW landfill	Existing Sampling Location (Already Monitored)
SW-2	Down gradient of Facility along Property Line	Existing Sampling Location (Already Monitored)
SW-3	Up gradient of Lined and Unlined MSWLF Units	Existing Sampling Location (Already Monitored)
SW-4*	Down gradient of New C&D Landfill	New Sampling Location

* Proposed for planned C&D landfill. See map for location and survey coordinates.

The sampling schedule is currently conducted in February and August of each plan year.
No changes to this schedule are proposed.

Table 2

Estimated Monitoring Well Completion Data

Halifax County Unlined Landfill

October, 1996

Monitoring Well	Top of Casing Elevation	Depth to Bottom, ft.	Screened Interval, ft.
MW-1	324.60	40	25.0 - 40.0
MW-2a	246.43	14	4.0 - 14.0
MW-3ad	252.68	19	9.0 - 19.0
MW-6s	253.26	23	8.0 - 23.0
MW-6d	253.22	40	25.0 - 40.0
MW-7s	250.44	17	2.5 - 17.5
MW-7d	249.09	40	25.0 - 40.0
MW-15	309.09	50	35.0 - 50.0
MW-16a	271.46	19	4.0 - 19.0
MW-17*	±310	±20	5.0 - 20.0
MW-18*	±280	±20	5.0 - 20.0

* Proposed for planned C&D landfill. Surface elevation and screen depths anticipated based on nearby test boring data. Actual depths will be determined based on conditions encountered during drilling.

All measurements given in feet.

Sampling and Analytical Schedule

	February	August
Old MSW Landfill	Appendix II	Appendix I and Triggered Appendix. II
New C&D Landfill	Appendix I	Appendix I
Surface Water Points	Appendix I	Appendix I

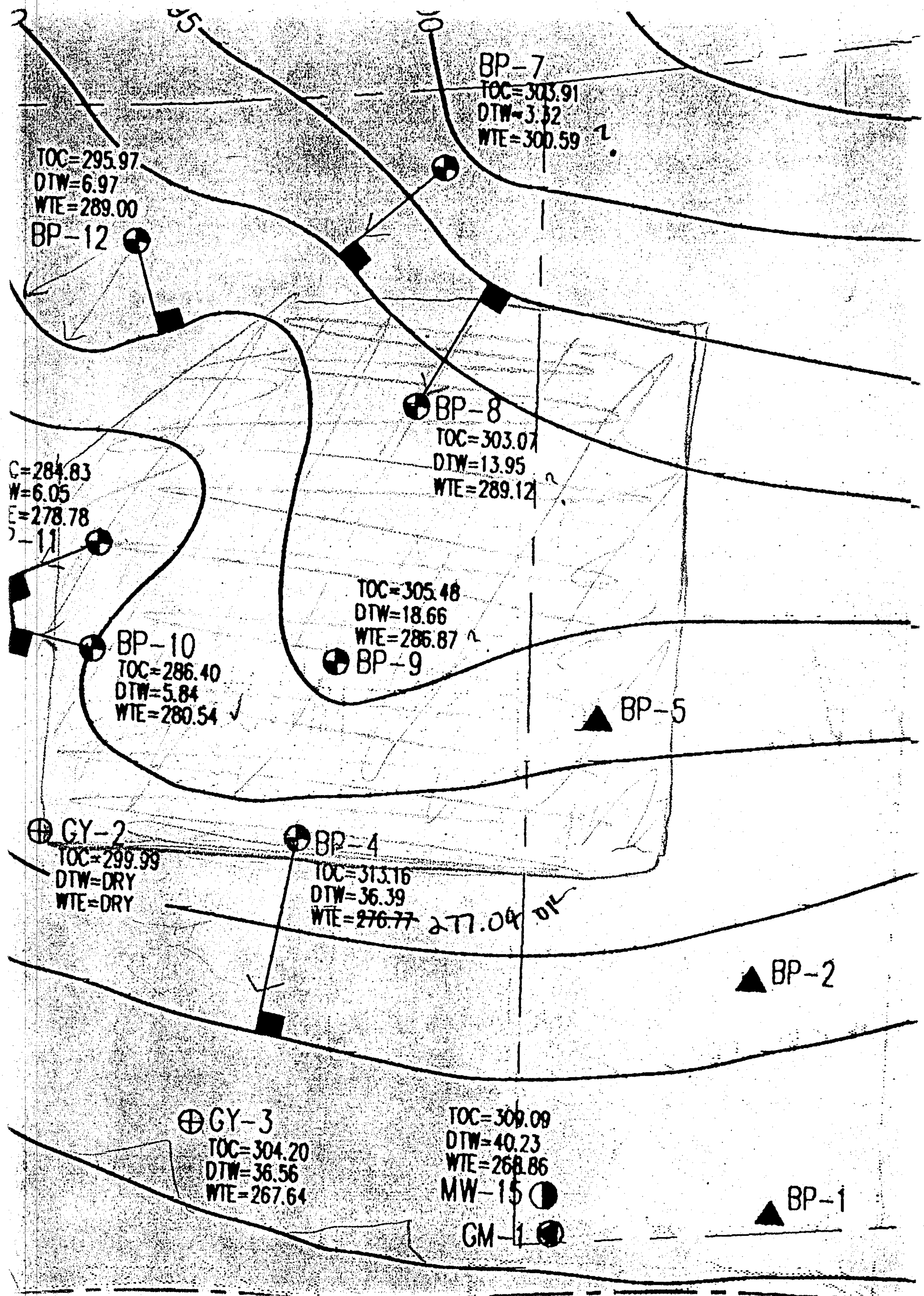
Table 4
Horizontal Ground Water Gradient and Velocity Calculations
Halifax County Landfill

Well No.	Hydraulic Conductivity (K)	Hydraulic Gradient (I)	Effective Porosity (n)	Ground Water Velocity (V)	
BP-3	0.29	0.023 .032	0.2	0.03	SM
BP-4	2.21	175 0.040 0.039	0.2	0.44	Silt
BP-6	10.80	0.070 0.042	0.2	3.78	ML
BP-7	22.84	0.112 0.088	0.2	12.79	ML
BP-8	3.20	0.050 .047	0.2	0.80	ML
BP-9	3.45	0.030 0.06	0.2	0.52	ML
BP-10	27.92	0.060	0.2	8.38	MH
BP-12	4.74	0.050	0.2	1.19	MH-CL per log
BP-13	9.46	0.093	0.2	4.40	MH

Notes: Ground Water Velocity Calculated from Equation:
$V=KI/n$

Hydraulic Conductivity in ft/day
Hydraulic Gradient in ft/ft
Effective Porosity in ft/ft
Ground Water Velocity in ft/day

Effective Porosity values from published literature.
Hydraulic Conductivity values from aquifer slug testing
Hydraulic Gradient values calculated from hydraulic gradient map


BP-7
TOC=303.91
DTW=3.32
WTE=300.59
TOC=295.97
DTW=6.97
WTE=289.00
BP-12
BP-8
TOC=303.07
DTW=13.95
WTE=289.12
C=284.83
W=6.05
E=278.78
TOC=305.48
DTW=18.66
WTE=286.87
BP-10
TOC=286.40
DTW=5.84
WTE=280.54
BP-9
BP-5
GY-2
TOC=299.99
DTW=DRY
WTE=DRY
BP-4
TOC=313.16
DTW=36.39
WTE=~~276.77~~ 277.09 ok
BP-2
GY-3
TOC=304.20
DTW=36.56
WTE=267.64
TOC=309.09
DTW=40.23
WTE=268.86
MW-15
BP-1
GM-1

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

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

11-17-97

Post-it® Fax Note 7671	Date 11-14-97 # of pages ▸ 5 3
To David Garrett	From Ellen Lorscheider
Co./Dept. GN Richardson	Co. Solid Waste Section
Phone # 828-0577	Phone # 733-0692 ext 345
Fax # 828-3899	Fax # 7334810

November 14, 1997

Mr. G. David Garrett, P.G.
G. N. Richardson & Associates
417 N. Boylan Avenue
Raleigh, North Carolina 27603

RE: Review of the Permit Application Report
Halifax County C & D Landfill
Permit 42-04

Dear Mr. Garrett,

The Solid Waste Section Hydrogeologic Unit has reviewed the above referenced Permit Application submitted by G. N. Richardson & Associates. Following are concerns which have been identified. Please provide responses to these comments and questions, and make revisions as necessary.

In order to satisfy Solid Waste Management Rules (15A NCAC 13B) Section .0503, please note:

A letter from the Natural Heritage Program dated December 11, 1990, a letter from the Department of Cultural Resources dated January 31, 1991, and "A Phase I Cultural Resource Study of the Proposed 55-Acre Halifax County Landfill" dated March 9, 1991, was used to show that plant, fish or wildlife; archeological or historical sites; and state park, recreation or scenic areas, etc., are not impacted by this site, according to Rule (1)(b)(i through iv). Since these letters and reports predate the addition of 30 acres for the C & D site, it needs to be verified that this new area is taken into consideration. Figure 9 included with the Cultural Resource Study does not appear to include the C & D area.

VERTICAL SEPARATION

Rule (2)(d)(i) states that "The bottom elevation of solid waste will be a minimum of four feet above the seasonal high water table." According to the potentiometric map (Drawing S1A), in comparison to the final base grade, this rule is not met, especially in the northeast part of the site. This can also be seen on the cross sections CD-1 and CD-3 at boring BP-8.

In order to satisfy Solid Waste Management Rules (15A NCAC 13B) Section .0504, please note:

POTENTIAL OR EXISTING SOURCES OF WATER POLLUTION

Two gas stations are mentioned in the report as possible sources of ground water contamination yet only one is shown on the Regional Characterization Map or the Local area map (Sheet No. 1 and 2) per Rule (1)(b)(ii).

SOIL BORING

BP-9 depth of hole is given as 35 and 36 feet respectively on lithology and screen depth columns, as well as the Total Depth and Boring Terminated labels, of the boring log. Correct log and corresponding tables.

BP-12 depth of hole is given as 25 and 26 feet, correct log and corresponding tables.

LABORATORY TESTING - TABLES AND APPENDIX E

Sample BP-7 -- field log indicates that this was a bulk sample and Table 2 indicates that it was a jar sample.

Sample BP-2 -- grain size distribution testing and Atterburg limits' results are included in Appendix E, but results are not included on Table 2.

Samples BP-3, BP-6, BP-8, BP-9 and BP-7 (see above note about sample types) are listed as bulk samples on Table 2. How was natural moisture content taken, and is it representative of an in situ result?

Samples B-4 and B-8 -- check USCS classification, especially the grain size distribution graph regarding percent fines.

Sample B-4 permeability test results for this sample violate the part of ASTM D5084 test which states that each of the 4 consecutive test results (before averaging) must be within 25% of the mean of the 4. The test result of 9.08×10^{-6} is not within this range. Should this test result be adjusted?

On Table 1B the Total Porosity of sample from boring BP-10 is reported as 0.46, is this correct?

On Table 1B what does Aquifer Thickness refer to, high water table to ... ?

On Table 1B all of the reported Effective Porosity values are 0.20. How could this be possible given the soils vary from a MH-CL to SM? Please include the literature where these values come from. The values could not be found in Groundwater and Wells, by Driscoll, as footnoted on Page 9 of the report.

GEOLOGICAL AND HYDROLOGICAL STUDY

The added 30 acre parcel, which partially includes the C & D facility, does not seem to be hydrogeologically characterized. Characterize all of this additional property, or explain that uncharacterized portion is to be used for buffer and monitoring only and is believed to have similar hydrogeologic characteristics as the rest of the property.

The geological and hydrological aspects of the seasonal spring, north of the site, need to be described in the report. What is the geology, at the spring, which controls the water? When is the spring observed (seasonally)?

In the second paragraph of Page 7, boring BP-1 is mentioned as encountering auger refusal. In the third paragraph the report states that "Unit 2, identified ... as bedrock and weathered rock ... was not encountered at the C & D site. All of the piezometers were completed within Unit 1a soils." These statements are in conflict to each other. Report needs to be amended to clearly state the actual geology.

Further evidence of the geology being different (or more complicated) than was presented in the report is made evident by the location of rock outcropping in the southeast portion of the site. This outcrop is shown on Drawing S1 -- Existing Site Conditions, and is not mentioned in the report or shown on any of the cross sections.

Locations of borings B-4 and B-8, included on Table 2, need to be shown on Sheet No. 5 (Existing Site Conditions).

Rule (1)(c)(i)(E) requires "information for each major lithologic units" be given. It appears that further distinction could be made of lithologic (hydrogeologic) units (fine-grained soils, coarser-grained soils, partially weathered rock, fractured rock). In-situ saturated hydraulic conductivity tests are needed from the C & D landfill area for each lithologic unit.

If samples from other locations are to be used as supplemental references , to represent units, it needs to be clearly proven how these lithological units are represented by each sample. For example, how do you know that the unit underlying the C & D site is made up of a lithology consistent with Unit-1a if you did not penetrate into the underlying Unit-1b?

The description of the Groundwater Flow Characteristics on Page 8 and 9 of the application discuss characteristics of the MSWLF and are not specific to the C & D site. Clarification in needed.

It is not stated which remolded samples are representative of the cover soil (per Rule (1)(c)(i)(F)). This needs to be included in a table and/or the report.

Monitoring Plan

The Ground Water Sampling and Analysis Plan (Appendix G) needs to be specific to the C & D facility only.

According to Rule .0504 (1)(g)(iv) well schematics showing proposed well interval, depth and construction must be included in the monitoring plan.

Potentiometric contours, as shown on Figure 2, indicate a westerly and southwesterly direction of flow on the southern side of the C & D facility. The lack of information on the southern side of the site leaves questions as to the actual direction of flow and if these monitoring well locations are appropriate.

Considering groundwater flow patterns and hydrogeology, are other monitoring wells needed?

Consideration should also be given to the monitoring of the seasonal spring location. As previously mentioned the geology of this spring needs to be better understood. The sedimentation basin may interfere with monitoring the spring or establishing monitoring wells that may be needed in this general area.

Corrections and/or clarifications of text, which are made concerning the aforementioned issues or any other issues which are deemed necessary, should be resubmitted to the Solid Waste Section. Please note the date of revision on each page. If there are any questions regarding this letter or if a meeting needs to be arranged to discuss these issues, please contact me at 919-733-0692, extension 345.

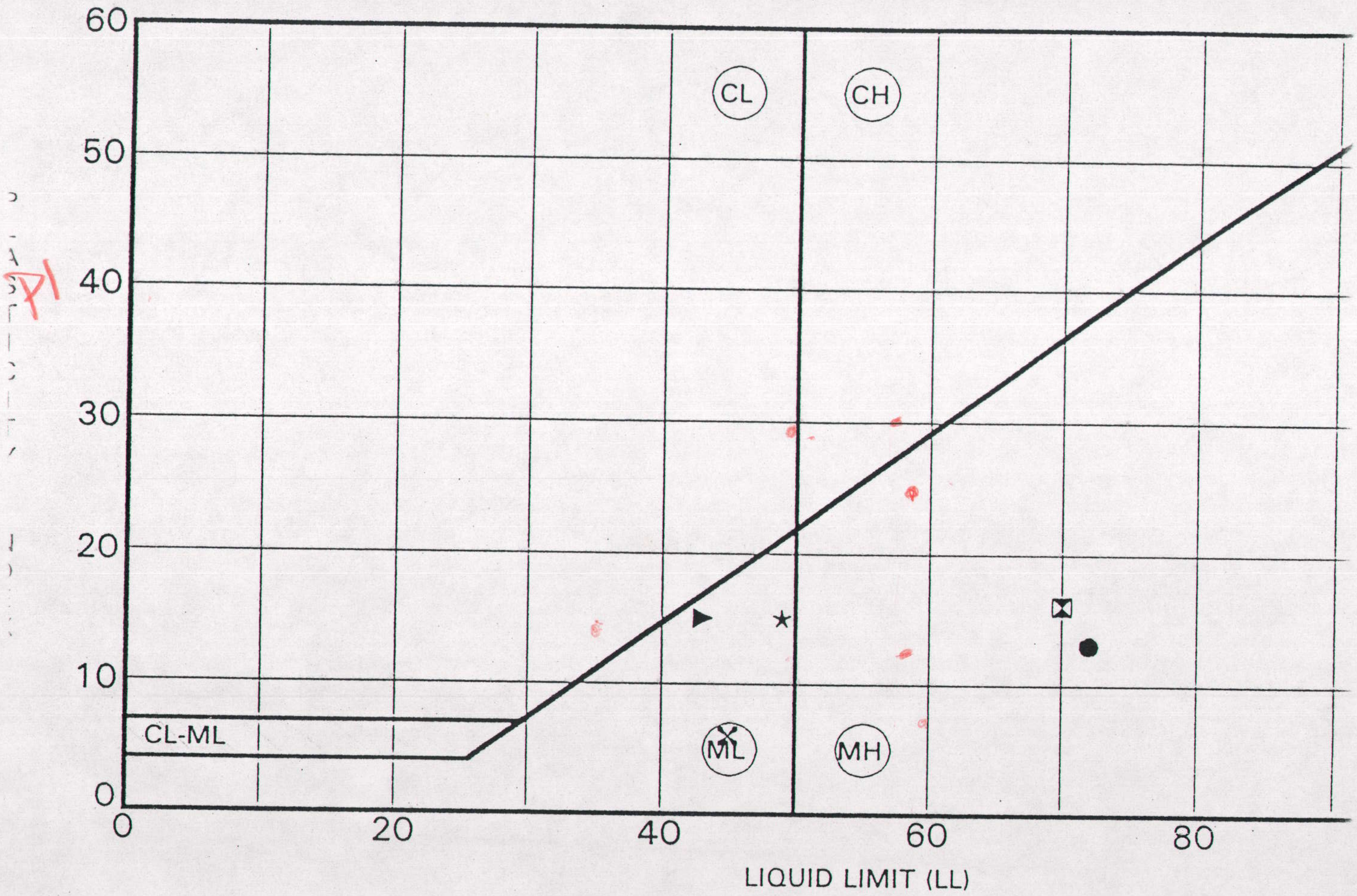
Sincerely,

Ellen B. Lorscheider

Ellen B. Lorscheider
Hydrogeologist

cc: Bobby Lutfy, Solid Waste Section
Sherri Coghill, Solid Waste Section

typo. Pg 1 Rule .0504 (1)-(6)



60
50
PI
40
30
20
10
0
CL
CH
CL-ML
ML
MH
0
20
40
60
80
LIQUID LIMIT (LL)

I, LEWIS O. BURR, CERTIFY THAT THIS PLAT WAS DRAWN UNDER MY SUPERVISION FROM AN ACTUAL SURVEY MADE UNDER MY SUPERVISION ON 8-94 & 4-10-95, THAT BOUNDARY DEFINITIONS FOUND IN RECORDED PAPERS DB 1081, PG 255 WERE USED AS THE PRIMARY GUIDES FOR THIS SURVEY: THAT THE BOUNDARIES NOT SURVEYED ARE CLEARLY INDICATED AS DRAWN FROM INFORMATION FOUND IN BOOK ---, PAGE ---; THAT THE RATIO OF PRECISION CALCULATED IS ONE IN 10000; THAT THIS PLAT WAS PREPARED IN ACCORDANCE WITH G.S. 47-30 AS AMENDED. WITNESS MY ORIGINAL SIGNATURE, REGISTRATION NUMBER AND SEAL

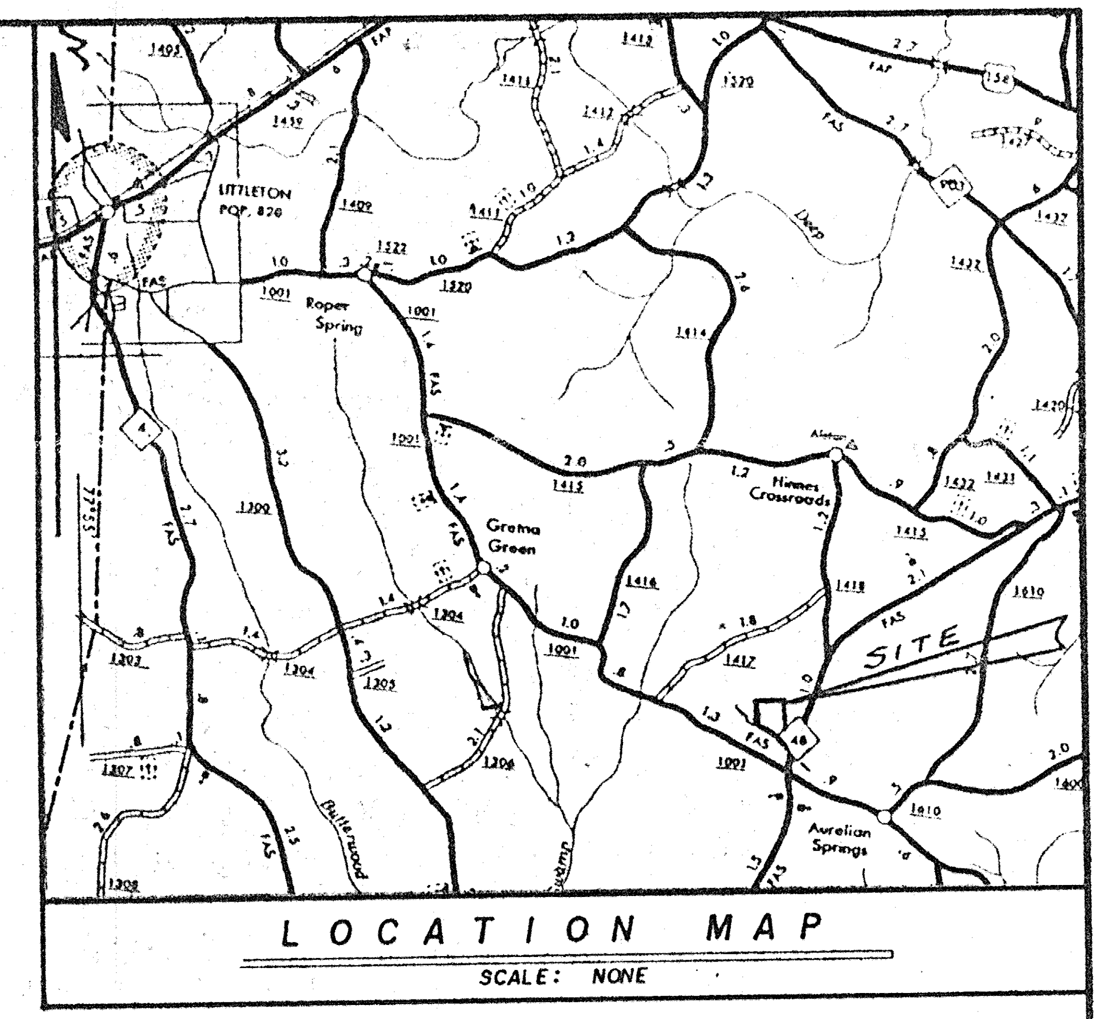
THIS 19TH DAY OF APRIL, A.D., 1995

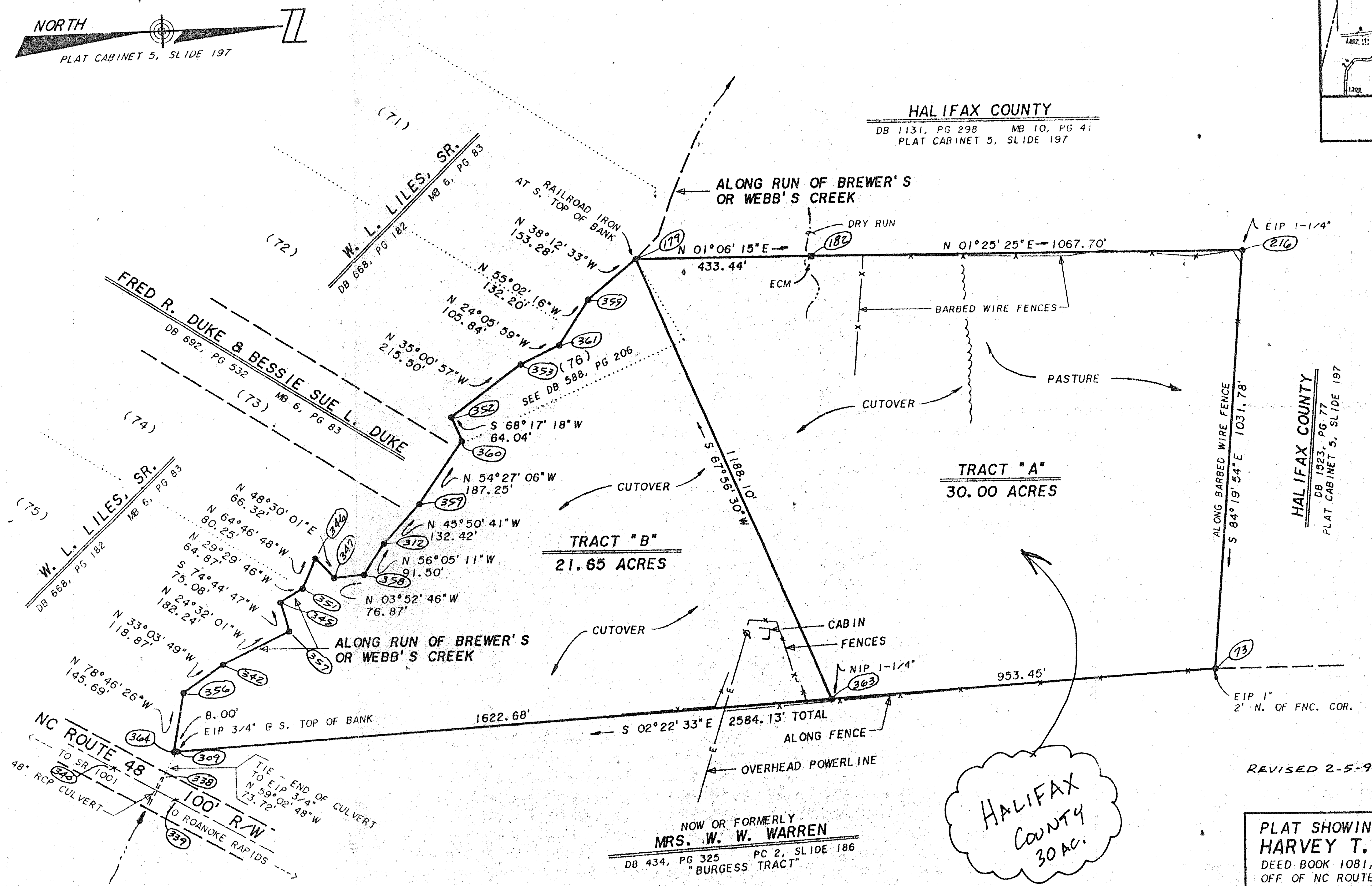
SURVEYOR'S SIGNATURE REGISTRATION NUMBER

NORTH CAROLINA, HALIFAX COUNTY
I, A NOTARY PUBLIC OF THE COUNTY AND STATE AFORESAID, CERTIFY THAT LEWIS O. BURR, A REGISTERED LAND SURVEYOR, PERSONALLY APPEARED BEFORE ME THIS DAY AND ACKNOWLEDGED THE EXECUTION OF THE FOREGOING INSTRUMENT.
WITNESS MY HAND AND OFFICIAL STAMP OR SEAL

THIS 19TH DAY OF APRIL, 1995

NOTARY PUBLIC
MY COMMISSION EXPIRES MARCH 5, 1996





NORTH CAROLINA, HALIFAX COUNTY
THE FOREGOING CERTIFICATE OF ANN BURR, NOTARY PUBLIC OF HALIFAX COUNTY, IS CERTIFIED TO BE CORRECT.
THIS _______ DAY OF ____________, 19 _____.
RECORDED _____ M. IN PLAT CABINET ______, SLIDE ______.

JUDY EVANS-BARBEE, HALIFAX COUNTY REGISTER OF DEEDS

REVISED 2-5-96: ADDED POINT NUMBERS DUMP83.

I HEREBY CERTIFY THAT THE SURVEY IS OF AN EXISTING PARCEL OR PARCELS OF LAND.

SURVEYOR'S SIGNATURE REGISTRATION NUMBER

PLAT SHOWING PROPERTY STANDING IN THE NAME OF HARVEY T. HAWKINS, JR & SELMA J. HAWKINS

DEED BOOK 1081, PAGE 255 ** FORMERLY M. C. CRAWLEY
OFF OF NC ROUTE 48 JUST EAST OF SR 1001 @ BREWER'S CREEK

SCALE: 1" = 200'	APPROVED:	DRAWN BY: L.B.
DATE: 4-15-95		REVISED: 2-5-96

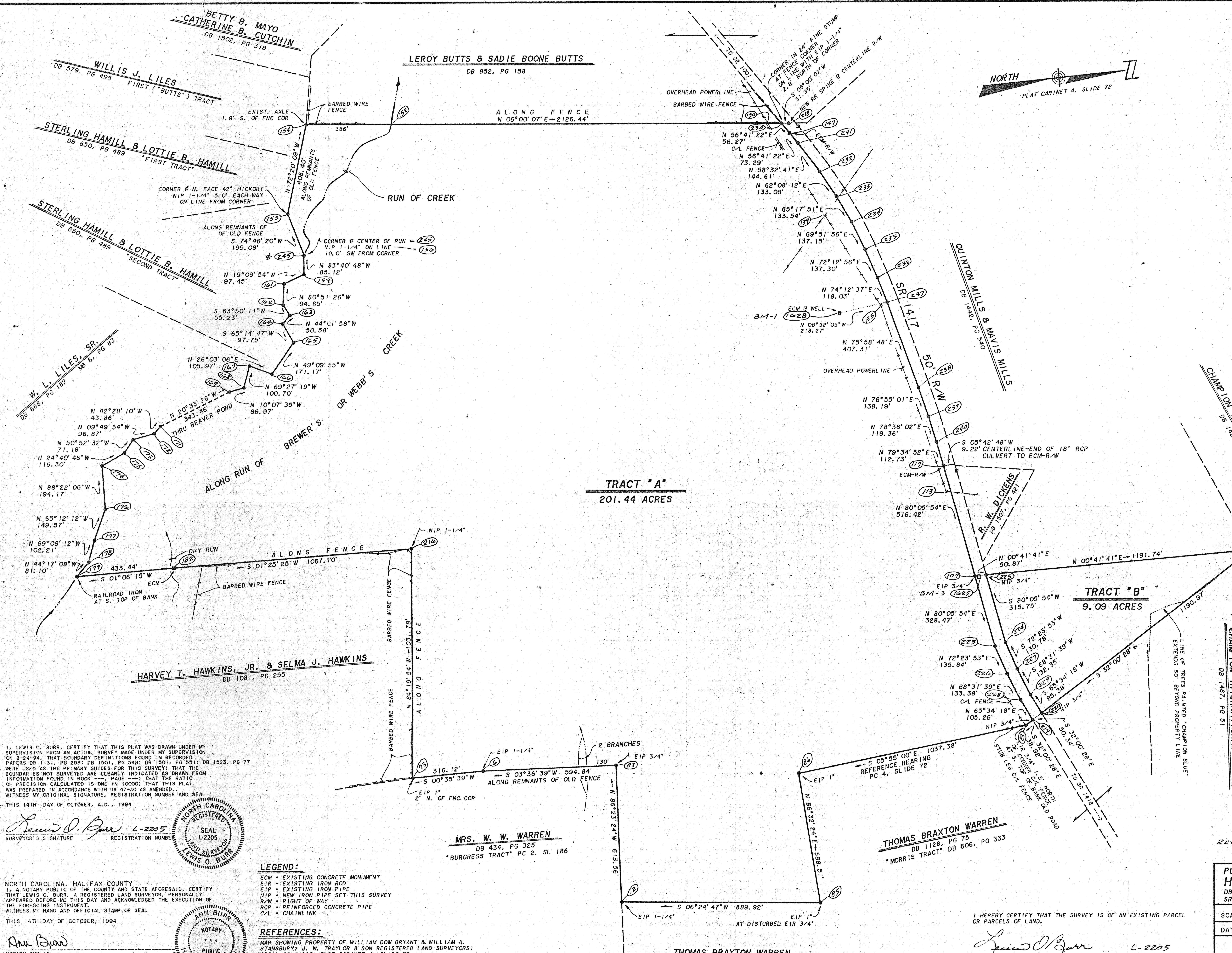
BUTTERWOOD TOWNSHIP HALIFAX COUNTY NORTH CAROLINA

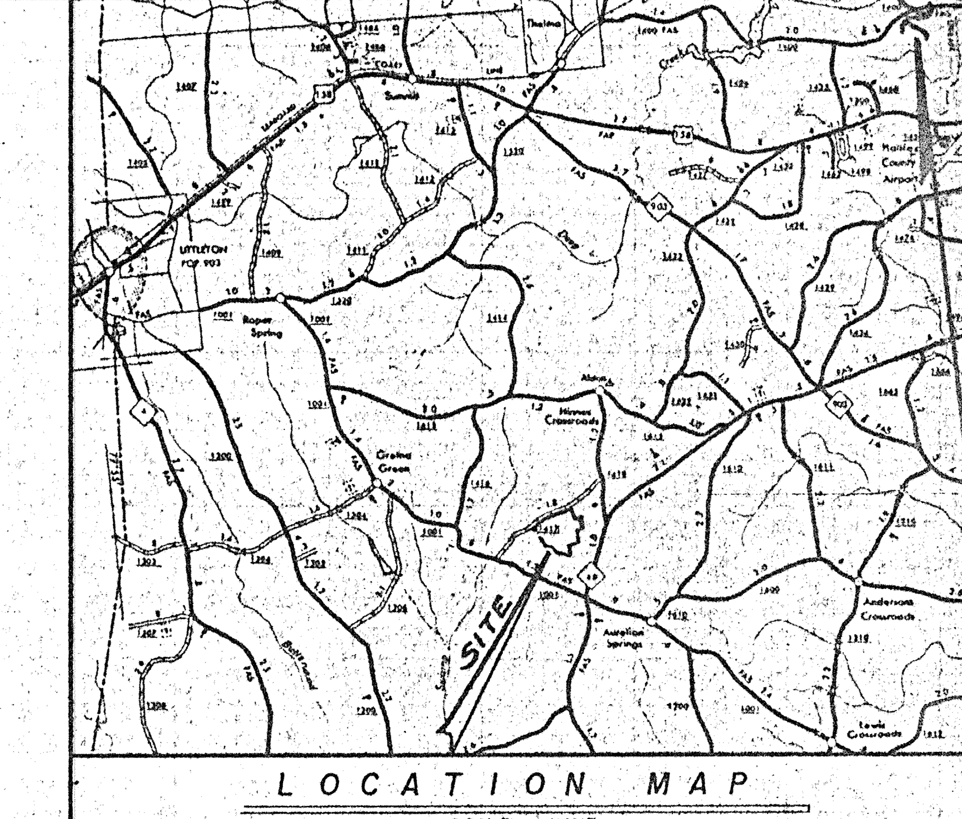
BURR & ASSOCIATES, P.A.
1400 GEORGIA AVENUE
ROANOKE RAPIDS, NC 27870
(919) 537-0369

DRAWING NUMBER: B & A 7-158

200 0 200 400 600
GRAPHIC SCALE - FEET

LEGEND:
ECM = EXISTING CONCRETE MONUMENT
EIR = EXISTING IRON ROD
EIP = EXISTING IRON PIPE
RCP = REINFORCED CONCRETE PIPE
NIP = NEW IRON PIPE SET THIS SURVEY





LOCATION MAP

SCALE: NONE

LAND AREA SUMMARY:

TRACT "A" SOUTH OF SR 1417 = 201.44 ACRES
TRACT "B" NORTH OF SR 1417 = 9.09
TOTAL LAND AREA THIS SURVEY = 210.53 ACRES

I, LEWIS O. BURR, CERTIFY THAT THIS PLAT WAS DRAWN UNDER MY SUPERVISION FROM AN ACTUAL SURVEY MADE UNDER MY SUPERVISION ON 8-24-94, THAT BOUNDARY DEFINITIONS FOUND IN RECORDED PAPERS DB 1131, PG 298; DB 1501, PG 548; DB 1501, PG 551; DB 1523, PG 77 WERE USED AS THE PRIMARY GUIDES FOR THIS SURVEY; THAT THE BOUNDARIES NOT SURVEYED ARE CLEARLY INDICATED AS DRAWN FROM INFORMATION FOUND IN BOOK ---, PAGE ---; THAT THE RATIO OF PRECISION CALCULATED IS ONE IN 10000; THAT THIS PLAT WAS PREPARED IN ACCORDANCE WITH GS 47-30 AS AMENDED.. WITNESS MY ORIGINAL SIGNATURE, REGISTRATION NUMBER AND SEAL

THIS 14TH DAY OF OCTOBER, A.D., 1994

Lewis O. Burr L-2205
SURVEYOR'S SIGNATURE REGISTRATION NUMBER

NORTH CAROLINA REGISTERED SEAL L-2205 LAND SURVEYOR LEWIS O. BURR

NORTH CAROLINA, HALIFAX COUNTY
I, A NOTARY PUBLIC OF THE COUNTY AND STATE AFORESAID, CERTIFY THAT LEWIS O. BURR, A REGISTERED LAND SURVEYOR, PERSONALLY APPEARED BEFORE ME THIS DAY AND ACKNOWLEDGED THE EXECUTION OF THE FOREGOING INSTRUMENT.
WITNESS MY HAND AND OFFICIAL STAMP OR SEAL

THIS 14TH DAY OF OCTOBER, 1994

Ann Burr
NOTARY PUBLIC

MY COMMISSION EXPIRES MARCH 5, 1996

ANN BURR NOTARY PUBLIC HALIFAX COUNTY, N.C.

LEGEND:

ECM = EXISTING CONCRETE MONUMENT
EIR = EXISTING IRON ROD
EIP = EXISTING IRON PIPE
NIP = NEW IRON PIPE SET THIS SURVEY
R/W = RIGHT OF WAY
RCP = REINFORCED CONCRETE PIPE
C/L = CHAINLINK

REFERENCES:

MAP SHOWING PROPERTY OF WILLIAM DOW BRYANT & WILLIAM A. STANSBURY; J. W. TRAYLOR & SON REGISTERED LAND SURVEYORS; APRIL 20, 1990; PLAT CABINET 4, SLIDE 72.

MAP SHOWING PROPERTY OF DENNIS A. ROSE; J. C. SHEARIN, SURVEYOR; FEBRUARY 9, 1962; MAP BOOK 10, PAGE 41.

MAP SHOWING PROPERTY OF CARRIE L. COOPER, A PORTION OF THE WEBB TRACT; SHEARIN & TRAYLOR, SURVEYORS; FEBRUARY 7, 9, 1951; MAP BOOK 6, PAGE 83.

I HEREBY CERTIFY THAT THE SURVEY IS OF AN EXISTING PARCEL OR PARCELS OF LAND.

Lewis O. Burr L-2205
SURVEYOR'S SIGNATURE REGISTRATION NUMBER

200 0 200 400 600
GRAPHIC SCALE - FEET

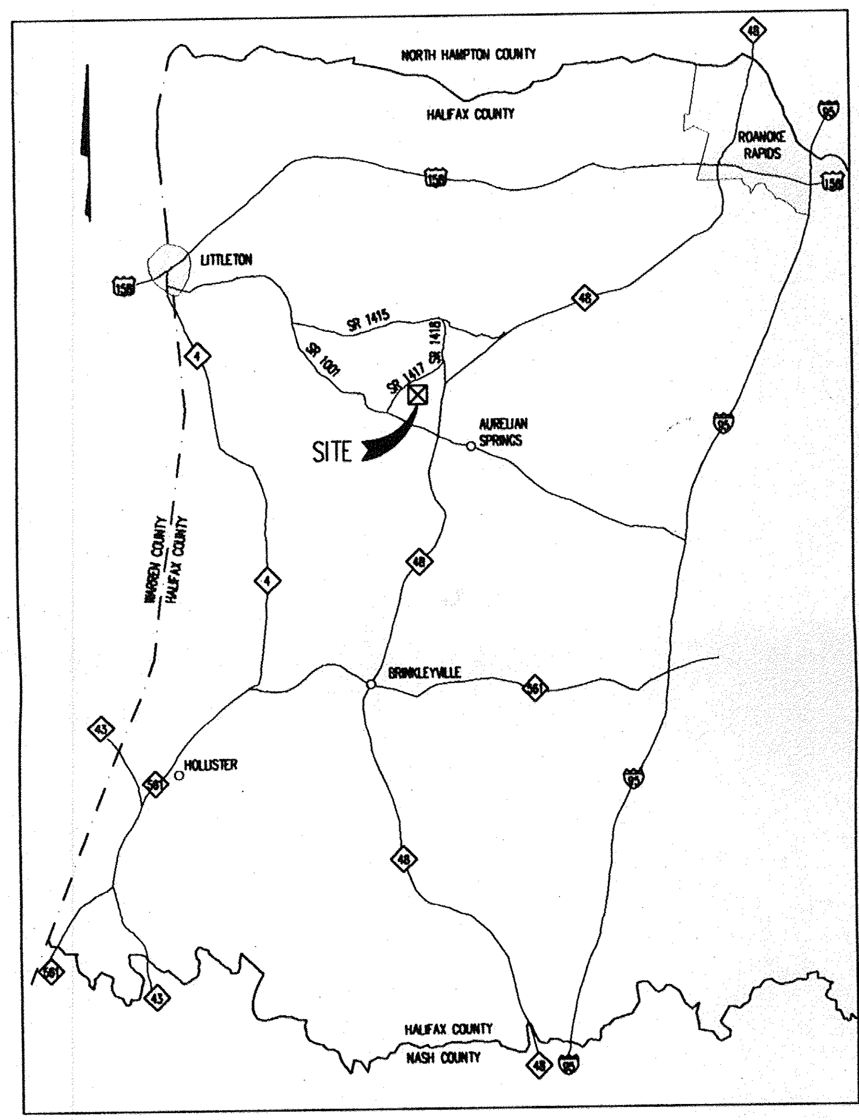
REVISED 2-5-96: ADDED POINT NUMBERS DUMP83 LB

PLAT SHOWING PROPERTY STANDING IN THE NAME OF HALIFX COUNTY DB 1131, PG 298; DB 1501, PG 548; DB 1501, PG 551; DB 1523, PG 77 SR 1417 BETWEEN SR 1001 AND SR 1418 JUST NORTH OF NC ROUTE 48		
SCALE: 1" = 200'	APPROVED:	DRAWN BY: L.B.
DATE: 10-1-94		REVISED: 2-5-96
BUTTERWOOD TOWNSHIP HALIFAX COUNTY NORTH CAROLINA		
BURR & ASSOCIATES, P.A. 1400 GEORGIA AVENUE ROANOKE RAPIDS, NC 27870 (919) 537-0369		DRAWING NUMBER: B & A 6-223

HALIFAX COUNTY SOLID WASTE DEPARTMENT
HALIFAX COUNTY, NORTH CAROLINA

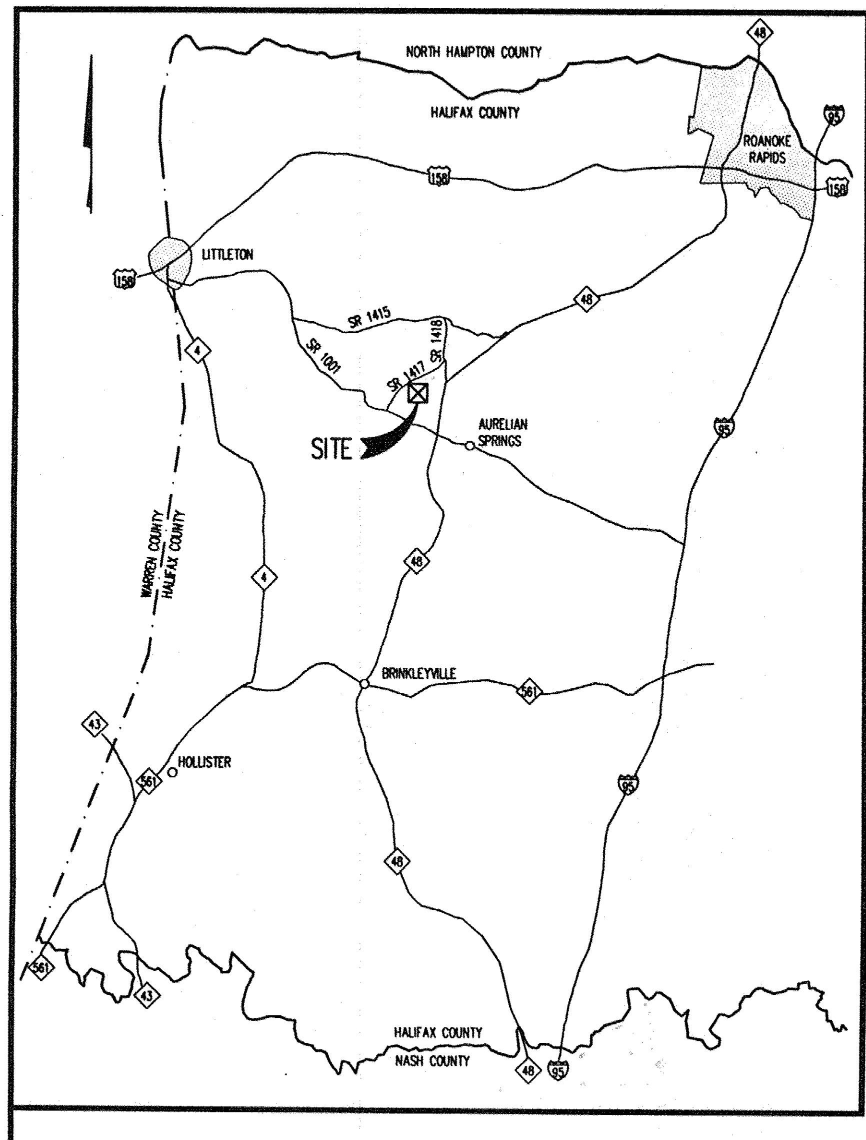
CONSTRUCTION & DEMOLITION DEBRIS (C&D) LANDFILL PERMIT APPLICATION

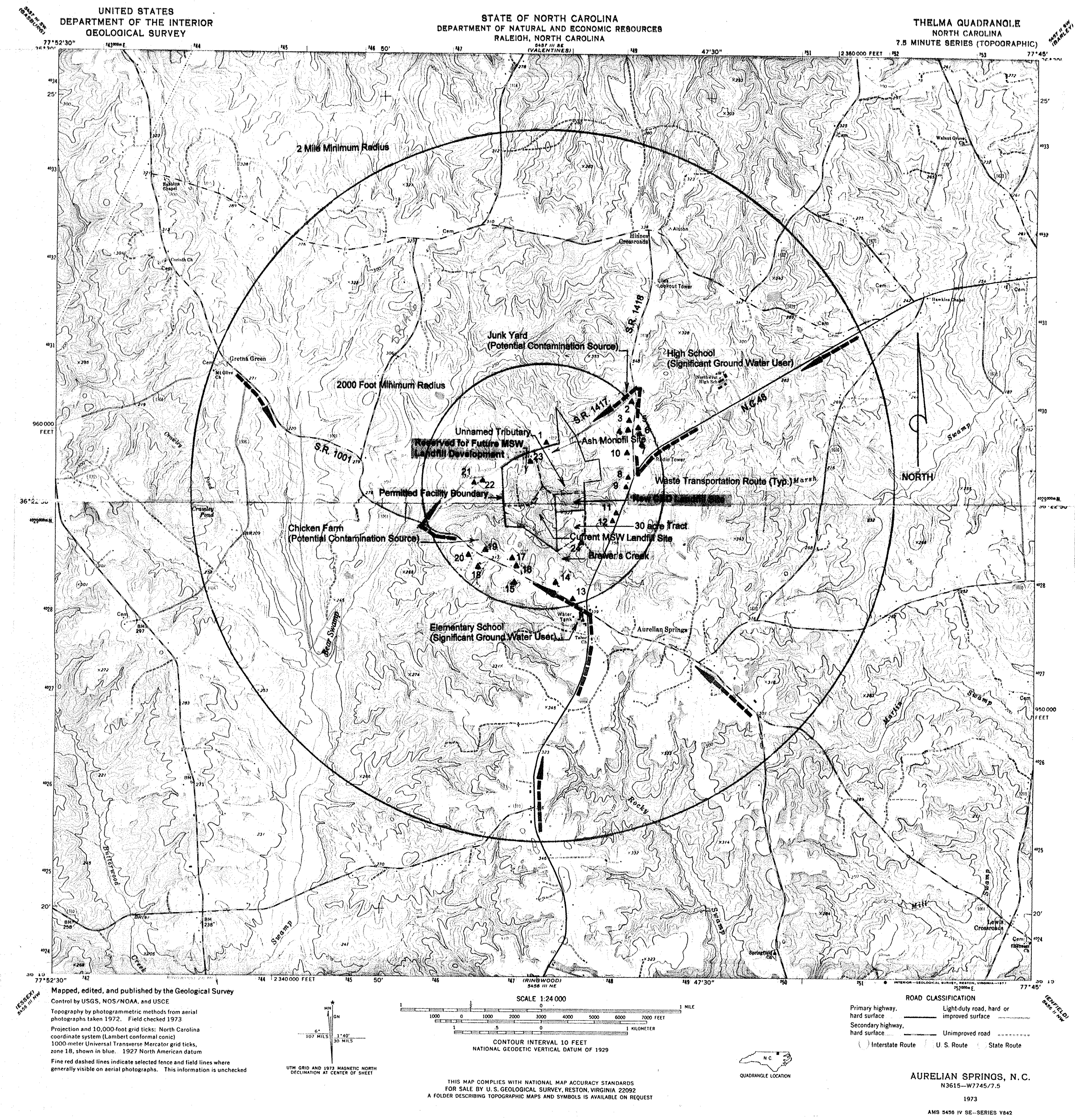
PERMIT 42-04
AUGUST 1997



SHEET NO.	DRAWING NO.	TITLE
1	G1	REGIONAL CHARACTERIZATION MAP
2	G2	LOCAL AREA MAP
3	G3	LOCAL AREA PHOTOS
4	G4	OVERALL FACILITY PLAN
5	S1	EXISTING SITE CONDITIONS
6	S1A	GROUND WATER POTENTIOMETRIC SURFACES
7	S2	BASE GRADING PLAN
8	FC1	FINAL COVER GRADING PLAN
9	FC2	FINAL COVER DETAILS
10	X1	CROSS SECTIONS
11	P1	PHASING PLAN
12	EC1	EROSION CONTROL PLAN
13	EC2	EROSION CONTROL DETAILS
14	EC3	EROSION CONTROL DETAILS
15	M1	MISCELLANEOUS DETAILS

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services
417 N. BOYLAN AVENUE RALEIGH, N.C. 27603
PHONE-919-828-0577 FAX-919-828-3899 WWW.GNRA.COM





NOTES

1. No public water supply wells or surface water intakes exist within 2 miles of the permitted facility boundary.

2. No residential subdivisions exist within 2 miles of the permitted facility boundary.

3. No public use airports exist within 5 miles of the permitted facility boundary.

4. Distances in Statute Miles

5. Map is a composite excerpt of indicated quadrangles.

D:\-CAD\HALIFAX-11\S-G1.dwg DATE: AUG 27, 1997 TIME: 9:59 AM

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SEAL

SEAL

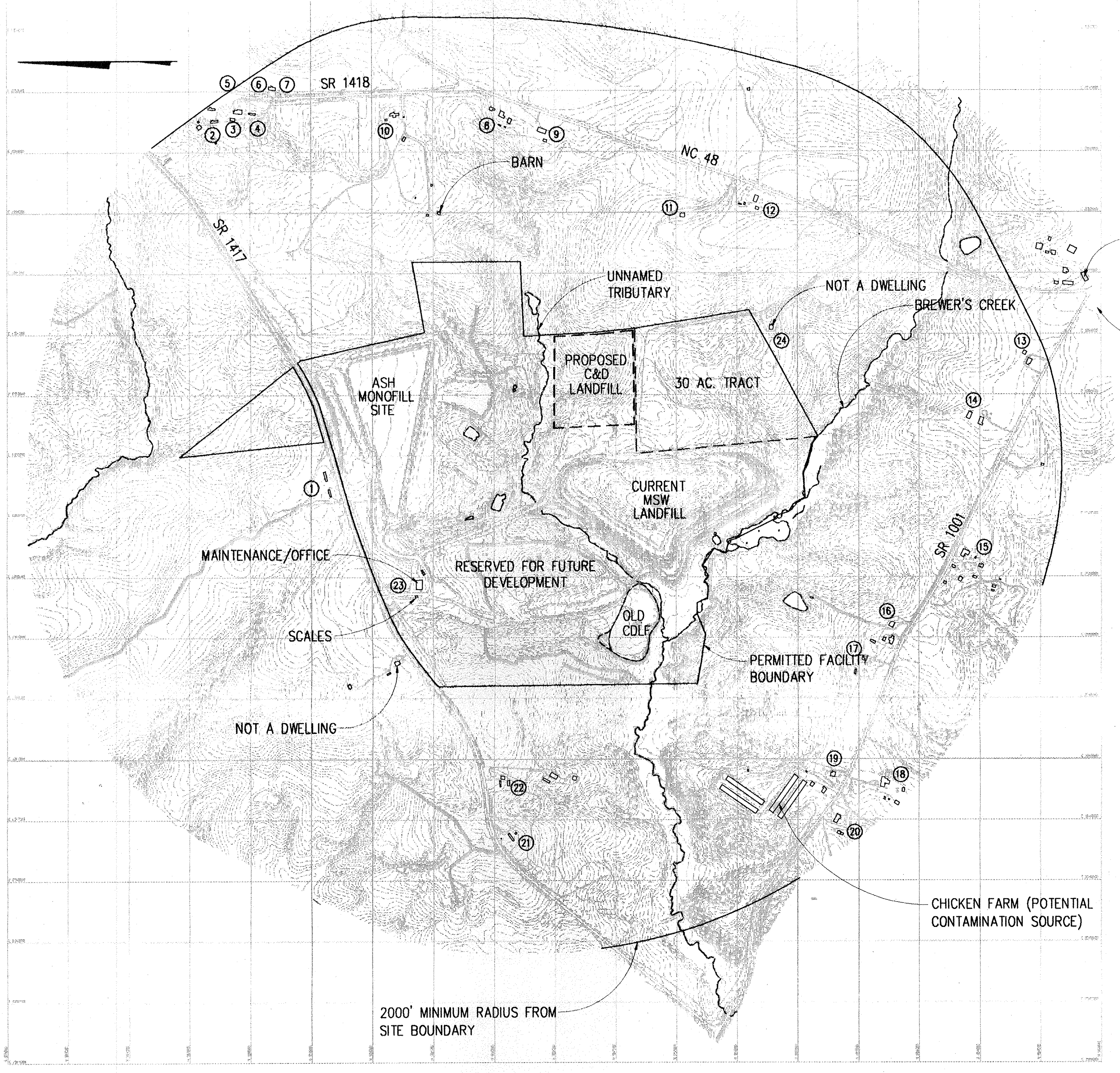
PROJECT TITLE:

HALIFAX COUNTY
C & D LANDFILL

DRAWING TITLE:

REGIONAL CHARACTERIZATION MAP

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG, 1997
SHEET NO. 1	DRAWING NO. G1



POTABLE WELL SURVEY

REF. NO.	OWNER NAME	STRUCTURAL TYPE
1	LUG, LEONARD	RESIDENCE
2	ALSTON, JR.	RESIDENCE
3	JONES, TOMMY	RESIDENCE
4	ALSTON, MARCHELL	RESIDENCE
5	HAWKINS, RONALD	RESIDENCE
6	DAVIS, ODELIA	RESIDENCE
7	DAVIS, JIMMY	RESIDENCE
8	WARREN, HARRY	RESIDENCE
9	JOHNSTON, MICHAEL	RESIDENCE
10	BUTTS, ALLEN	RESIDENCE
11	WARREN, CHRIS	RESIDENCE
12	UNKNOWN	RESIDENCE
13	DUKE, FRED, JR.	RESIDENCE
14	DUKE, FRED, SR.	RESIDENCE
15	MAYO, BILLY	RESIDENCE
16	LANCASTER, SANKEY	RESIDENCE
17	UNKNOWN	RESIDENCE
18	UNKNOWN	RESIDENCE
19	BUTTS, JESSIE	RESIDENCE
20	UNKNOWN	RESIDENCE
21	UNKNOWN	RESIDENCE
22	UNKNOWN	RESIDENCE
23	HALIFAX COUNTY	LANDFILL
24	HAWKINS	FORMER RESIDENCE

BASED ON WATER WELL SURVEYS CONDUCTED IN 1991 & 1994

NOTES:

1. THE PROPERTY IS ZONED AGRICULTURAL/RESIDENTIAL.
2. NO COMMERCIAL/INDUSTRIAL BUILDINGS OR HISTORIC SITES EXIST WITHIN A 2000 FOOT RADIUS OF THE SITE.
3. NO PORTIONS OF THE SITE EXIST WITHIN A 100 YEAR FLOODPLAIN, PER FIRM MAPPING.
4. MSW CONTOURS CURRENT AS OF MARCH 1996.
5. THERE ARE NO UNDERGROUND UTILITIES WITHIN THE FACILITY.
6. THERE ARE NO PUBLIC WATER SUPPLY SURFACE INTAKES WITHIN 2000 FEET OF THE SITE.

DIGITAL BASE MAPPING PERFORMED BY PIEDMONT AERIAL SERVICES

0 400' 800' 1200'

1" = 400'

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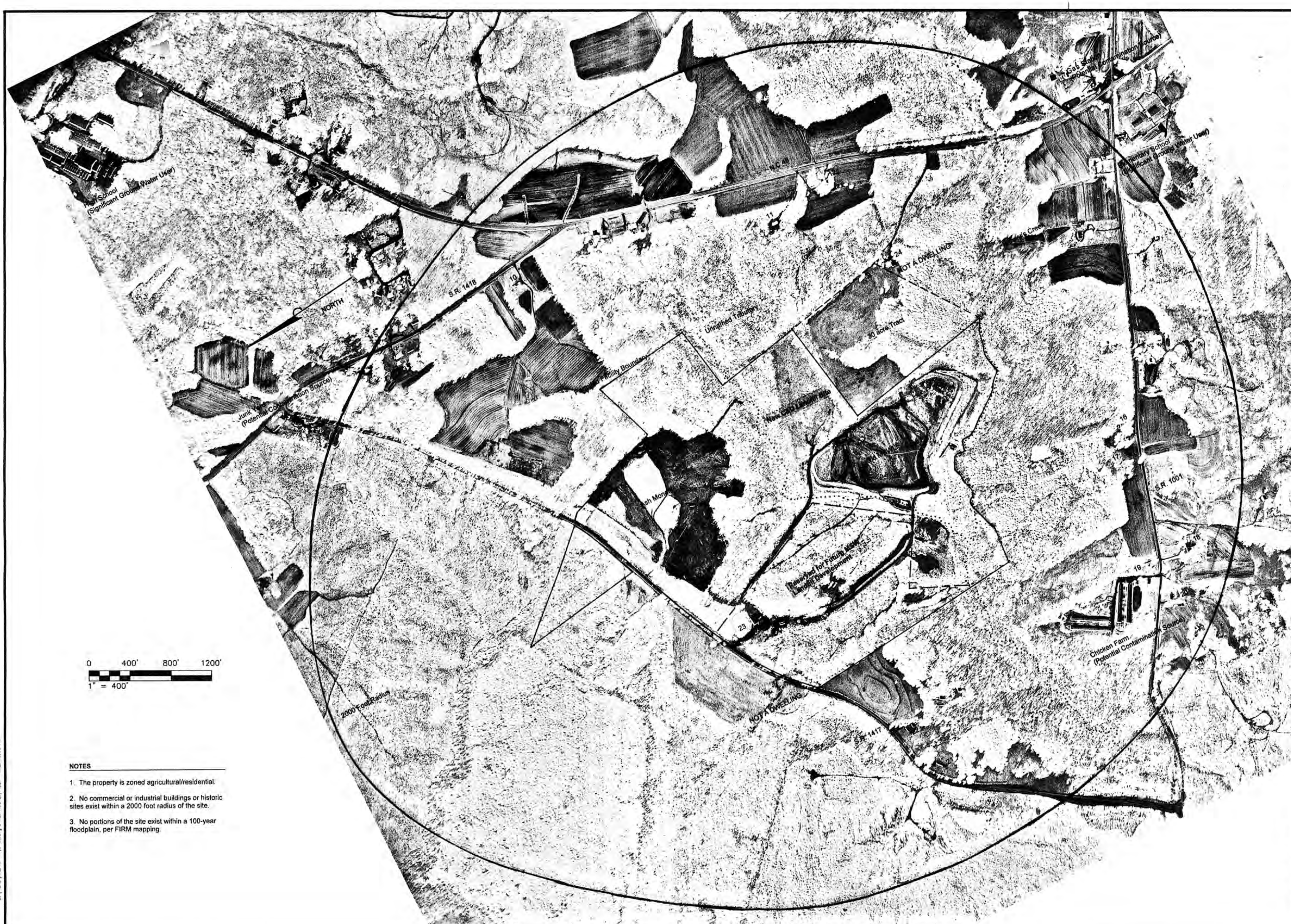
HALIFAX COUNTY
C & D LANDFILL

LOCAL AREA MAP

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALFAX-11
SCALE: AS SHOWN	DATE: AUG, 1997
SHEET NO. 2	DRAWING NO. G2



NOTES

1. The property is zoned agricultural/residential.

2. No commercial or industrial buildings or historic sites exist within a 2000 foot radius of the site.

3. No portions of the site exist within a 100-year floodplain, per FIRM mapping.

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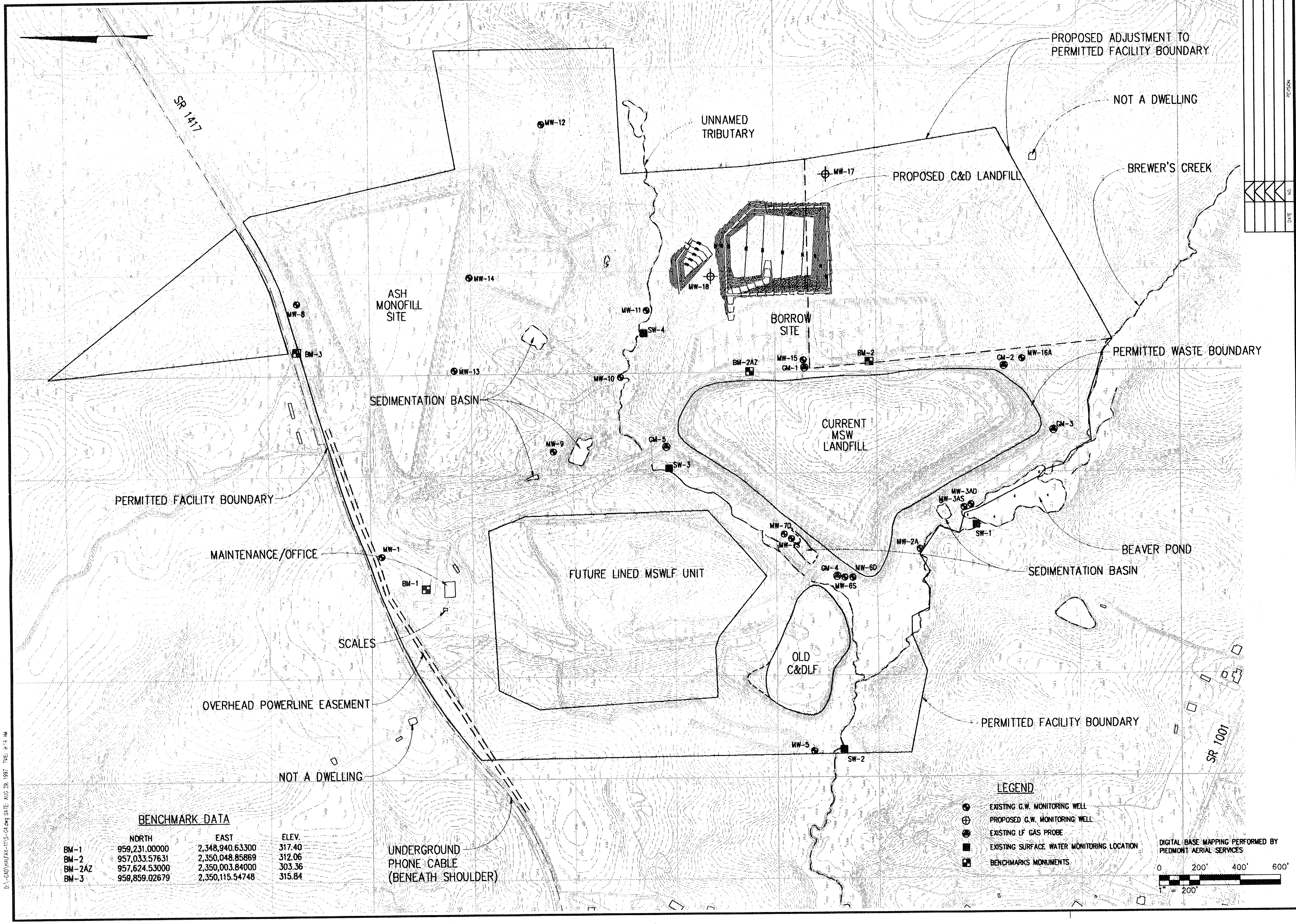
PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: LOCAL AREA PHOTOS

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: 1"= 400'	DATE: AUG, 1997
SHEET NO. 3	DRAWING NO. G3



BENCHMARK DATA

	NORTH	EAST	ELEV.
BM-1	959,231.00000	2,348,940.63300	317.40
BM-2	957,033.57631	2,350,048.85869	312.06
BM-2AZ	957,624.53000	2,350,003.84000	303.36
BM-3	959,859.02679	2,350,115.54748	315.84

DATE | NO. | REVISION

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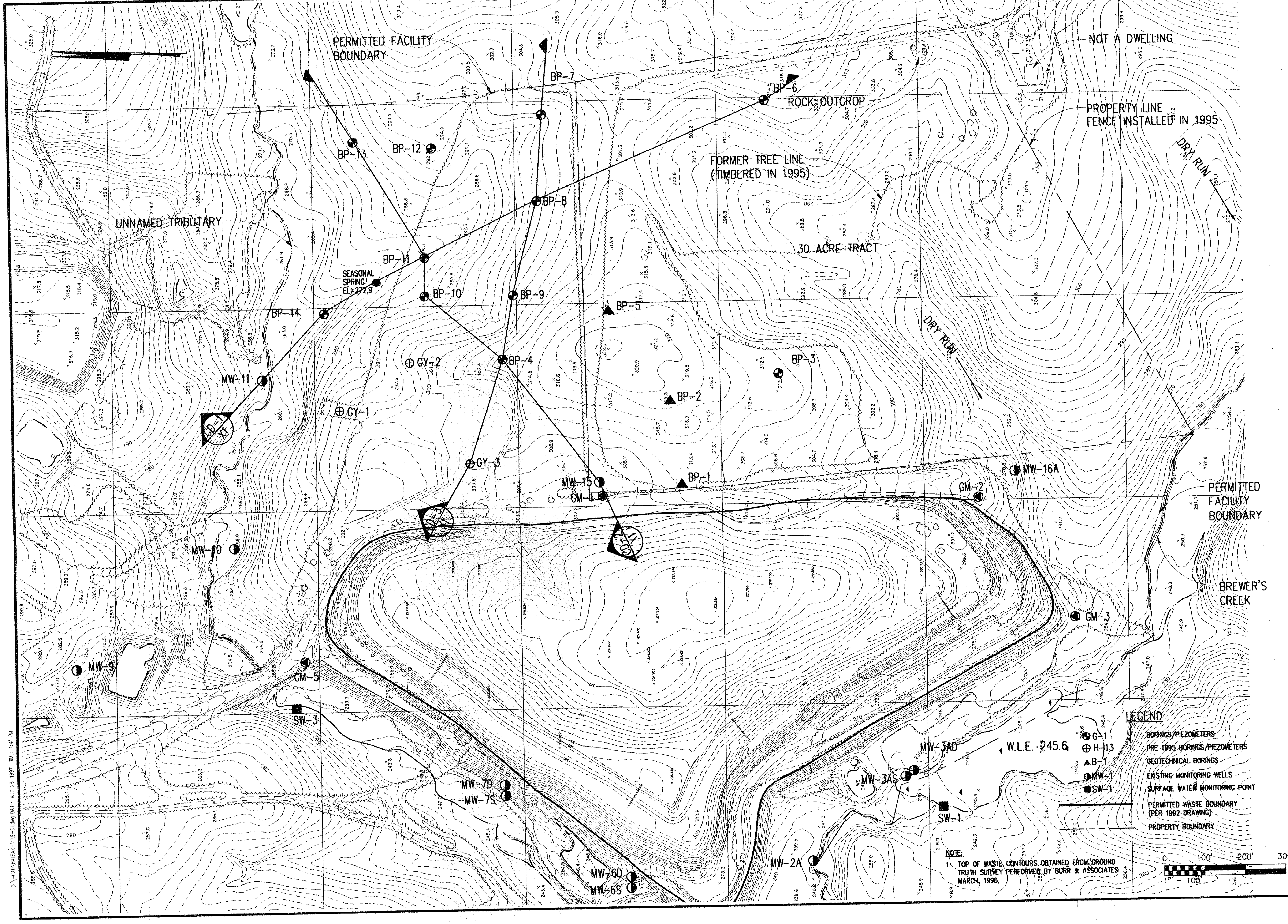
SEAL: NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021... PIETER K. SCHEER
SEAL: NORTH CAROLINA LICENSED GEOLOGIST SEAL 983 G. DAVID GARRETT

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: OVERALL FACILITY PLAN

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALFAX-11
SCALE: AS SHOWN	DATE: AUG, 1997
SHEET NO. 4	DRAWING NO G4



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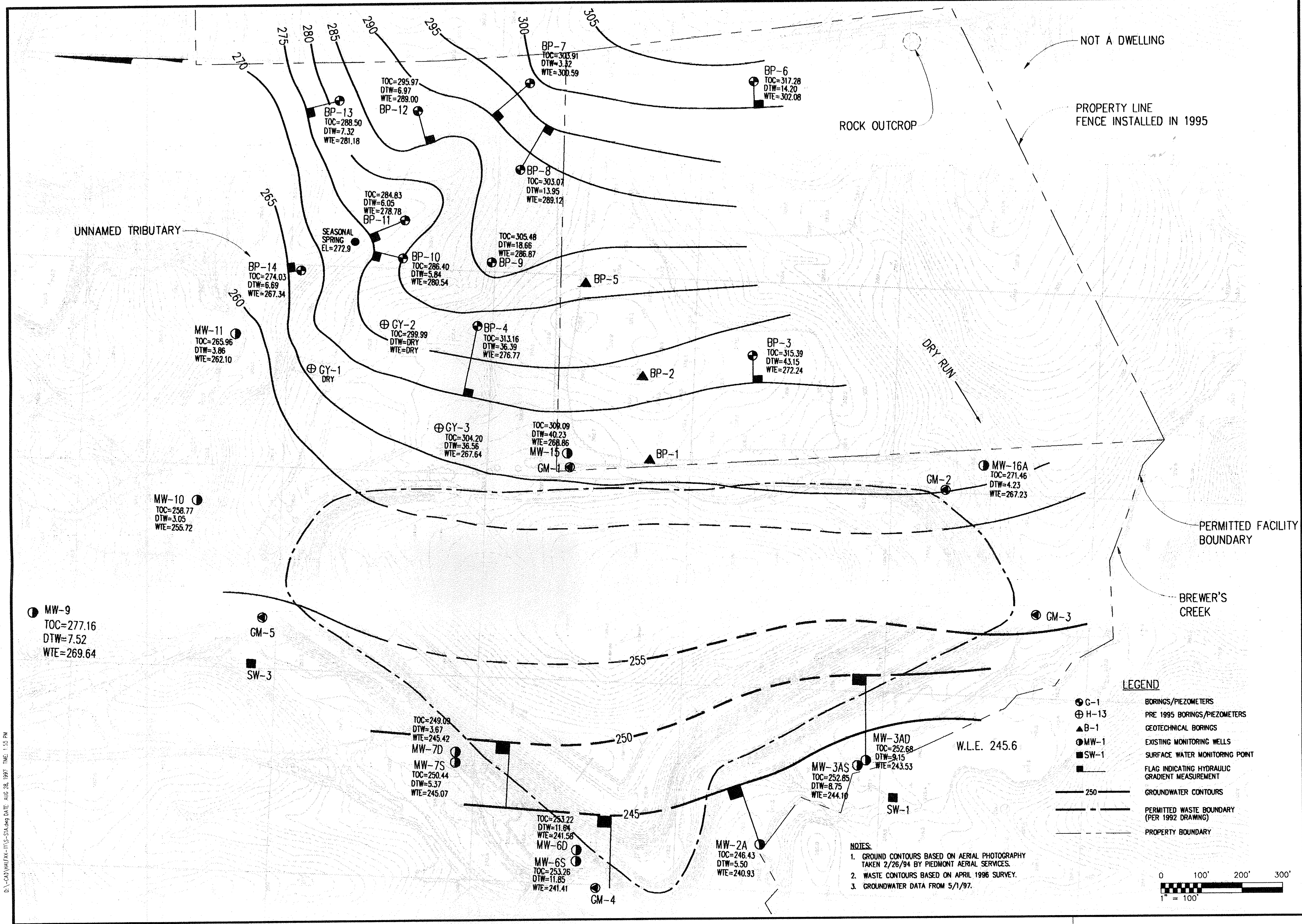
SEAL

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: EXISTING SITE CONDITIONS

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO.: 5	DRAWING NO.: S1



D:\-CAD\HALIFAX-11\S-S1A.dwg DATE: AUG 28, 1997 TIME: 1:55 PM

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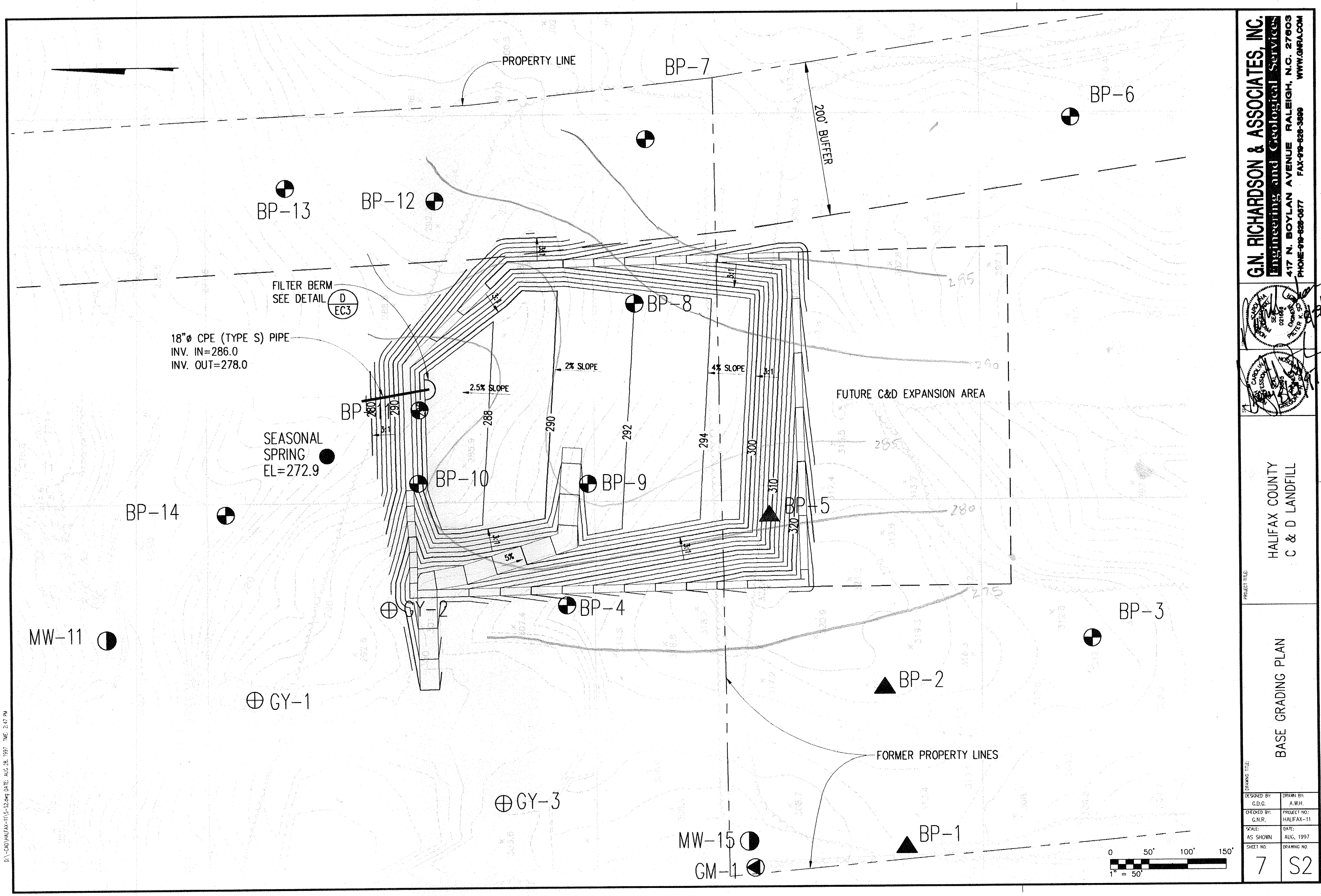
SEAL: NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021646 PIETER K. SCHEER
SEAL: NORTH CAROLINA LICENSED GEOLOGIST SEAL 983 G. DAVID GARRETT

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: GROUND WATER POTENTIOMETRIC SURFACE AS OF 5/1/97

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO. 6	DRAWING NO. S1A



PROPERTY LINE
BP-7
BP-6
200' BUFFER
BP-13
BP-12
FILTER BERM
SEE DETAIL D EC3
18"ø CPE (TYPE S) PIPE
INV. IN=286.0
INV. OUT=278.0
BP-8
2% SLOPE
4% SLOPE
2.5% SLOPE
FUTURE C&D EXPANSION AREA
BP-11
SEASONAL
SPRING
EL=272.9
BP-10
BP-9
BP-5
BP-14
5%
GY-2
BP-4
BP-3
MW-11
BP-2
GY-1
FORMER PROPERTY LINES
GY-3
MW-15
BP-1
GM-1
0 50' 100' 150'
1" = 50'
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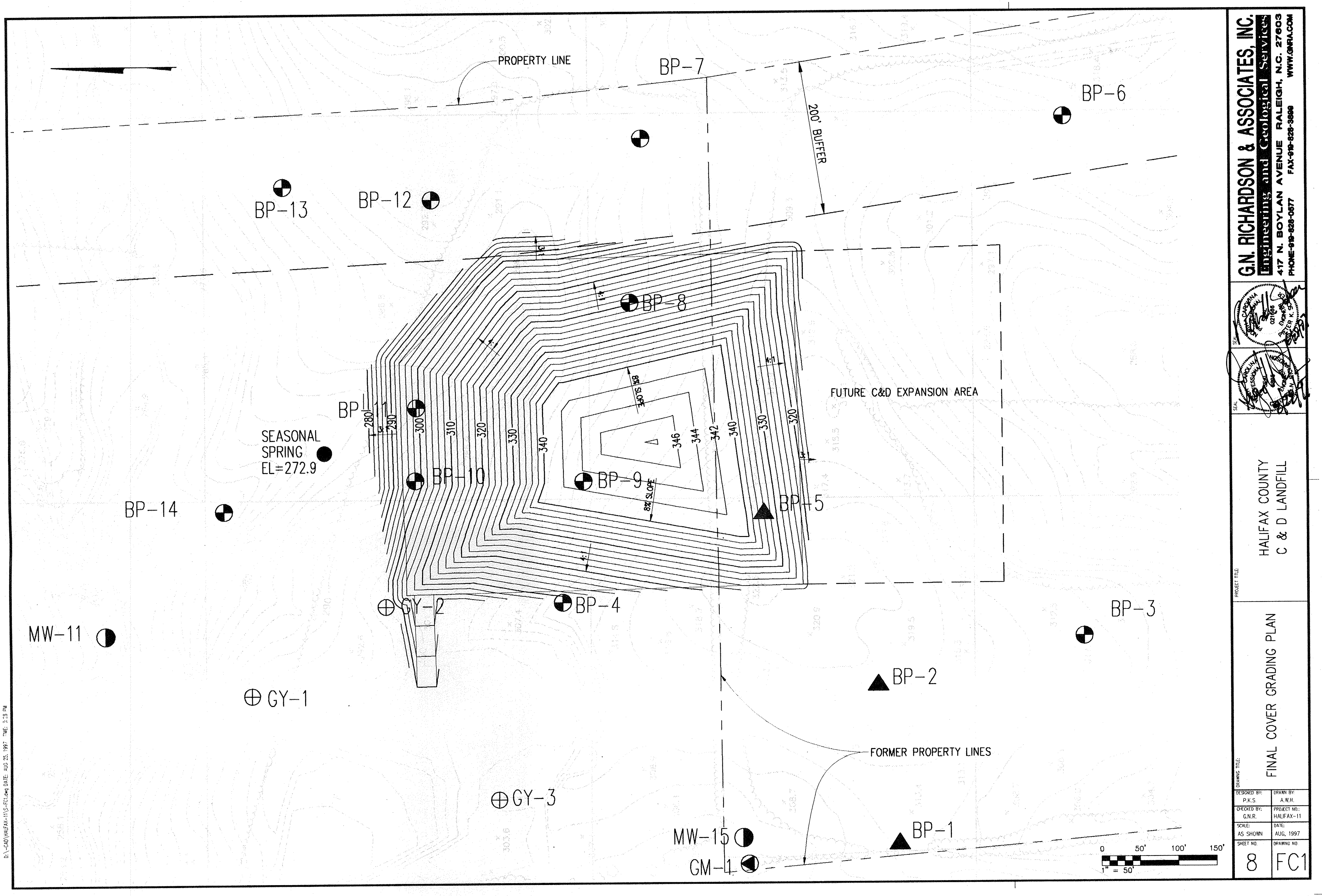
PROJECT TITLE:
HALIFAX COUNTY
C & D LANDFILL
DRAWING TITLE:
BASE GRADING PLAN
DESIGNED BY: C.D.G.
DRAWN BY: A.W.H.
CHECKED BY: G.N.R.
PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN
DATE: AUG. 1997
SHEET NO. 7
DRAWING NO. S2



PROPERTY LINE
BP-7
200' BUFFER
BP-6
BP-13
BP-12
BP-8
FUTURE C&D EXPANSION AREA
BP-11
SEASONAL SPRING EL=272.9
BP-10
BP-9
BP-5
BP-14
GY-2
BP-4
BP-3
MW-11
BP-2
GY-1
FORMER PROPERTY LINES
GY-3
MW-15
BP-1
GM-1
8% SLOPE
0 50' 100' 150'
1" = 50'
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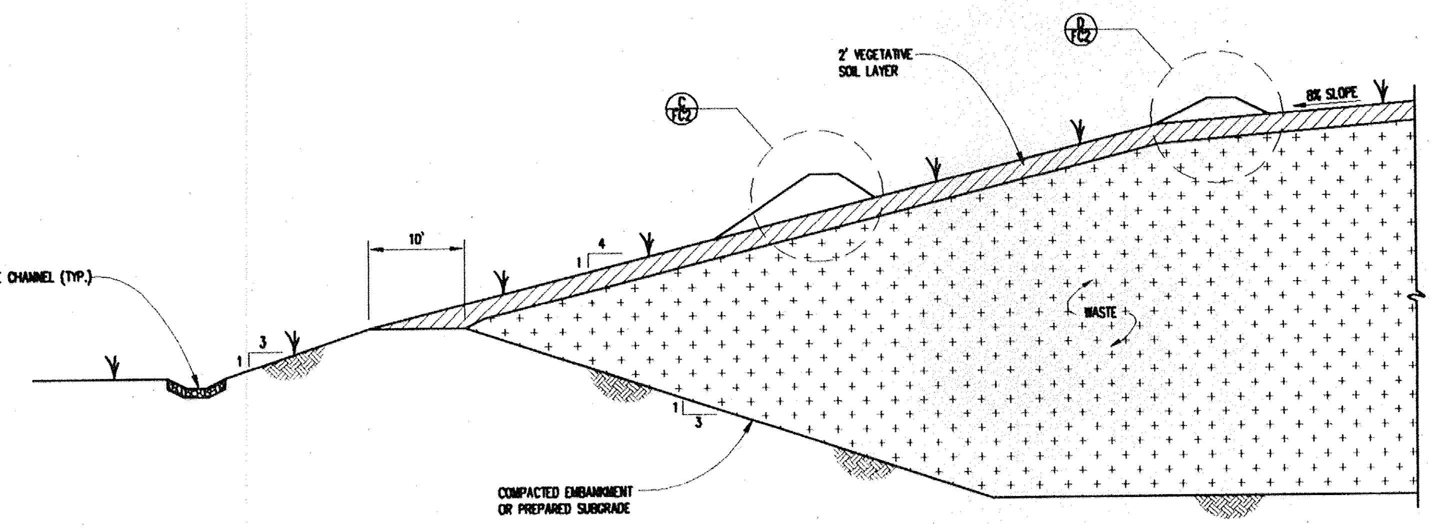
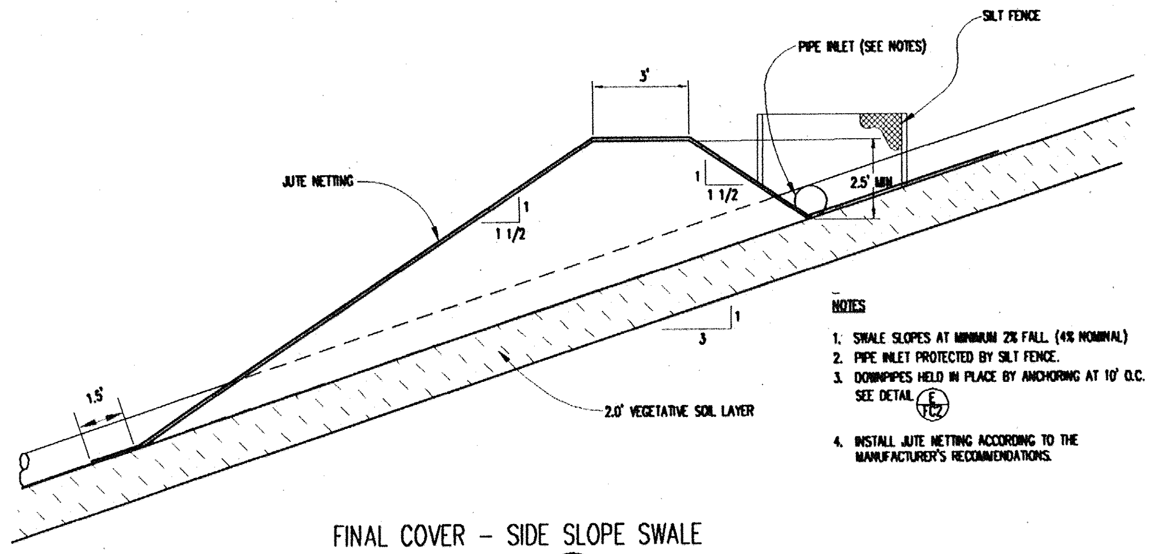
PHONE-919-828-0577 FAX-919-828-3899 WWW.GNRA.COM
HALIFAX COUNTY
C & D LANDFILL
FINAL COVER GRADING PLAN
DESIGNED BY: P.K.S.
DRAWN BY: A.W.H.
CHECKED BY: G.N.R.
PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN
DATE: AUG, 1997
SHEET NO. 8
DRAWING NO FC1



TYPICAL FINAL COVER CROSS SECTION

DETAIL A / FC2
SCALE: 1"= 10'

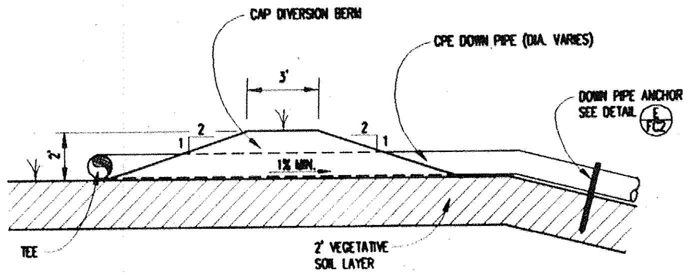


NOTES

1. SWALE SLOPES AT MINIMUM 2% FALL. (4% NOMINAL)
2. PIPE INLET PROTECTED BY SILT FENCE.
3. DOWNPIPES HELD IN PLACE BY ANCHORING AT 10' O.C. SEE DETAIL E / FC2
4. INSTALL JUTE NETTING ACCORDING TO THE MANUFACTURER'S RECOMMENDATIONS.

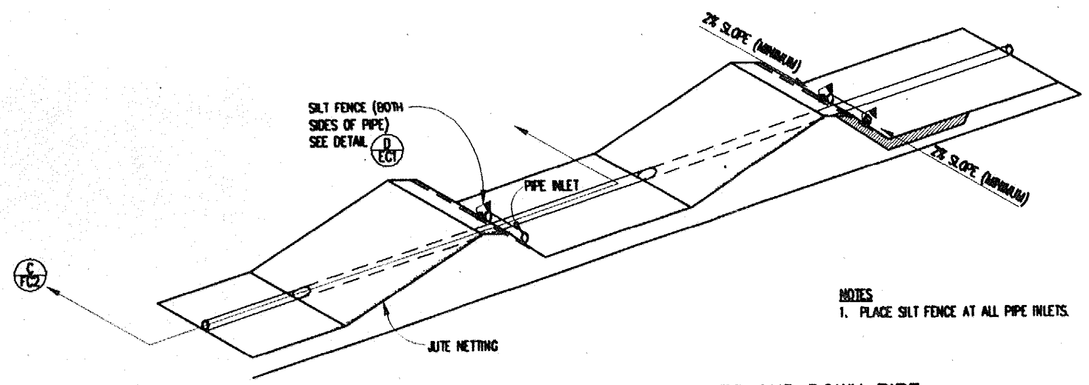
FINAL COVER - SIDE SLOPE SWALE

DETAIL C / FC2
N.T.S.



CAP DIVERSION BERM

DETAIL B / FC2
SCALE: 1"= 4'-0"

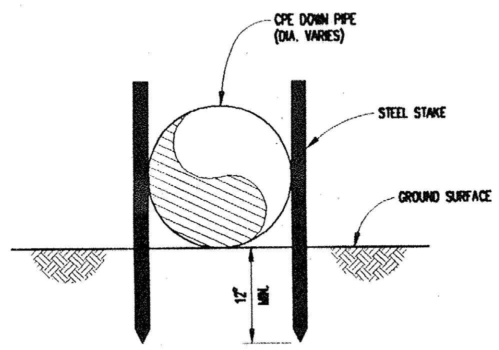


NOTES

1. PLACE SILT FENCE AT ALL PIPE INLETS.

SIDE SLOPE DRAINAGE SWALES AND DOWN PIPE

DETAIL D / FC2
N.T.S.



NOTES:

1. ANCHOR PIPE WITH STRAPPING UPPER HALF OF PIPE. ATTACH STRAPPING TO STEEL STAKES.
2. PLACE ANCHORS AT 10' O.C.

DOWN PIPE ANCHOR (TYP.)

DETAIL E / FC2
SCALE: 1"= 1'-0"

0 4' 8' 12'
1" = 4'-0"

0 10' 20' 30'
1" = 10'

0 4' 8' 12'
1" = 4'-0"

0 1' 2' 3'
1" = 1'-0"

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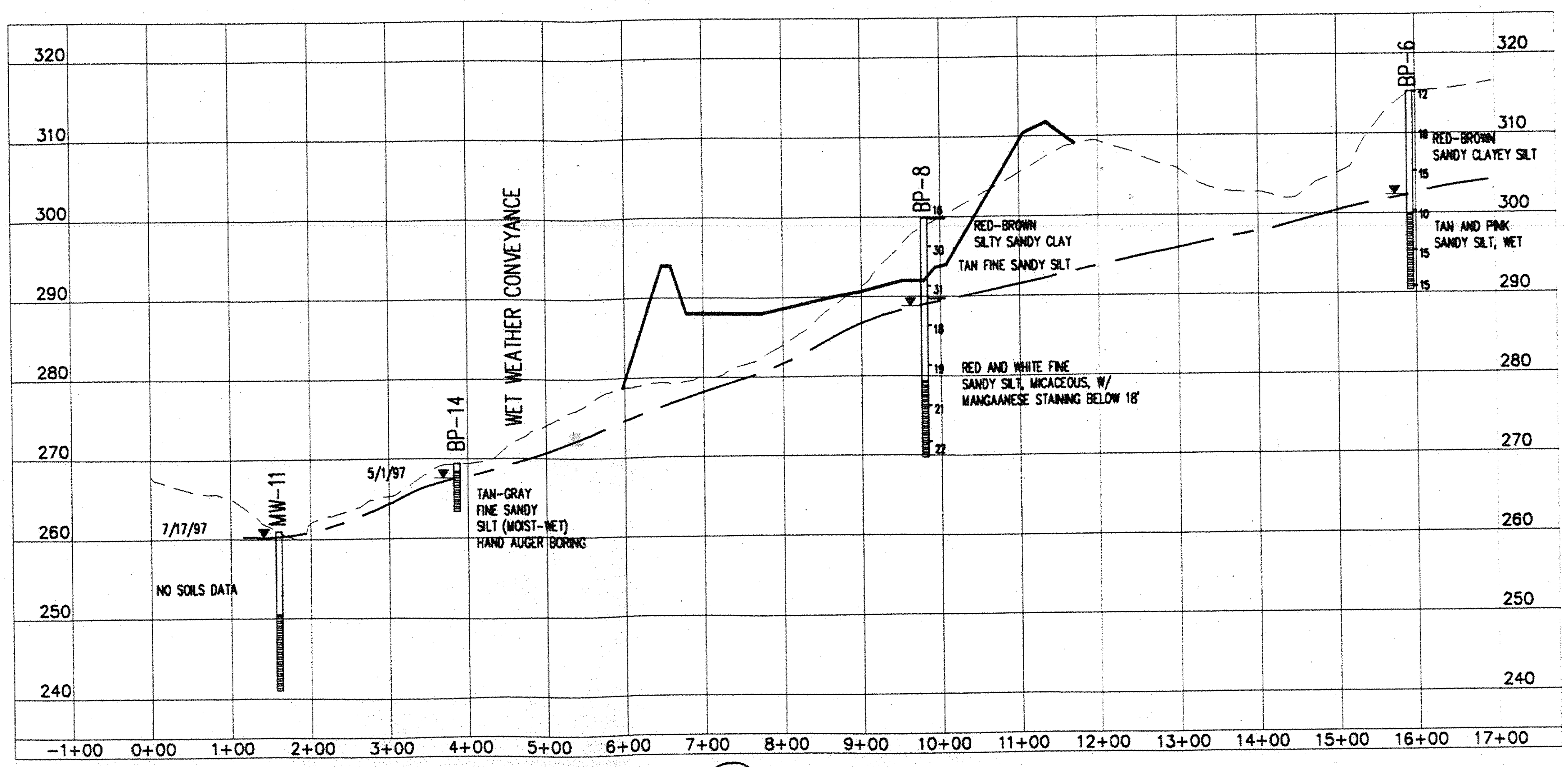
PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: FINAL COVER DETAILS

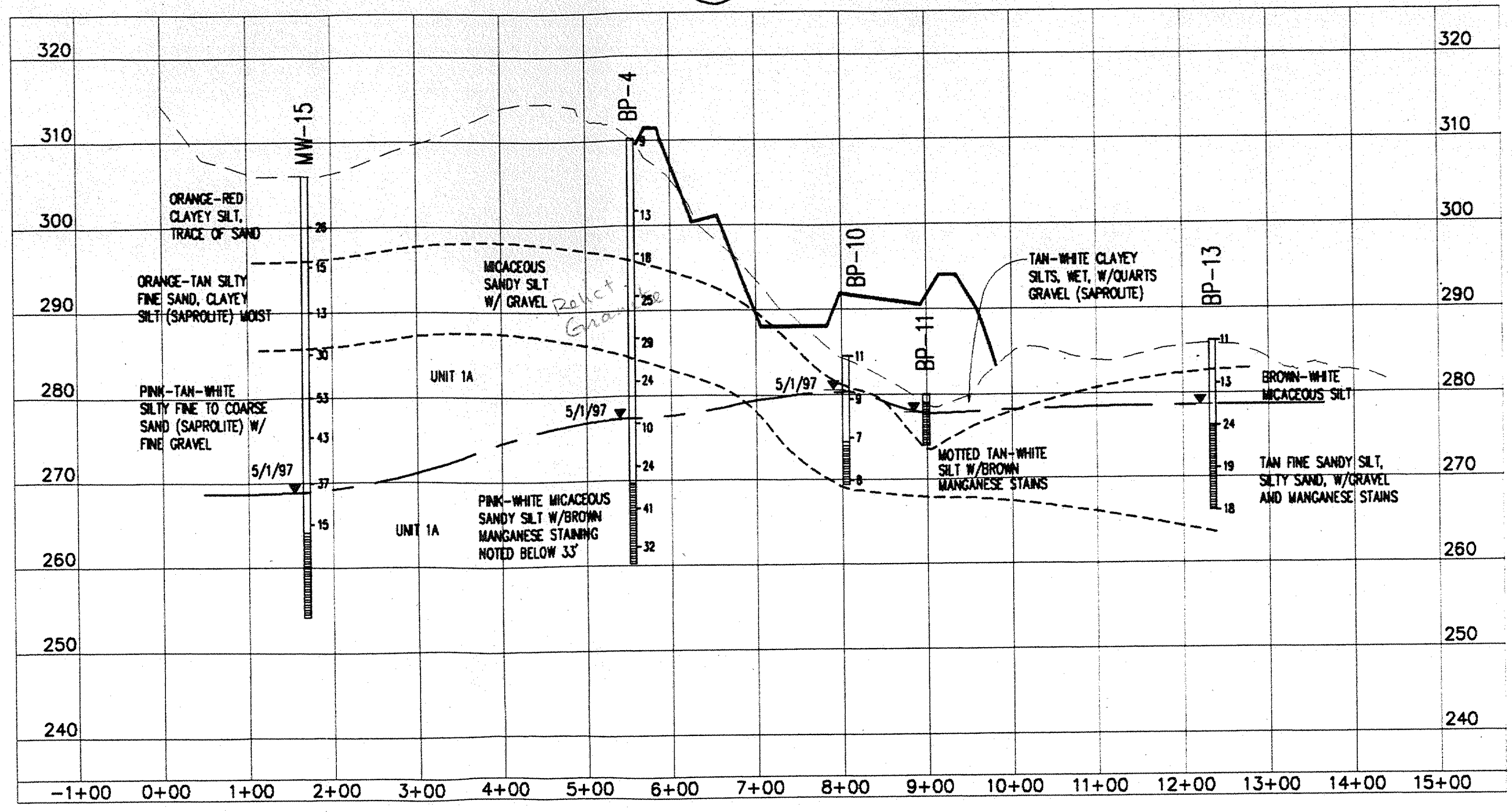
DESIGNED BY: P.K.S.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG., 1997
SHEET NO. 9	DRAWING NO. FC2

D:\...\HALIFAX-11\...FC2.dwg DATE: AUG 28, 1997 TIME: 3:28 PM

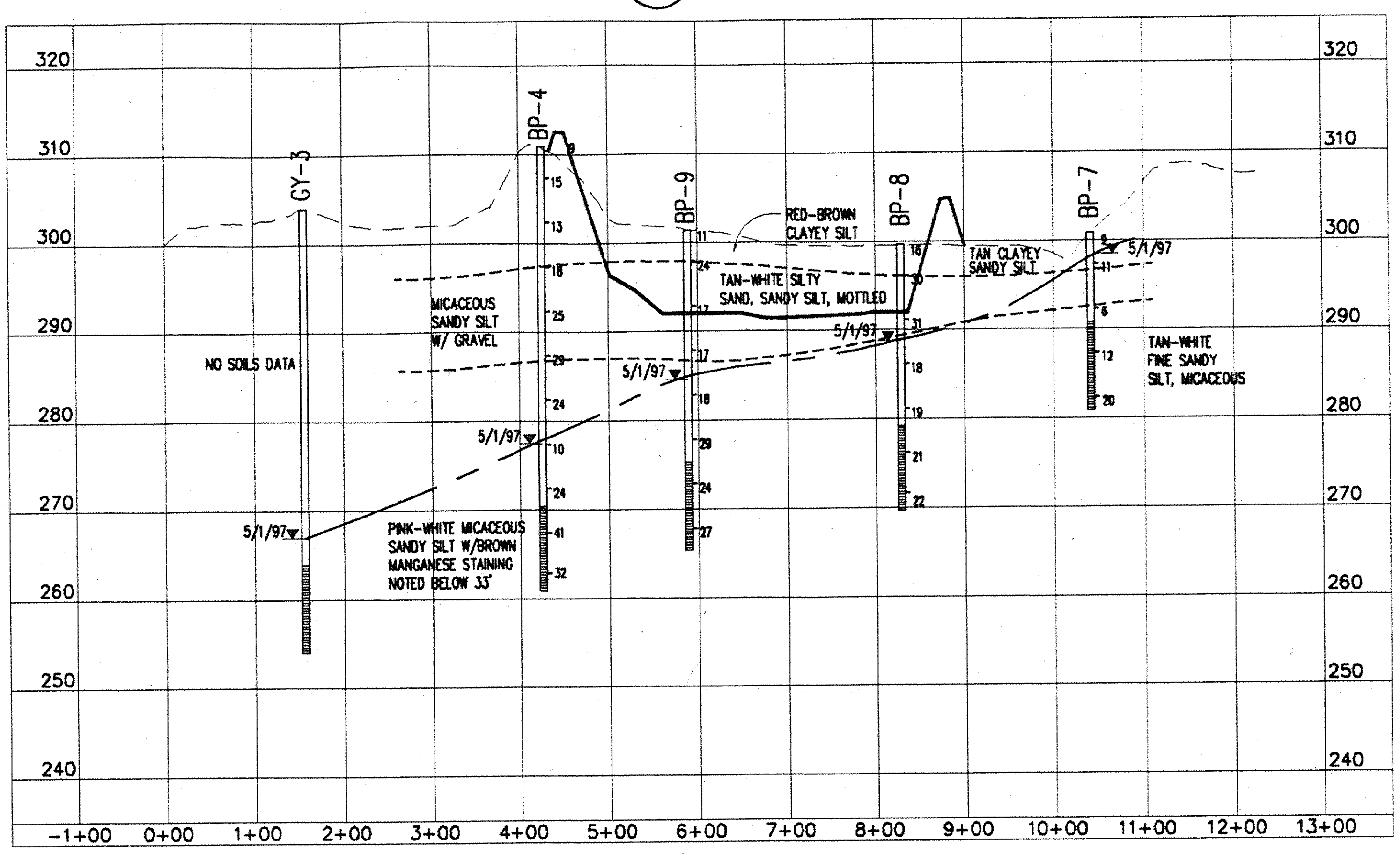
D:\-CAD\HALFAX-11\S-X1.dwg DATE: AUG 28, 1997 TIME: 3:35 PM



CD-1 / X1 CROSS SECTION



CD-2 / X1 CROSS SECTION



CD-3 / X1 CROSS SECTION

LEGEND

- EXISTING GROUND
- BASE OF LINER ELEVATION
- WATER TABLE
- 14 STANDARD PENETRATION RESISTANCE VALUE

1" = 10' VERT.

0 100' 200' 300'

1" = 100'

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: C.D.G.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG 1997
SHEET NO. 10	DRAWING NO. X1

DRAWING TITLE: HYDROGEOLOGICAL CROSS SECTIONS

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

SEAL: NORTH CAROLINA LICENSED GEOLOGIST SEAL 983 G. DAVID GARRETT

SEAL: NORTH CAROLINA PROFESSIONAL ENGINEER SEAL 021680 PIETER K. SCHEER

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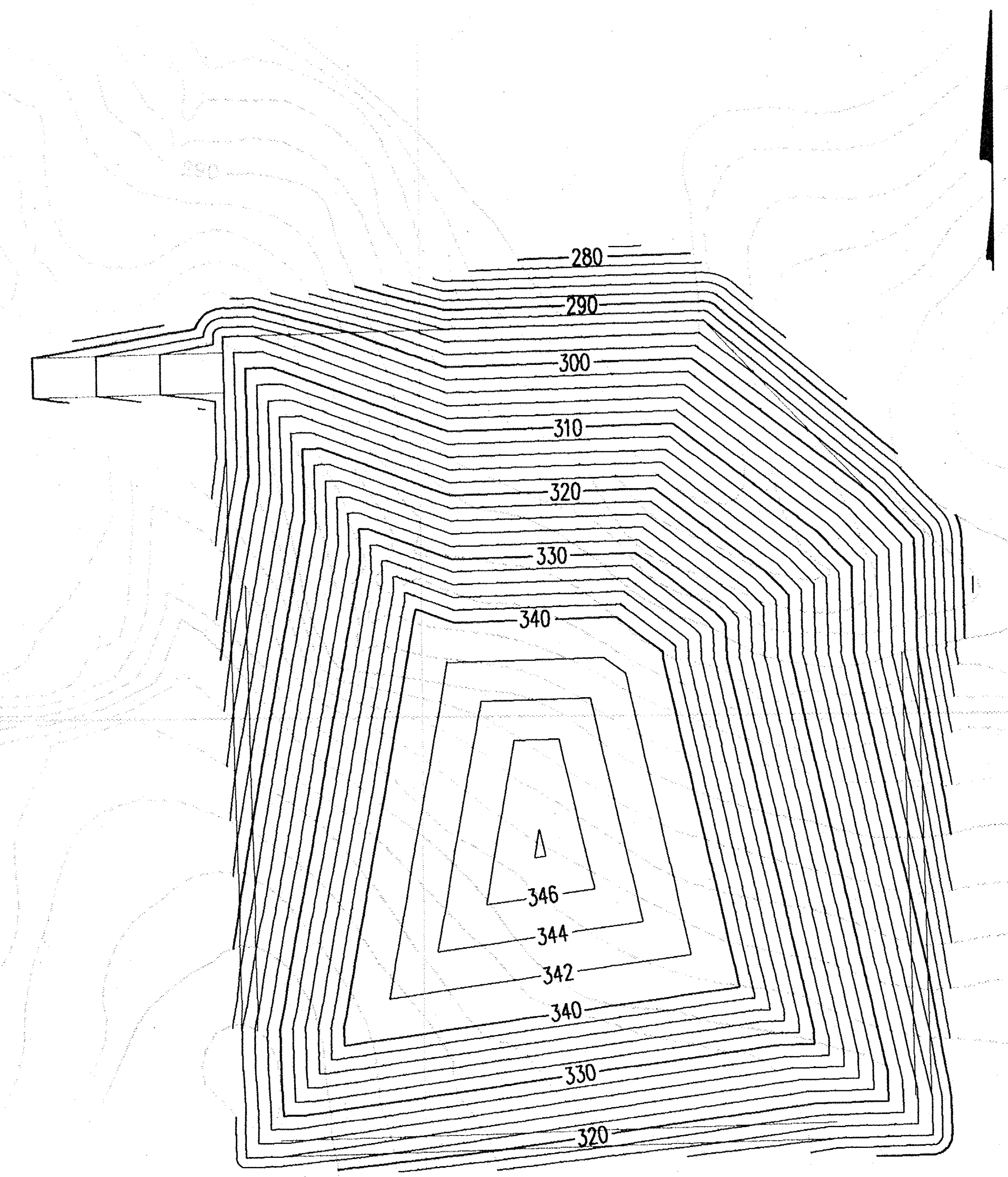
CELL 1
YEAR 0 TO YEAR 5

0 50' 100' 150'
1" = 50'



CELL 2-4
YEAR 5 TO YEAR 20

0 50' 100' 150'
1" = 50'

DATE	NO.	REVISION

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SEAL

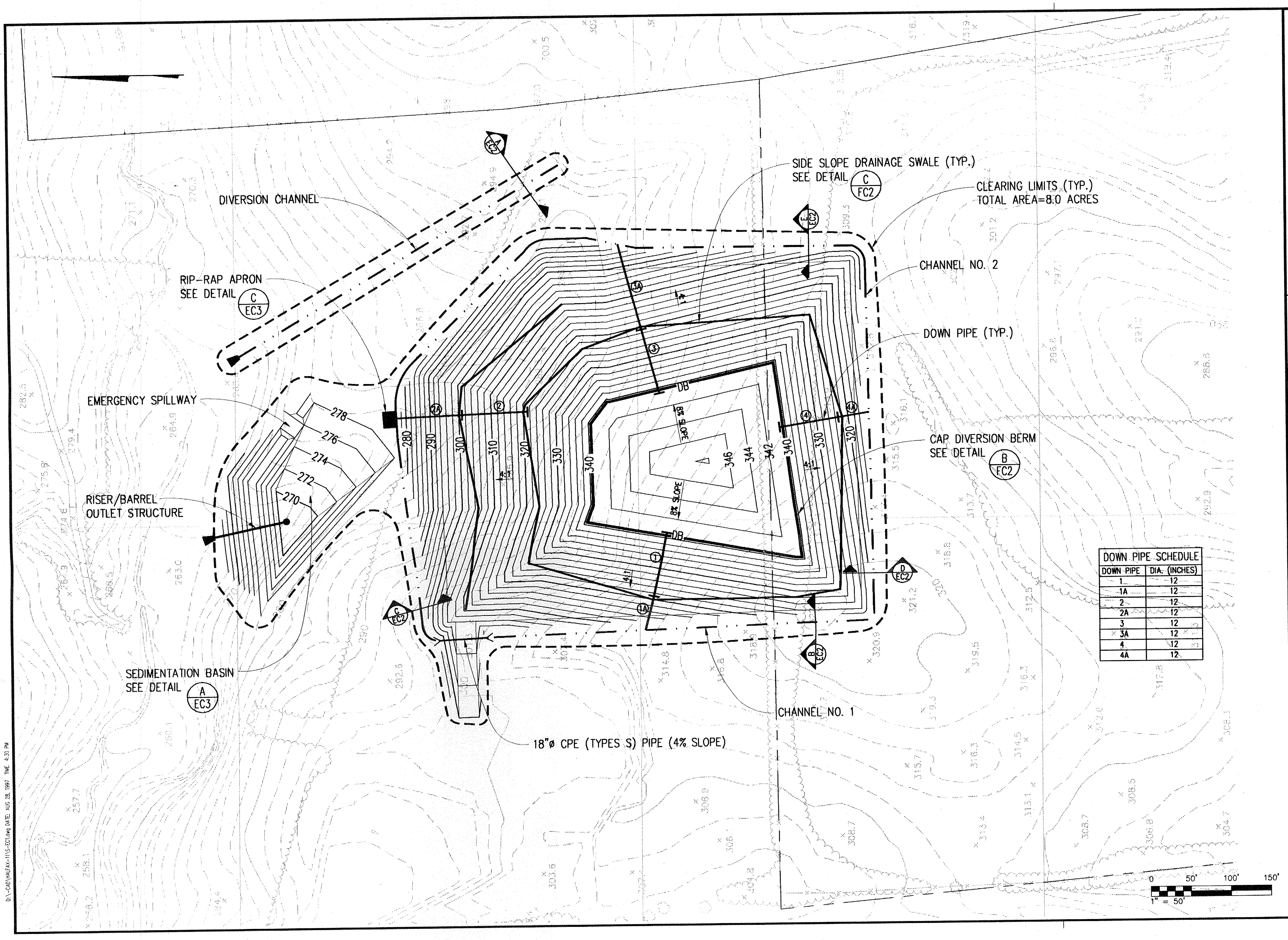
SEAL

PROJECT TITLE:
HALIFAX COUNTY
C & D LANDFILL

DRAWING TITLE:
PHASING PLAN

DESIGNED BY: P.K.S.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO. 11	DRAWING NO. P1

D:\-CAD\HALIFAX-11\S-P1.dwg DATE: AUG 28, 1997 TIME: 3:58 PM



DOWN PIPE SCHEDULE

DOWN PIPE	DIA. (INCHES)
1	12
1A	12
2	12
2A	12
3	12
3A	12
4	12
4A	12

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WWW.GNRA.COM

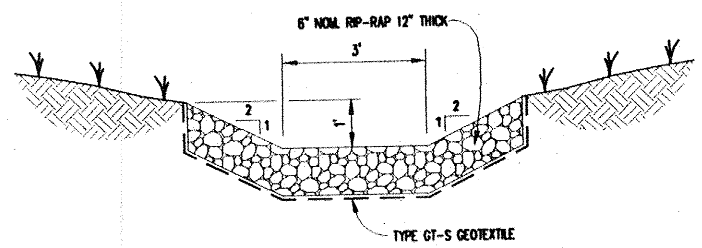
SEAL

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: EROSION CONTROL PLAN

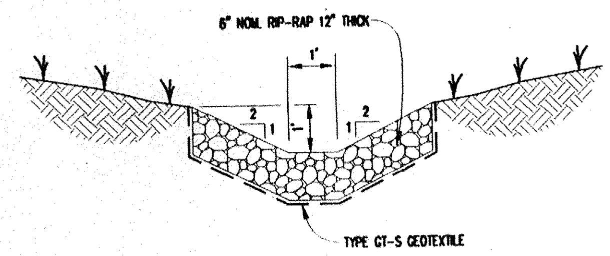
DESIGNED BY: P.K.S.	DRAWN BY: A.W.H.
CHECKED BY: G.D.G.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO. 12	DRAWING NO. EC1

D:\-CAD\HALIFAX-11\S-EC1.dwg DATE: AUG 28, 1997 TIME: 4:30 PM



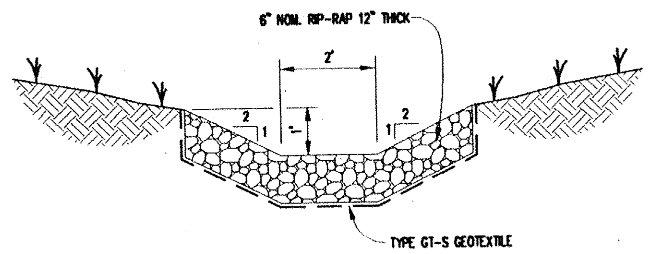
DIVERSION CHANNEL

DETAIL (A / EC2)
SCALE: 1"= 2'-0"



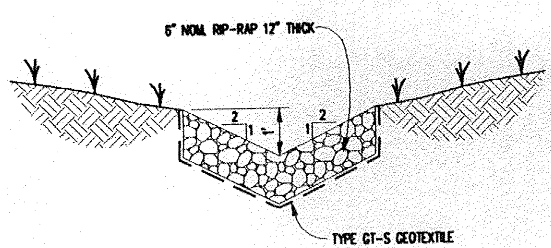
CHANNEL NO. 1A

DETAIL (B / EC2)
SCALE: 1"= 2'-0"



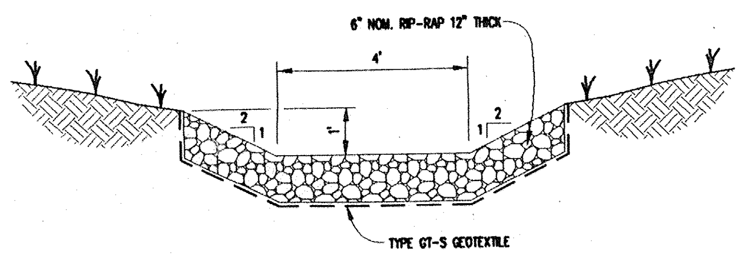
CHANNEL NO. 1B

DETAIL (C / EC2)
SCALE: 1"= 2'-0"



CHANNEL NO. 2A

DETAIL (D / EC2)
SCALE: 1"= 2'-0"



CHANNEL NO. 2B

DETAIL (E / EC2)
SCALE: 1"= 2'-0"

0 2' 4' 6'
1" = 2'

D:\-CAD\HALFAX-11\s-ec2.dwg DATE: AUG 28, 1997 TIME: 4:38 PM

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services
417 N. BOYLAN AVENUE RALEIGH, N.C. 27603
PHONE-919-828-0577 FAX-919-828-3899 WWW.GNRA.COM

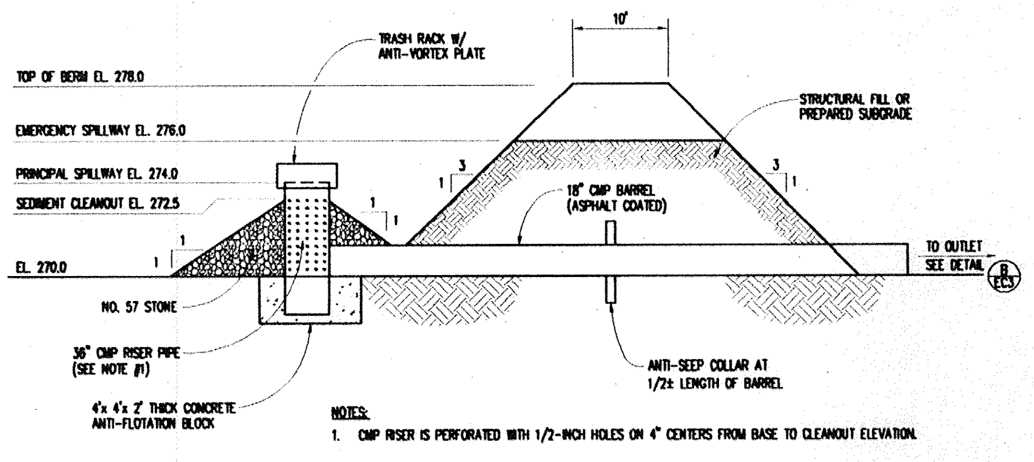
NO.	DATE	REVISION

SEAL

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

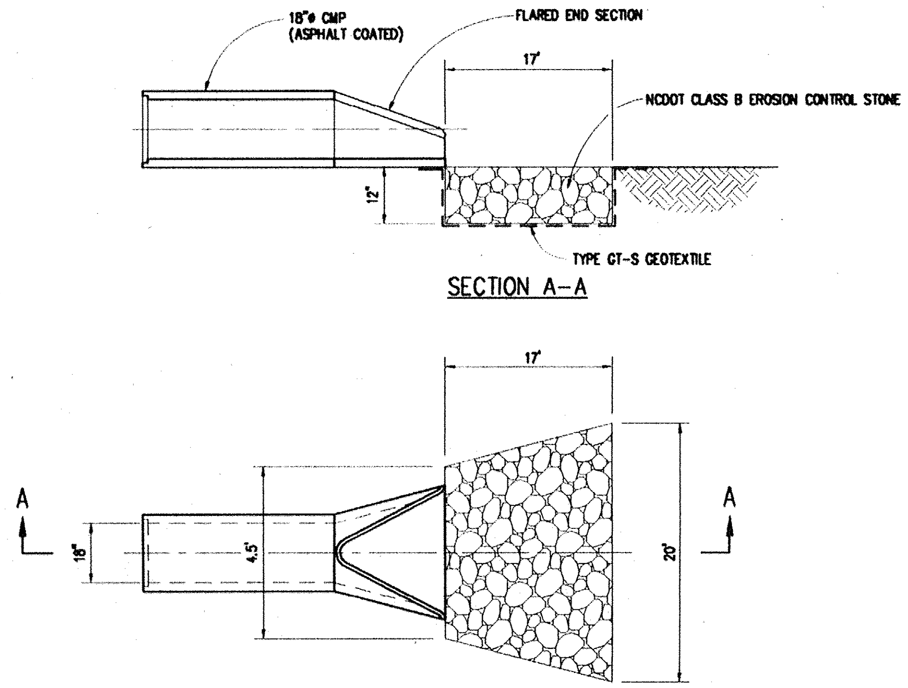
DRAWING TITLE: EROSION CONTROL DETAILS

DESIGNED BY: P.K.S.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALFAX-11
SCALE: AS SHOWN	DATE: AUG, 1997
SHEET NO. 13	DRAWING NO. EC2



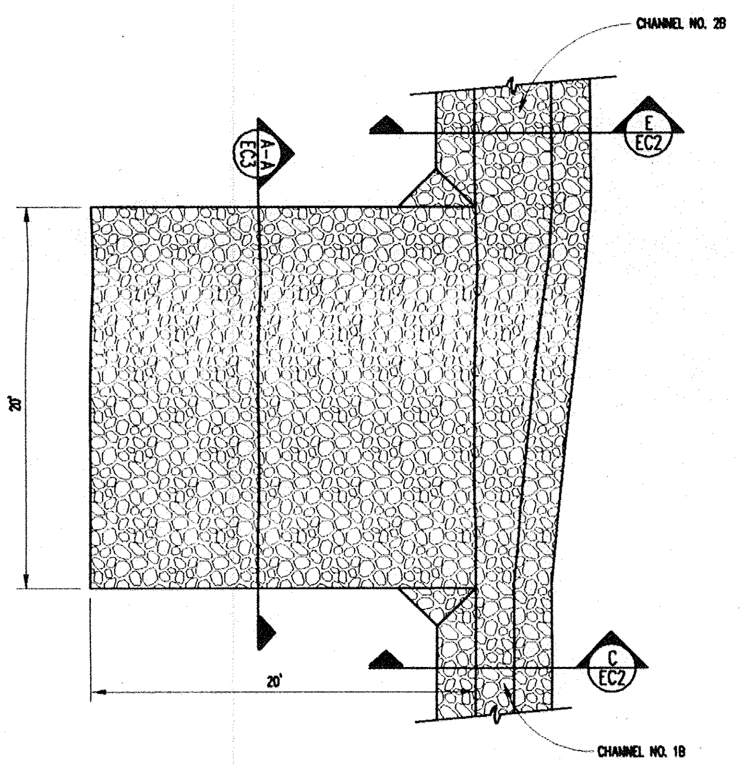
SEDIMENT BASIN CROSS-SECTION

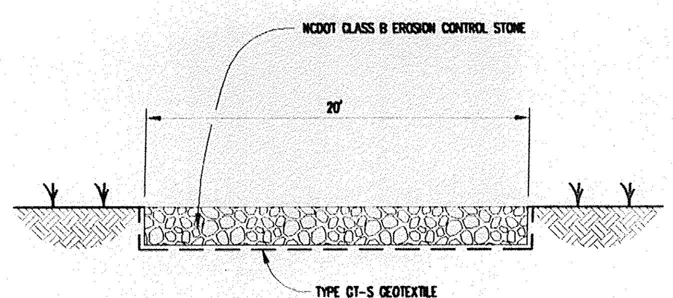
DETAIL A / EC3
N.T.S.



BARREL OUTLET

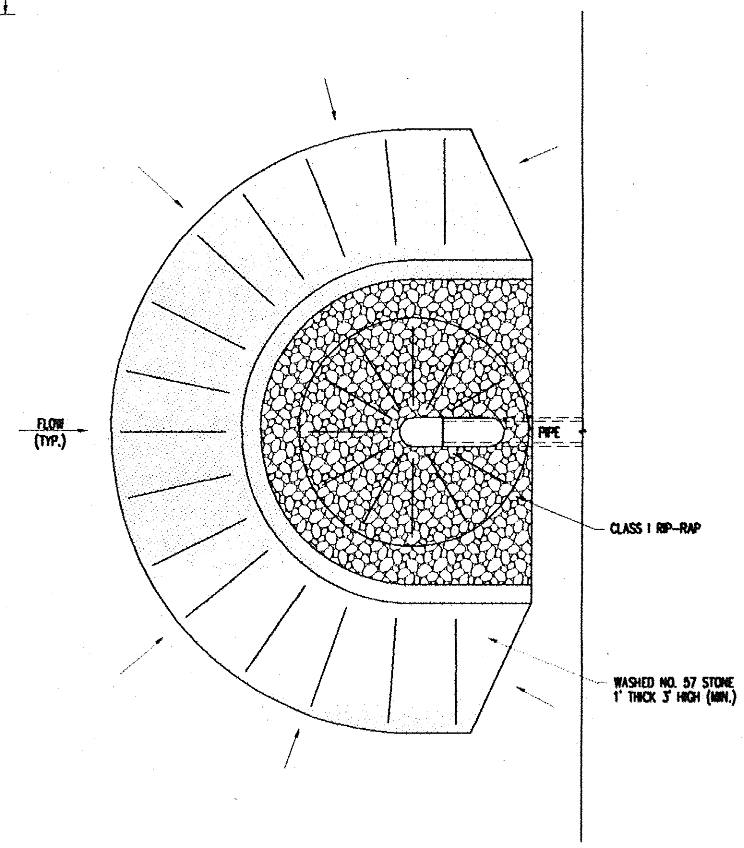
DETAIL B / EC3
N.T.S.

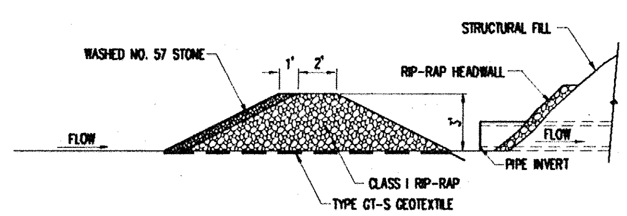




RIP-RAP APRON AT TERMINATION OF CHANNELS 1B & 2B

DETAIL C / EC3
SCALE: 1"= 5'





FILTER BERM

DETAIL D / EC3
N.T.S.

0 5' 10' 15'
1" = 5'-0"

NO.	DATE	REVISION

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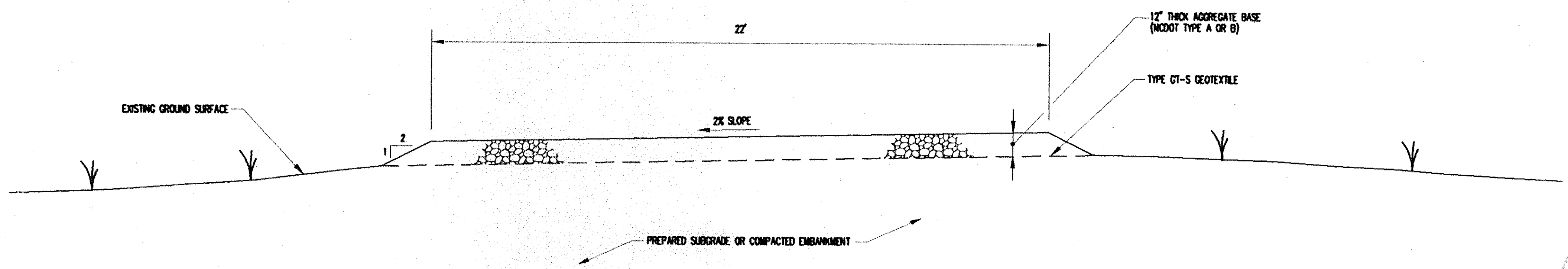
SEAL 021665 ENGINEER PETER K. SCHER
SEAL 8893 GREGORY N. RICHARDSON

PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: EROSION CONTROL DETAILS

DESIGNED BY: P.K.S.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALIFAX-11
SCALE: AS SHOWN	DATE: AUG, 1997
SHEET NO. 14	DRAWING NO. EC3



ALL WEATHER ACCESS ROAD

DETAIL A / M1

N.T.S.

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PROJECT TITLE: HALIFAX COUNTY C & D LANDFILL

DRAWING TITLE: MISCELLANEOUS DETAILS

DESIGNED BY: P.K.S.	DRAWN BY: A.W.H.
CHECKED BY: G.N.R.	PROJECT NO.: HALFAX-11
SCALE: AS SHOWN	DATE: AUG. 1997
SHEET NO. 15	DRAWING NO. M1