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# CHAPTER 12 IMPERMEABLE COVER

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# CHAPTER 12 IMPERMEABLE COVER

#### 12.1 REMEDIAL DESIGN REQUIREMENTS

#### <u>12.1.1 Consent Decree Requirements</u>

The Remedial Design Action Plan (RDAP) included in the Consent Decree states the following (p.7):

"The remedial action for control of air emissions is intended to mitigate the release or threat of release of Hazardous Substances, including odors associated with decaying hide waste, in the East Hide Pile."

"The remedial action shall consist of stabilizing the side slopes of the East Hide Pile, installing a gas collection layer, capping with a synthetic membrane to establish impermeability, and soil cover in accordance with [RDAP] Attachment A...."

Attachment A to the RDAP states that:

"Impermeable covers shall be designed and constructed to include at a minimum the following:

(a) A vegetated top layer which shall be,

(1) of a thickness designed to accommodate the maximum depth of root penetration and the rate of anticipated soil loss, but in any event no less than 6 inches;

(2) capable of supporting vegetation that minimizes erosion and minimizes continued maintenance;

(3) planted with a persistent species with roots that will not penetrate beyond the vegetative and drainage layers;

(4) designed and constructed with a top slope of between 3 percent and 5 percent after settling and subsidence or, if designed and constructed with a slope of greater than 5 percent, an expected soil loss of less than 2 tons/acre/year using the USDA universal soil loss equation; and (5) designed and constructed with a surface drainage system capable of conducting effective run-off across the cap.

(b) A middle drainage layer that shall be:

(1) of a thickness designed to accommodate the expected amount of settling and the maximum volume of water that could enter the drainage layer, but in any event no less than 6 inches;

(2) consisting of a material whose permeability exceeds  $1 \times 10^{-3}$  cm/sec., i.e. a sand in the SW or SP range of the Unified Soil Classification System or coarser material.

(3) designed and constructed with a bottom slope of at least 2 percent; and

(4) designed and constructed to prevent clogging.

(c) A bottom impermeable layer consisting of the following:

(1) an impermeable synthetic membrane having a thickness of at least 40 mils;

(2) a bedding layer designed to prevent clogging of the underlying gas collection layer and to provide a stable base for overlying layers (The gas collection layer may itself serve as the bedding layer provided that it will support the weight of the cap and will not abrade the synthetic membrane.);

(3) a final upper slope of at least 2 percent

The thickness of the vegetated top layer and drainage layer combined shall be designed so that the impermeable layer is wholly located below the average depth of frost penetration in the area of interest, unless the Settlers can demonstrate during remedial design that a reduction in thickness of the overlying layers will not affect the integrity of the synthetic membrane."

#### <u>April 1992</u>

A discussion of the functions and requirements of the impermeable cover was presented in Section 2.3 of the Pre-Design Investigation (PDI) Task S-3 Interim Final Report (Golder, 1990a). This section is included in Appendix 12-A as a reference.

# 12.1.2 Remedial Design Work Plan Requirements

The Remedial Design Work Plan (RDWP; Golder, 1990b) establishes that the 100% Design Report is to include the following impermeable cover design elements:

- 1. Final design of slopes;
- 2. Cover section;
- 3. Stabilization mechanism, location, and sections;
- 4. Definition of cap extent;
- 5. Grading plan; and,
- 6. Gas vent spacing.

#### 12.2 DESIGN SUMMARY

The design process for the impermeable cover on the East Hide Pile followed a specific logic. The results from this process lead to an alternative to the cover design specified in the Record of Decision (ROD) and Consent Decree. The logic and conclusions drawn at each stage of the design process are summarized herein. The stages of the design process were as follows:

- a) Stability analysis of the East Hide Pile under existing conditions;
- b) Establishment of a preliminary grading plan for the East Hide Pile cover, followed by the stability analysis for the as-graded configuration;
- c) Analysis of ROD Cover Stability;
- d) Identification of ROD Cover Stabilization Methods; and,
- e) Identification of an Alternative Cover.

The stability analysis of the East Hide Pile in its current configuration was conducted for several cross-sections where the slope geometry and soil conditions are critical. It was concluded that the pile is stable under present conditions, except for the surface sloughing mode which can be ameliorated by placement of the cover. The slope stability analyses for the existing conditions is discussed in detail in Section 12.3.1.1.

The grading plan initially designed for the East Hide Pile utilized a minimum slope of 5 percent and maximum slope of 33 percent. The stability analysis for the as-graded condition showed that the East Hide Pile would be stable for that grading configuration. The slope stability analyses for the regraded configurations is discussed in detail in Section 12.3.1.2.

#### <u>April 1992</u>

The stability of the ROD specified cover on the East Hide Pile was then assessed for the proposed grading plan. The stability of the cover section is controlled by the friction on the weakest interface. For the ROD impermeable cover cross-section, the weakest interface is between the middle drainage sand layer and the geomembrane, with typical interface friction angles between 17 to 19 degrees. The conclusion reached was that the ROD specified cover would not be stable in this configuration.

The next step in the design process consisted of evaluating methods to stabilize the ROD specified cover. Two alternatives were identified. The first consisted of placing the cover at a uniform 20 percent slope, which corresponds to a factor of safety of 1.5 for the critical interface friction angle. This approach, while being stable, would have required a significant amount of fill which would have encroached well into Wetland 1C. The second alternative consisted of placement of the cover at a 20 percent slope with construction of a retaining wall at the edge of Wetland 1C. The retaining wall would have been a massive structure on the order of 1,000 feet long, having a height of nearly 22 feet, whose construction would have caused significant impact to the wetlands. A structure of this size would also require considerable maintenance, present a safety hazard and have a negative visual impact. In addition, the structure would be a barrier to wildlife.

To minimize wetlands disturbance and avoid the problems associated with grading the East Hide Pile with flatter slopes, the next step in the design process consisted of identifying an alternative impermeable cover design. This alternative impermeable cover system includes a gas collection system which consists of 6 inch diameter fiberglass piping wrapped in geotextile and embedded in 12

inches of open-graded medium gravel (AASHTO No. 8). The gas collection system is discussed further in Chapter 15. A 10 ounce/square yard nonwoven geotextile separates the gravel from an overlying geomembrane. The geomembrane comprises textured 60-mil high-density polyethylene (HDPE) and is in turn overlain by a geocomposite drainage layer. The geocomposite drainage layer consists of a geonet with a geotextile factory heat bonded on both sides (Tex-Net TN3002CN, or equivalent). An 18 inch cover soil layer overlies the geocomposite and consists, from bottom to top, of 14 inches of select fill and 4 inches of topsoil. The surface will be vegetated.

Stability analyses confirmed that this alternative cover is stable at slopes of 33 percent. The stability analyses for the alternate cover is presented in detail in Section 12.3.1.3.

## 12.3 DESIGN CONSIDERATIONS

#### 12.3.1 Slope Stability

Slope stability analyses were conducted on the East Hide Pile for existing and remediated conditions. Four crosssections were analyzed for existing conditions. Sections E-E' and F-F' represent areas where the geometry is most critical, while Sections P-P' and V-V' drawn through Boreholes 9 and 11, respectively, represent areas where additionally weaker soils were encountered. Remediated conditions were analyzed for Sections F-F', P-P' and V-V' which were found to have the lowest factors of safety for existing conditions. The locations of these cross-sections are identified on Figure 12-1. The results of the slope stability analyses are presented in Appendix 12-B for existing conditions and in Appendix 12-C for remediated conditions.

Two series of slope stability analyses were conducted both for existing and remediated conditions: one representing the long-term groundwater condition without a perched water table and the other including the effect of a possible perched water table. Groundwater levels were based upon borehole observations as presented in the PDI Task S-2 Interim Final Report (Golder, 1990c).

Because the materials that form the hide pile were found to cohesionless soils, the critical behave as failure mechanism was generally shallow surface sloughing with semi-planar failure surfaces parallel to the slope where the surficial soils are locally weaker or where water tables are present. The analysis of planar failure surfaces in cohesionless soils is most appropriately conducted using the infinite slope theory (Lambe & Whitman, In order to model possible deeper seated failure 1969). mechanisms for the long-term groundwater condition,

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analysis was carried out using the PCSTABL5M version of the computer program STABL developed by Purdue University (Purdue University, 1988). Circular failure surfaces were analyzed using the simplified Bishop method, applying restrictions to the failure initiation and termination zones to preclude the shallow surface sloughing mode, which was analyzed separately as described above. The PCSTABL5M program permits analysis of large numbers of potential circular failure surfaces per run and automatically searches for the most critical; in this case 400 surfaces per run were analyzed. The slope stability results are summarized on Table 12-1.

The cross-sections analyzed for the individual slope stability runs are illustrated in Appendices 12-B and 12-C. The soil parameters used for the analyses were those recommended in the PDI Task S-2 Interim Final Report (Golder, 1990c) as described below.

A unit weight (saturated) of 100 pcf and an effective angle of shearing resistance of 25 degrees with zero cohesion was used for the Surficial Material.

Unit weights determined from undisturbed Shelby tube samples of Fill and Hide Residue prior to extrusion indicated a range of values of 65 to 130 pcf, reflecting variations in the local degree of compaction and the degree of saturation associated with perched water tables. A conservative value of 125 pcf was selected for slope stability calculations. Shear strength parameters for the Fill and Hide Residue were assessed from the results of triaxial tests and SPT 'N' values. For heterogeneous materials of this nature, the most reliable triaxial strength parameters were obtained by considering all of the test results together to define a single failure envelope that accounts for the volumetric changes associated with the development of shearing ("steady state" shear strength) rather than by assessing distinct values for each test from the Mohr circles. A large number of results were conveniently assessed in this way by plotting the failure points on a p'-q plot, where:

$$p' = \frac{\sigma 1' + \sigma 3'}{2} \qquad q = \frac{\sigma 1' - \sigma 3'}{2}$$

 $\sigma$ 1' and  $\sigma$ 3' being the major and minor principal effective stresses at failure. The conventional Mohr-Coulomb failure parameters c' and  $\sigma$ ' are related to the slope ( $\psi$ ) and intercept (d) of the p'-q plot as follows:

$$\sin \phi' = \tan \psi$$

$$c' = \frac{d}{\cos \phi'}$$

A p'-q plot for the Fill and Hide Residue is presented in Appendix 12-B. The data is reasonably consistent, both between consolidated undrained tests with pore pressure measurement and consolidated drained tests, for both undisturbed samples and specimens remolded at field water content and density. A "best fit" line through the data gave an effective angle of friction of 37 degrees and an effective cohesion of 2 psi. A lower bound line corresponds to an effective angle of friction of 34 degrees and zero effective cohesion.

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The SPT results for Fill and Hide Residue are plotted against depth in Appendix 12-B. The data showed a range of values, as would be expected for a heterogeneous material of this nature, with a clear trend of increasing 'N' value with depth. Using the work of Schmertmann (1975) to account for overburden effects and noting low 'N' values which are likely to have been affected by piping, suggested an effective angle of shearing resistance of 35 degrees.

It was considered unwise to rely on a cohesive strength component for such a heterogeneous material and a prudent allowance was also made for possible future degradation of material properties as a result of continuing anaerobic decomposition of the hide materials. Considering this and the above discussions, effective shear strength parameters of zero cohesion and 34 degrees friction angle were selected for the Fill and Hide Residue.

In the specific cases of Boreholes 9 and 11, it was recognized that the SPT 'N' values indicate possibly lower shear strengths of the Fill and Hide Residue locally; these boreholes are not, however, located at the geometrically critical sections of the East Hide Pile from a stability point of view. Based on the work of Schmertmann (1975), lower bound effective angles of shearing resistance of 31 degrees and 28 degrees were interpreted for the Fill and Hide Residue in Boreholes 9 and 11, respectively, as detailed in Appendix 12-B.

A unit weight (saturated) of 120 pcf and an effective angle of shearing resistance of 36 degrees with zero cohesion were selected for the Outwash Sand. A unit weight (saturated) of 125 pcf and an effective angle of shearing resistance of 37 degrees with zero cohesion were selected for the Glacial Till.

# <u>12.3.1.1 Existing Conditions</u>

The case of shallow surface sloughing was analyzed for the existing conditions using the infinite slope model and the average slope of Section F-F' equal to 26 degrees. A factor of safety of 1.0 was obtained for the long-term groundwater condition. For perched water table conditions, analyses were performed for seepage emerging from and parallel to the slope; factors of safety of 0.2 and 0.5 were obtained, respectively, confirming the controlling influence of perched water tables on the current stability.

conducted for the Circular analyses were long-term groundwater condition for Sections E-E', F-F', P-P' and Vv'. Factors of safety of 2.1, 1.9, 1.5, and 1.8 were obtained, respectively, indicating that Section F-F', P-P' and V-V' are the most critical, and confirming that, as anticipated, deeper failure surfaces are less critical than surface sloughing for this type of material. Circular analyses were also conducted for Section F-F' adopting a conservative perched water table, affecting the upper half of the slope with a phreatic surface at approximately 75 percent of the slope height. A factor of safety of 1.9 was calculated, comparable to that of the long-term groundwater case.

For the type of profile determined for the East Hide Pile, in which no weaker layers have been detected interlayered with other soils, circular surfaces are expected to be more critical than non-circular surfaces. However, as a verification, a limited number of feasible non-circular potential failure surfaces were also analyzed for the longterm groundwater condition on Section F-F', using PCSTABL5M with the Spencer method. These yield a minimum factor of safety of 2.0.

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The computer data for each PCSTABL5M run are included in Appendix 12-B with cross-sections showing the critical failure surfaces.

#### 12.3.1.2 Remediated Conditions

Slope stability analysis were conducted on remediated conditions for the most critical sections determined for existing conditions, that is, Sections F-F', P-P' and V-V'. Perched water table conditions were not analyzed since the construction of an impermeable cover will prevent the development of perched conditions.

As discussed above, the critical failure mechanism prior to remediation is shallow surface sloughing associated with cohesionless, Surficial Materials. This failure mechanism is precluded with the proposed remediated plan, since compacted granular fill will be placed to flatten the slopes. Proof rolling of the Surficial Material on the existing slope surface will be undertaken prior to placement of the fill in areas where the existing slope is 2.5H:1V or flatter, which can be achieved by drum and rear wheel drive rollers. The surface of existing slopes steeper than 2.5H:1V can not be proof rolled; however, the thickness of compacted fill in front of these slopes will be significant and will be sufficient to prevent sloughing.

The cross-section geometries analyzed for these remediated condition are illustrated with their individual slope stability run outputs in Appendix 12-C. Additional materials used in the remediated condition analyses, or any modifications made to the soil parameters previously used in the existing condition analyses, are discussed below.

The conservative assumption that the cover materials provide weight only (unit weight 120 pcf) and have zero shear strength was made.

Select fill material to be used for grading purposes beneath the cover was analyzed with a unit weight of 125 pcf and an effective angle of shearing resistance of 33 degrees with zero cohesion. Materials chosen for this fill will have to meet these standards as required in the construction specifications.

Sections F-F', P-P' and V-V' were analyzed for the longterm groundwater condition, with alternate unit weights of 125 and 115 pcf for the Fill and Hide Residue, to reflect the variability of this material.

The factors of safety obtained in these analyses were 2.3, 2.2 and 2.8 for Sections F-F', P-P' and V-V', respectively.

The analysis of the slope stability of the East Hide Pile in the remediated condition concludes that the proposed grading plan is acceptable. The computer output data from the PCSTABL5M runs and cross-sections showing the critical failure surfaces for the remediation conditions are included in Appendix 12-C.

## 12.3.1.3 Cover Interface Friction

A testing program using representative soils and geosynthetic samples was undertaken to verify the interface friction angle selected for the design. A detailed discussion of the laboratory testing program conducted to evaluate the interface friction angle between the cover soil and the different geosynthetics used in the hide piles covers is presented in Appendix 11-E. The results of this program indicate that the minimum residual interface

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friction angle between a soil cover of the type that has been specified for the East Hide Pile and the geotextile or geocomposite, or between the geocomposite and the textured HDPE, is 30 degrees.

The grading plan for the East Hide Pile cover has been designed in such a way that the slopes do not exceed 33 percent (18.3 degrees). For slopes of 18.3 degrees or less, under the assumption of infinite slope, the calculated factor of safety with respect to sliding of the cover is 1.7 for the minimum friction angle of 30 degrees.

Additional interface friction testing shall be performed using the actual borrow sources for cover material and geosynthetics prior to construction, as outlined in the specifications.

# 12.3.2 Soil Erosion

Calculations of soil loss based on the USDA Universal Soil Loss Equation as presented in the USEPA document entitled "Evaluating Cover Systems for Solid and Hazardous Waste" (Lutton, 1982, Revised Edition) are included in Appendix 12-D. These calculations show an expected soil loss of 1.66 tons per acre per year, below the specified 2 tons per acre per year. Establishing vegetative cover as quickly after construction as possible should further aid in the prevention of soil loss.

#### <u>12.3.3 Frost Penetration</u>

The Alternate Cover Design Report (Golder, 1989) concluded that the depth of frost penetration for an average winter at the Site would be contained within a cover thickness of 16 inches. The cover soil on the East Hide Pile has a design thickness of 18 inches. Thus, frost prevention in an average winter will be contained within the cover soil. The geocomposite drain will serve to prevent the formation of water films during thawing.

#### 12.3.4 Settlement

The allowable settlement for which a structure has to be designed depends on its specific characteristics and function. The impermeable cover to be constructed on the East Hide Pile is not a structure sensitive to settlements, because it is very flexible and will not support other structures. Therefore the assessment of the effects of settlements included in this section considers strains that could occur in the cover and the maintenance of appropriate drainage.

Calculations of the maximum differential settlement of the cap as a consequence of variations in the thickness of the hide pile are presented in Appendix 12-E. These calculations are based on one-dimensional compressibility which is appropriate for the present case of a wide, flexible loaded area. Additional calculations are presented in Appendix 12-E of the maximum differential settlement of the cap as a consequence of the heterogeneity in the properties of the soils. These calculations were based on Schmertmann's et al method (1978) as directed by USEPA: this method strictly applies for rigid a axisymmetric load of finite extent. In order to use the method, the hide pile was approximated as a circle of equivalent area. Schmertmann's method also relies upon static cone resistance data. Such data were not available in the present case and was approximated from the SPT 'N' values using the correlations presented by Robertson, et al. (1983) and Kasim, et al. (1986). Settlements were calculated for maximum and minimum 'N' value profiles in order to compute maximum differential settlements.

The maximum differential settlement obtained by the onedimensional method is 0.01 feet in a distance of 100 feet, while the maximum predicted by Schmertmann method is 0.01 feet in a distance of 140 feet. This indicated that neither the integrity of the cap nor the drainage gradients would be adversely affected by the maximum credible settlements which are conservatively estimated by the onedimensional method. Preloading of the hide piles prior to construction of the cap is therefore not necessary.

## 12.3.5 Cover Drainage

Calculations of the required thickness and hydraulic conductivity of the drainage layer in the ROD cover were carried out using the HELP (Hydrologic Evaluation of Landfill Performance) computer program developed by the U.S. Army Corps of Engineers. Output data from the program is included in Appendix 12-F. The HELP model is an automated water balance method which allows computation on a daily basis over a period of years, providing more representative results than manual water balance calculations which are typically performed on a monthly basis for a single year. Water balance calculations, and the HELP model in particular, are generally used to evaluate potential leachate generation in landfills. In the present case, however, the method was used to provide a conservative verification of the adequacy of the drainage layer located between the cover soil and the geomembrane.

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A one-dimensional model is inherent in the water balance method, so that only a single gradient can be used to compute surface runoff. In the present case the maximum overall drainage path length was used in conjunction with the minimum slope to be conservative. Using a drainage layer permeability of 1 x  $10^{-3}$  cm/sec, the minimum specified in the RDAP, lead to a required drainage layer thickness in excess of 8 feet. Assuming a drainage layer thickness of 12 inches, the minimum permeability required to maintain the maximum head within the soil cover was approximately 5 x  $10^{-2}$  cm/sec.

The capacity of the geocomposite drainage layer and the required granular medium may be compared via the transmissivity, which is the product of the hydraulic conductivity and the thickness. The transmissivity of the required granular drainage layer is therefore 1.5 x  $10^{-4}$  $m^2/sec.$ A geocomposite alternative such as Tex-Net TN3001CN (manufactured by Fluid Seal Systems Inc.) or equivalent, has a transmissivity of 1 x  $10^{-3}$  m<sup>2</sup>/sec under a surcharge load of 2,000 psf. The synthetic drainage medium therefore has a transmissivity one order of magnitude higher than required by conservative calculations.

As a further check, the geocomposite drain was directly modelled by two alternative methods:

- a. Modelling the physical thickness of the geocomposite in conjunction with its actual transmissivity and porosity, a negligible wilting point and field capacity.
- b. Modelling the geocomposite as a 12-inch thick gravel layer and scaling the permeability to provide a transmissivity equivalent to the geocomposite.

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The maximum head over the geomembrane under 20-year conditions was 10.5 inches, calculated by method 'a' above, confirming that the proposed design of the geocomposite drainage layer is conservative.

## 12.3.6 Chemical Compatibility of Geomembrane

The gases emitted from the Hide Piles were discussed in the Remedial Investigation Phase II, Volume 1, Section 4, p. VI-10, Prepared by Roux Associates for Stauffer Chemical Company (1984).

The gaseous release rates from boreholes totalled 1.82 scfm (standard cubic feet per minute) for the East Hide Pile. The gases emitted from the East Hide Pile and West Hide Pile boreholes were listed in Table IV-2 of the Remedial Investigation Phase II, Volume I, Section 4 as cited above and include the following constituents:

Compound	<u>Greatest</u>	Concentration
Hydrogen Sulfide		21,000 ppm
2-Propanethiol		180 ppm
Methanethiol		110 ppm
Ethanethiol		19 ppm
Carbon Oxide Sulfide	e	13 ppm
Carbon Disulfide		11 ppm
Dimethyl Disulfide		7.8 ppm
2-Butanethiol Isomer	r	5.5 ppm
Benzene		2.3 ppm
Toluene		1.6 ppm
Methyl Furan Isomer		1.4 ppm
Trichlorofluorometha	ane	0.63 ppm

The chemical compatibility of the HDPE geomembrane was evaluated from the available literature and discussions with the following manufacturers and research organizations:

> Geosynthetic Research Institute National Seal Company Gundle Lining Systems Union Carbide SLT North America

The information obtained relates to both transmissibility and the effect on mechanical properties over time and is summarized in the following paragraphs.

The Geosynthetic Research Institute (GRI) provided various tests of compatibility of HDPE with concentrated liquid benzene and toluene. After an immersion period of three months, HDPE immersed in benzene shows good performance in tensile strength and weight tests. The performance of specimens immersed in liquid toluene was classified as poor. GRI also provided data evaluating the rate of water vapor transport through HDPE. A 30 mil HDPE geomembrane had a vapor transport value of 0.02 g/m<sup>2</sup>-day, while a 96 mil HDPE geomembrane had a vapor transport value of 0.006 g/m<sup>2</sup>-day.

SLT North America conducted tests for chemical compatibility and found that HDPE has excellent resistance to immersion in gaseous hydrogen sulfide at temperatures of 68 degrees F and 140 degrees F. SLT North America also indicated that HDPE has good resistance to chlorinated hydrocarbons. Tests for methane gas permeability conducted by SLT North America indicated an average value of 2.06 cc/100 sq in/24 hours Atm for 60 mil sheet. Tests have been conducted by Union Carbide on the contact of hydrogen sulfide with HDPE geomembrane. Chemically, there is nothing for the hydrogen sulfide to react with in the polyethylene. Union Carbide has concluded that the hydrogen sulfide behaves like water and does not penetrate polyethylene. In terms of vapor transmissibility, hydrogen sulfide gas is considered less likely to emit through a HDPE geomembrane than water vapor.

Gundle Lining Systems conducted chemical immersion tests on 60 mil HDPE for a period of the thirty days. The effect on mechanical properties of the HDPE was only slight after being immersed in concentrated sulfuric acid. Gundle also conducted chemical immersion tests of their HDPE product Gundline HD. The product was immersed in a concentrated mixture of sodium sulfide and sodium hydroxide known as "Black Liquor". The mechanical properties of the Gundline HD were not affected after a period of sixty days.

In conclusion, the chemical compatibility of the proposed HDPE geomembrane with the identified gases from the East Hide Pile appears to be good. Likely vapor transmissibility through the HDPE geomembrane is low and conservative calculations indicate that the volume of transmitted gas would be below detection limits.

12.4 IMPERMEABLE COVER DESIGN

12.4.1 Impermeable Cover Grading

The East Hide Pile is located in the north-central portion of the Site, close to the Site boundary. The northern and western sides of the hide pile are bounded by Wetland 1C. The West Branch of the Aberjona River (Wetland 2A) runs along the southern edge of the hide pile. A bedrock outcrop exists to the east of the hide pile. Boston Edison Right-of-Way No. 14 runs east-northeast across the hide pile. The location and extent of the East Hide Pile, as defined by the Consent Decree, is shown on Sheet 11-2A.

The existing peak elevation of the hide pile is around 108 feet, sloping to Wetland 1C with overall slopes of around 2.5H:1V to 3H:1V increasing locally to 1.5H:1V.

The impermeable cover extends over the full area of the East Hide Pile as defined in Attachment F of the Consent Decree, and to the base of the topographic pile where this covers a larger area.

The grading plan for the impermeable cover on the East Hide Pile has been designed to: 1) increase the stability of the slopes, 2) minimize impact on wetland functionality, and 3) optimize constructability.

A grading plan incorporating a minimum slope of 3 percent and a maximum slope of 33 percent has been designed for the impermeable cover on the East Hide Pile. The relatively flat areas near the top of the East Hide Pile are sloped at a minimum of 3 percent to promote efficient drainage. A maximum slope of 33 percent was chosen in cover areas to achieve a reasonable slope stability factor of safety as discussed in Sections 12.3.1.2 and 12.3.1.3.

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This grading plan is most suitable for wetlands revegetation and wildlife accessibility to the wetlands, since it avoids vertical or semi-vertical retaining structures and, at the same time, reduces to a minimum encroachment into the wetlands. The effects of this construction on the wetlands are minimized, but will involve synthetics, soil, and rip-rap protection placed along the water's edge, and in isolated areas, into the standing water.

Constructability is maximized by the use of long straight contours and smooth constant slopes. The design avoids any cutting of the hide piles. Construction considerations are discussed, in detail, in Section 12.4.5.

The grading plan for the East Hide Pile is presented on Sheet 12-1 and cross-sections are shown on Sheets 12-2 through 12-4.

#### <u>12.4.2 Surface Water Drainage</u>

The surface water management design consists of a rip-rap drainage channel (see Details 1 and 2, Sheet 12-8) around the northern and eastern perimeter of the hide pile, a riprap toe drain along the edge of Wetland 1C (see Details 2 and 3, Sheet 12-7), and a collection pipe to transmit discharge from the geocomposite drainage layer. The design of these features is discussed in the following sections.

## 12.4.2.1 Drainage Channel

The rip-rap drainage channel receives flow from: a) surface water run-off from the surrounding natural ground to the east of the hide pile and from the cover surface and, b) water collected in the geocomposite drainage layer in the eastern section of the hide pile. Flow is divided in the channel adjacent to the gas treatment system (Sheet 12-1)

and water is conveyed to the north and south of the hide The channel discharges to Wetland 1C at the north pile. side of the East Hide Pile through a transition (see Detail 3, Sheet 12-8) to the remediated wetland. At the southern end, the channel discharges via an 18 inch diameter concrete culvert to an existing channel that discharges to the Western Branch of the Aberjona River. Along part of the northeastern edge of the East Hide Pile, the channel is routed via an 18 inch diameter concrete culvert under the regraded slope so as to limit construction to within the Site boundary. Channel profiles are presented on Sheets 12-5 and 12-6.

The rip-rap drainage channel was designed using the United Soil States Department of Agriculture, Conservation Service, Technical Release TR55 hydrologic program (SCS, TR55 was used to estimate the maximum flow in the 1986). channel based on a 24 hour, 100 year storm. The size and shape of the channel, the maximum depth of flow and type of channel lining were found by using Manning's equation with the maximum expected flow. The TR55 program output and associated calculations are included in Appendix 12-G.

The two sections of drainage channel running to the south and to the northwest along the eastern side of the hide pile have a base width of 2 feet and a depth of 1.5 feet, with 2H:1V side slopes. The base width of the north channel increases to 4 feet along the northern side of the hide pile in the section downstream of the culvert. The entire length of the channel is rip-rap lined. The rip-rap is 1.5 feet thick, with stone having a mean diameter of 0.5 feet. The cover tie-in is shown on Sheet 12-7 Detail 4 and the channel cross sections may be found on Sheet 12-8, Details 1 and 2.

#### <u>12.4.2.2 Geocomposite Discharge</u>

The impermeable cover section includes a geocomposite drainage layer to collect water which infiltrates the cover soil. Discharge from the geocomposite is conducted to the wetlands in several ways depending upon location. Along the west side of the East Hide Pile the drainage layer will discharge into the wetlands via the rip-rap toe drain (see Details 2 and 3, Sheet 12-7). The Western Branch of the Aberjona River, located along the southern edge of the East Hide Pile, will be remediated with a gravel/cobble lining. The geocomposite is to be extended to discharge directly into the channel. A drainage collection pipe (see Details 5 and 6, Sheet 12-7) is utilized to intercept flow from the geocomposite for a short section along the northeast edge of the hide pile parallel to the 18 inch diameter concrete culvert. Along the eastern and northern edge of the East Hide Pile the geocomposite discharges into the rip-rap channel provided for surface water drainage.

#### 12.4.2.3 Toe Drain

The rip-rap toe drain provides a discharge media from the geocomposite drainage layer to the existing wetlands, and provides protection of the cover system from water at the toe of slope. The mean diameter of the rip-rap stone is 0.5 feet with an average thickness of 16 inches. The rip-rap will extend a minimum of 5 feet horizontally up the slope (Sheet 12-1). A 16 ounce/square yard nonwoven geotextile is utilized to prevent migration of fine particles into the rip-rap layer. Details 2 and 3 on Sheet 12-7 show tie-ins of the toe drain to Wetland 1C.

## 12.4.3 Gravel Access Road

A gravel access road is located along the east side of the East Hide Pile (see Sheet 12-1). The road will function to provide access to the gas treatment system at the crest of the hide pile and for maintenance to the cover system. Outside the cap limits, the road cross section consists of a 3 inch gravel layer (AASHTO #57 or equivalent), as shown in Detail 4, Sheet 12-8. To maintain the permeable cover system requirements, the cross section of the access road within the cap limits consists, from bottom to top, of a 16 ounce/square yard nonwoven geotextile, a 13 inch structural fill layer and a 3 inch gravel layer (AASHTO #57), as shown in Detail 5, Sheet 12-8. Calculations for determining the road cross section may be found in Appendix 12-H. In both cases, the gravel shall be placed on a competent subgrade as approved by the Design Engineer.

## 12.4.4 Erosion And Sedimentation Control

Proper erosion and sedimentation control measures will be maintained during the construction of the remedy. Straw bales and silt fences (see Details 6 and 7, Sheet 12-8) will be placed along the perimeter of the hide pile to prevent the transport of sediments into the adjacent wetland. The straw bales and silt fences will be properly maintained and replaced as needed until the construction of the cover system has been completed and vegetation has developed. If necessary, temporary erosion control measures such as erosion mat and diversion swales at the crest of slope should be utilized prior to permanent Additional erosion and sedimentation details vegetation. are provided in the Specifications.

# 12.4.5 Construction Considerations

Prior to placement of the impermeable cover, all existing above ground vegetation is to be cleared, tree trunks cut

to ground surface, and the root mat left in place. Woody material from above ground and other vegetation will be chipped and composted for later placement as fill under the permeable cover.

Fill material to be placed to grade the slopes will be compacted in horizontal layers not greater than 12 inches loose thickness to a minimum density equivalent to 95 percent of the Standard Proctor. Prior to construction of the cover, hide pile slopes equal to or flatter than 40 percent will be proof rolled to compact the Surficial Materials. Where existing slopes are steeper than 40 percent, the thickness of fill will be significant and will function to prevent surface sloughing. A roller of 10 ton minimum weight will be used for proof rolling. All fill placement and cover construction will be carried out from toe to crest of the slopes, so that the slope stability of the hide pile is not temporarily reduced by construction operations. Existing vegetation shall be cleared in stages just in advance of the filling operation.

Material excavated elsewhere on the Site will be the primary source of fill to regrade the slopes of the hide pile. The fill material on the slopes shall be granular soil, free of any deleterious materials such as wood, construction debris and saturated soils. Specific requirements for fill materials are presented in the Specifications.

Monitoring well OW-32 located in the southwest corner of the East Hide Pile (see Sheet 11-6) and existing gas vents will be decommissioned prior to placement of the cover on the hide pile. The procedure for decommissioning is discussed in the Specifications.

Boston Edison Right-of-Way No. 14 runs east-northeast across the hide pile. The two power poles located on the hide pile are to be removed and relocated outside the cover area by the Boston Edison Company prior to placement of the cover on the hide pile.

Graded gravel for the gas collection layer (AASHTO #8) will be carefully placed on the prepared subgrade. Gas collection pipes are to be wrapped with a 10 ounce per square yard nonwoven geotextile to prevent infiltration of fines into the collection pipe network. The geotextile will be sewn along its length and at seams between adjacent sheets. After completion of the geotextile wrap, gravel shall be carefully placed around the pipes to achieve a 12 Locations of the pipes shall be clearly inch thickness. marked and subsequent construction of the cover should be organized to avoid damage to the pipes. Installation of the piping, geotextile, and gravel collection layer shall be closely monitored in accordance with the Specifications.

The 10 ounce per square yard geotextile will then be placed to cover the gas collection layer. All seams in the geotextile shall be carefully sewn and reviewed for quality control by the Q.A. Inspector.

Installation of the 60 mil textured HDPE geomembrane will include deployment of the sheet and heat seaming of all seams. Contractor personnel completing the geomembrane installation shall be experienced with textured HDPE, and all seaming personnel shall be qualified on the project prior to actually performing any seaming of HDPE sheet in place. The seaming process will be carefully monitored, with all seams being tested along their length by vacuum box or air pressure testing. Additionally specimens will be obtained at intervals from the seams for destructive tests to ensure seam quality. Any seams which do not pass the required QA/QC testing will be cap stripped.

The geocomposite drainage layer will be installed above the seamed geomembrane. Contractor personnel will have to complete this operation carefully to minimize potential for damage to the geomembrane. Adjacent sheets of geocomposite will be seamed by overlapping and tying the geonet together with plastic ties and sewing the upper geotextile sheets. When seaming between a geotextile and a geocomposite is required, the geotextile will be sewn to one of the geotextiles of the geocomposite. All seaming will be reviewed by the Q.A. Inspector.

The soil cover will then be placed directly over the geocomposite. The soil shall be placed in a manner that minimizes imposed stress on the underlying geocomposite and geomembrane, by using low ground pressure earth moving equipment and maintaining a minimum thickness of 12 inches of soil between placing equipment and the geocomposite at all times. So as to enhance stability of the hide pile, cover soil shall be placed from the base of the pile toward the top. Cover soil will be nominally compacted by the action of the placing equipment only.

In areas where the impermeable cover ties into wetlands or perimeter drainage facilities, careful construction will be required to properly build the transition details. In these areas a number of geotextiles will have to be joined with multiple seams all of which will be inspected. In areas of the wetlands, subgrades are likely to be easily disturbed so it is important that the contractor minimize potential disturbance by the use of properly sized and operated equipment. The access road to the gas treatment system will be constructed of compacted fill placed to reach road subgrade and capped with a minimum of 3 inches of graded gravel surfacing. The road will tie into the permeable cover to be constructed to the east of the East Hide Pile.

#### REFERENCES

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		TABLE 12-1 EAST HIDE PILE STABILITY				
GROUNDWATER		FAILURE	FACTOR	FACTOR OF SAFETY		
SECTION	CONDITION	MODE	EXISTING	REMEDIATED		
F-F'	Long Term	Surface Sloughing	1.0	N/A		
		Circular	1.9	2.3		
		Non-Circular	2.0			
	Perched Water	Surface Sloughing				
	Table	- seepage emerging from slope	0.2	N/A		
		- seepage parallel to slope	0.5	N/A		
		Circular	1.9	N/A		
E-E'	Long Term	Circular	2.1			
P-P'	Long Term	Circular	1.5	2.2		
V-V'	Long Term	Circular	1.8	2.8		

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APPENDIX 12-A Impermeable Cap Requirements

#### IMPERMEABLE CAP REQUIREMENTS

This section is reproduced from the PDI Task S-3 Interim Final Report (Golder Associates, 1990).

#### 2.3 Impermeable Cap Requirements

The RDAP specifies an impermeable cap will be placed over the East Hide Pile in order to mitigate odors and collect gases to be treated. The impermeable cap will include (from bottom to top):

- 1. A gas collection layer;
- 2. A bedding layer;
- 3. An impermeable synthetic geomembrane;
- 4. A middle drainage layer; and,
- 5. A vegetated top layer.

The RDAP divides the cap components into three layers; a bottom impermeable layer consisting of the gas collection layer, bedding layer, and geomembrane; a middle drainage layer; and a vegetated top layer. The following sections will discuss the functions and requirements of the three cap layers.

#### 2.3.1 Impermeable Layer

The bottom impermeable layer shall consist of the following in accordance with Attachment A of the RDAP:

- 1. A gas collection layer;
- 2. A bedding layer designed to prevent clogging of the underlying gas collection layer, and provide a stable base for overlying layers. The gas collection layer can also function as the bedding layer, provided it will support the weight of the cap and not abrade the overlying geomembrane;
- 3. An impermeable synthetic membrane having a minimum thickness of 40 mil; and,
- 4. A final grade of at least 2 percent.

The purpose of the gas collection system is to collect and convey the gas generated from the East Hide Pile through a network of piping to the temporary gas treatment system. The Remedial Design Work Plan (Golder Associates, 1990a) indicates that the piping shall be 6 inches in diameter and embedded in gravel. The gravel will allow gas to flow to The thickness of gravel the piping system. is not specifically mentioned in any document, however, the ROD indicates a gravel layer 12 inches thick in Figure 12. It is anticipated that the gravel layer would be a minimum of 12 inches thick to allow for sufficient coverage around the piping system.

One of the most important properties for a gas collection layer is its absolute permeability (generally expressed in  $cm^2$ ), that depends exclusively on the properties of the porous media and measures the flow capacity of any fluid through that media. When applied to a specific fluid, a coefficient of permeability (generally expressed in cm/sec) is defined, which also depends on the fluid properties. In the case of liquid fluids, the coefficient of permeability is generally called hydraulic conductivity. Hydraulic conductivity values determined for one fluid allow the other hydraulic conductivity for any fluid to be calculated.

For the borrow areas potentially usable for the gas collection layer in this project, hydraulic conductivity tests have been conducted on samples using distilled water, as an indirect measurement of their flow capacity, and from which hydraulic conductivity values could be determined for

other fluids during the design stage. Since no specification of absolute permeability or hydraulic conductivity has been given in any of the governing documents, a hydraulic conductivity of  $1.0 \times 10^{-3}$  cm/sec is proposed as the minimum required for this layer.

As stated in the RDAP, the function of the bedding layer is to prevent clogging of the underlying gas collection system and provide a stable base for overlying layers. Since a geomembrane overlies the bedding layer, its function to prevent clogging is redundant. Also, the load from overlying layers is minimal and the gas collection system could also function as the bedding layer. Therefore, the need for a bedding layer will be re-evaluated as part of the design.

The property of importance for the bedding layer is the gradation and texture of the particles. A coarse and angular bedding layer may abrade and inbed into the overlying geomembrane, compromising its integrity. Also, a bedding layer that has a finer particle size distribution than the gas collection layer may migrate downward and clog the gas collection layer. As suggested in the Remedial Design Work Plan (p. 23) it may be advantageous to use a geotextile directly on top of the bedding layer to provide a cushion and clean working surface for the placement of the geomembrane. If the bedding layer contains finer particles than the underlying gravel, the use of а geotextile between the bedding layer and the gas collection layer would prevent particle migration downward.

A geomembrane having a minimal thickness of 40 mil is required by the RDAP to be placed on top of the bedding layer. The function of the geomembrane is to establish impermeability to prevent the migration of gases to the air

#### 3

#### **Golder Associates**

and percolation of water into the East Hide Pile. No material type is specified. The choice for a geomembrane is basically related to its durability, strength, and constructability. The durability of a geomembrane is related to its chemical, physical, and mechanical The mechanical properties are related, properties. in part, to the sheet thickness. Strength properties and survivability are increased with a thicker sheet.

High density polyethylene (HDPE) is widely used for landfill liners and closures, because it is more resistant to most chemical substances than other geomembrane polymers (Reference 8). HDPE is also a low cost material relative to other liner options.

Considering the advantages discussed above, as well as Golder's experience, HDPE is tentatively recommended as the impermeable layer component. There are various properties of importance for HDPE including thickness, strength, and puncture resistance. The minimum standards for HDPE flexible membrane liner are outlined in the National Sanitation Foundation (NSF) Standard Number 54. Typically thicknesses for HDPE liners are 40 or 60 mils. Generally, field testing allows for a variance in thickness of 10 percent. The minimum strength requirements for 40 and 60 mil HDPE are listed below:

	<u>40 m11</u>	<u>60 m11</u>
Tensile Strength at Yield (lb/in. width)	70	120
Tensile Strength at Break (lb/in. width)	120	180
Elongation at Yield (Percent)	10	10
Elongation at Break (Percent)	500	500

Golder Associates

The NSF does not give minimum requirements for puncture resistance. Typically landfill liner specifications for geomembranes require puncture resistance of 40 and 60 pounds for 40 and 60 mil HDPE, respectively.

## 2.3.2 Middle Drainage Layer

A drainage layer is required to be placed on top of the geomembrane. The RDAP specifies in Attachment A that the middle drainage layer shall be:

- "(1) of a thickness designed to accommodate the expected amount of settling and the maximum volume of water that could enter the drainage layer, but in any event no less than 6 (six) inches;
  - (2) consisting of a material whose permeability exceeds 1 x  $10^{-3}$  cm/sec., i.e., a sand in the SW or SP range of the Unified Soil Classification System or coarser material;
- (3) designed and constructed with a bottom slope of at least 2 percent; and,
- (4) designed and constructed to prevent clogging."

The function of the drainage layer is to transmit the maximum volume of water that could enter the system to prevent ponding effects. The significant properties of the drainage layer are gradation and hydraulic conductivity as specified by the RDAP. The gradation of the drainage layer is important since it is related to permeability. The angularity is also important for the survivability of the underlying geomembrane, to minimize abrasions and scratches during installation.

The thickness of the drainage layer will depend on design calculations. The RDAP specifies a thickness of no less than 6 inches. It must be considered that the thickness of cover over the geomembrane should be, at a minimum, equal

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to the depth of frost penetration to allow for a functioning drainage layer throughout the year. The ACDR indicated that the average frost depth will not penetrate a 16 inch cover.

#### 2.3.3 Vegetated Top Layer

A vegetated layer is required to be placed above the drainage layer. The RDAP in Attachment A specifies the vegetated top layer shall be:

- "(1) of a thickness designed to accommodate the maximum depth of root penetration and the rate of anticipated soil loss, but in any event no less than 6 inches;
- (2) capable of supporting vegetation that minimizes erosion and minimizes continued maintenance;
- (3) planted with a persistent species with roots that will not penetrate beyond the vegetative and drainage layers;
- (4) designed and constructed with a top slope of between three (3) percent and five (5) percent after settling and subsidence or, if designed and constructed with a slope of greater than five (5) percent, an expected soil loss of less than two (2) tons/acre/year using the USDA universal soil loss equation; and,
- (5) designed and constructed with a surface drainage system capable of conducting effective run-off across the cap."

The functions and requirements of the upper vegetated layer are well outlined above. The properties relative to these functions include gradation, organic content and soil fertility. These properties are important to properly design a consistent seed and fertilizer program for rapid and persistent vegetative growth.

APPENDIX 12-B Existing Slope Stability Calculations Shear Strength Parameters for Fill and Hide Residue

Golder	SUBJECT Estimation	of d'and c' Fre	m p'-g plot
	JOD NO. 9036400	Made by AP	Date 12-18-91
Associates	Ret. ISAT	Reviewed per	Sheet ) of 3

Objective: To estimate \$\overline{0}' and \$C'\$ for the Fill and Hide Residue From the results of triaxial tests plotted on a \$p'-9\$ plot, where: \$\overline{0}' = effective angle of shearing resistance \$C' = effective cohesive strength.

Reference : Lambe-Whitman, Soil Mechanics, 1969, "Use of a p-g Diagram," p. 141-2.

Four types of triaxial test were performed on Method : the Fill and Hide Residue : 1. Undisturbed Consolidated - Drained 2. Undisturbed Consolidated - Undrained with pore pressure measurement 3. Remolded C-D 4. Remolded C-U w/o p.p.m. The failure points were platted on a p'-q plot, where:  $p' = \frac{\sigma_1' + \sigma_3'}{2}$  $g = \frac{\sigma_1 - \sigma_3}{2}$ with: p! = effective normal stress at Failure q = shear stress q = major principal effective stress at Failure O3 = minor " " " From the plotted data, a." best Fit" line was drawn through the data to determine the slope (4) and intercept (d) of the p'-g plot.  $\phi'$  and c' were determined From  $(\psi)$  and (d) using the equations ;  $\sin \phi' = \tan \psi$  and  $c' = \frac{d}{\cos \phi'}$ . A lower bound line was drown through the data to determine the iower bound p'and c' values

using the same relationships as above.

Golder	SUBJECT Estimation	of d'and c' From	~ p-g plot
Associates	Job No. 703 6100 Ref. 15 R.T	Made by RD Checked Ald Beviewert ACR	Date 12-18-9/ Sheet 2 of 3

Calculations :

,

i) "Best Fit" line : 
$$\gamma = 31^{\circ}$$
 and  $d = 1.6 \text{ ps.}$   
 $\sin \phi' = \tan \gamma$   
 $\sin \phi' = \tan(31^{\circ})$   
 $\phi' = 36.9^{\circ} = 37^{\circ}$   
 $c' = \frac{d}{\cos \phi}$   
 $c = \frac{1.6}{\cos(37)} = 2 \text{ psi}$ 

2) Lower Bound line:  $\Psi = 29^{\circ}$  and d = 0

$$\sin \phi' = \tan \psi$$
  

$$\sin \phi' = \tan(27)$$
  

$$\phi' = 33.7^{\circ} \approx 34^{\circ}$$
  

$$c' = \frac{d}{\cos \phi}$$
  

$$c' = \frac{c}{\cos \phi} = 0 \text{ psi}$$





F 3

Golder	SUBJECT ESTIMAT	E & FOR FILL & HIDE	RESIQUE
Associates	Job No. 983-6700 Ref.	Made by AC Checked VEA7 Reviewed MCR	Date in it is a state of the st

OBJECTIVE TO ESTIMATE Q'FOR THE FILL HIDE RESIDUE USING N-VALUES BASED ON SCHMERTHANN, 1975-

REFERENCE: NMEASUREMENT OF IN-SITU SHEAR SMENGTH. JOHN & SCHMERTMANN, 1975

ASSUMPTIONS

DOES NOT APPLY FOR DEPTHS LESSTHAN 2M.

2) USE SPT VALUES FROM EAST HIDE PILE.

3) ASSUME WATER TABLE DEPTH AT 23'

CALCULATIONS:

1) CALCULATE OVERBURDEN PRESSURE AT 10', 20', 30', 35'

2) DETERMINE N FROM ATTAUTO GATA (low values considered subsoprently) 30' = 10 30' = 20 35' = 24.5

Golder	SUBJECT ESTIMATE	O SE FUI O DECT	RECIDIE
Associates	Job No. 903-6900 Ref.	Made by PAC Checked UEE7 Reviewed MC	Date and the second sec

CALCULATIONS (com'd)

3) DETERMINE & FROM ATTACHED THELE

Dept	$\sim$	$\mathcal{O}^{+}$
10'	7.3	350
20'	10	34°
30'	<i>2</i> 0	37.50
35'	24,5	38.50

FOR OVERALL STABILITY CALCULATIONS TAKE  $\phi'=35^{\circ}$ .

.





h :

shear strength from the SPT must be treated as just that -- an estimate. However, the pressure of circumstances often force<sup>2</sup> angineers to make such estimates and the writer offers the following as the state-of-theart on this subject.

Man May

2.21 • in Stands: As part of his very thorough review of the stateof-the-art of the SPT, defello (1971, pp. 26-31) studied the published N-+ correlation data -- which he found mcager. He reviewed the data of Gibbs and Holtz (1957), assumed an equation based on Prandtl-Caquot-Builsman idealized theory, and found by statistical evaluation that the G & H data fit the equation with good confidence. Figure 1 herein presents this correlation, as adapted from defello's Figure 11. He then checked this correlation prediction method against mostly unpublished data from private sources and found reasonable agreement provided one considered <u>Figure 1</u> as usually conservative and does not apply it to SFIs at "very shallow depths" (writer's interpretation = less than 2 m.).

The above can produce only rough estimates of  $\checkmark$  in sands. An experienced engineer with a sample in hand can perhaps estimate  $\checkmark$  triaxial with better accuracy. However, this SFT method does provide the engineer with a rough check and some documentation. But, variablem other than  $\checkmark$  can have a great influence on the N-value. For example Barthélamy (1974) found in the Duke University chamber that N reduced about 55% when he added 10% mica to a sand, but kept the same triaxial  $\checkmark$  of about 39 degrees. Adding the mica reduced the triaxial initial tangent modulus,  $E_1$ , by about 60%. Obviously, a soil's compressibility has great importance.

One can also estimate  $\bullet$  using relative density as an intermediate parameter, but defello recommended against this common practice. The correlation most used for the estimate of relative density is that based on the research of Gibbs and Holtz (1957). To reduce conservatism at high  $D_r$  many engineers now include the modifications proposed by Bazaraa (1967). Eigure 2 presents these correlations in a form conveniont for easily estimating relative density from the N-values. Because of general agreement with the philosophy expressed by Meyerhof (1965), most engineers no longer modify the N-value when testing below







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Golder	SUBJECT ISRT-3	0% Des. Rpt - 1	EPA Comments
Associates	Job No. 903-6400 Rel. Question 10	Made by UEE'7 Checked PON Reviewed	Date 1-17-91 Sheet 1 of 2

Objective:

Using the blowcount, overburden pressure and depth relationship for boreholes #9 \$ #11, determine the & for each hole using figure 1 from In Situ Messurement Soil Properties, Specialty Conference of the Geotechnical Engineering Division · ASCE, June, 1975.

Procedure: For borehole #9,



For Leptr = 10 A, N=5, p'= 1250 F=f For po', Convert psf to kgf/cm<sup>2</sup>  $p_{o}^{\prime} = 1250 \operatorname{ref} \left( \frac{1}{14} \frac{f^{2}}{r^{2}} \right) \frac{1}{2.54^{2}} \frac{(4.45 \times 1)}{(1.45 \times 1)^{2}} \left( \frac{1}{1.45} \frac{k_{q}f}{(1.45 \times 1)^{2}} \right)$ po'= 0.610 kgf/cm² Use po = 0.6 kgf/cm² From Gaune 1 A= 31°

Golder	SUBJECT /SRT-3	30% Des Rot-EPA	A Comments
Associates	Job No. 903-6400 Ret. QUESTION 10	Made by UEET Checked FCN Reviewed MCR	Date $1 - 17 - 91$ Sheet $2$ of $2$



For Depth = 10ft,  $N \approx 3$ ,  $p' \approx 1240 \text{ psf}$ For  $p'_{o}$ , convert psf to  $kgf/cm^2$   $p'_{o} = 1240 \text{ psf} \left( \frac{1 \text{ ft}^2}{144 \text{ m}^2} \right) \frac{4.45 \text{ M}}{2.54^2 \text{ cm}^2} \left( \frac{1.45 \text{ M}}{1.16} \right) \frac{1 \text{ kof}}{9.81 \text{ M}} \right)$   $p'_{o} = 0.606 \text{ kgf/cm^2}$   $\frac{1 \text{ kee}}{1.16} p'_{o} = 0.60 \text{ kgf/cm^2}$   $= 0.606 \text{ kgf/cm^2}$   $\frac{1 \text{ kee}}{1.16} p'_{o} = 0.60 \text{ kgf/cm^2}$   $= 1.610 \text{ figure 1}, \quad \mathcal{O} = 26^{\circ}$ This value is lower than the minimum of value of 28° model of  $m^2$  of  $m^2$  solves that  $m^2$  minimum of  $p'_{o} = 26^{\circ}$  $\therefore \text{ Adopt } \phi = 28^{\circ}$  for analysis Section F-F'- Existing Conditions Surface Sloughing - Long-Term and Perched Water Tables

Golder	SUBJECT ISRT - Ea	st Hide Pile St	Tability
	JOO NO. 903-6400	Made by DOKL	Date 5/14/92
Associates	Ret. INDUSTRI - PLEX INDBURN/MA	Reviewed Mer	Sheet 3 of 1/4

cot \$ = cot 26 = 2.05 From the attached jigure A = 0.25 Jon Yu= 0.6 :. F.S. = 0.96 × 0.25 = 0.24 11

3) Perched Water Table, Seepage Parallel to Slope Assume seepage surface is 20% is depth is sloughing  $Tu = \frac{\chi}{T} \frac{\chi_w}{S} \cos^2\beta$   $= 0.8 \times 60.4$  cos<sup>2</sup>26 = 0.40 Form the attacked Jeanse A = 0.50

From the attached Jugure A = 0.50 FS = 0.96 × 0.5 = 0.48,1

42

4/2

i:



- y \* total unit weight of soil
- y<sub>w</sub>= unit weight of water
- C'= cohesion intercept } Effective
- $\phi$  = friction angle  $\int$  Stress
- $r_u = pore pressure ratio = \frac{u}{\gamma H}$
- u = pore pressure at depth H

Steps:

- Determine ru from measured pore pressures or formulas at right
- 2 Determine A and B from charts below

3 Colculate F = A 
$$\frac{\tan \phi}{\tan \beta}$$
 + B  $\frac{C}{\gamma H}$ 











STABILITY CHARTS FOR INFINITE SLOPES.

Golder	SUBJECT ISRT - East Hide Pile Stability
Associates	Job No. 903-6400 Made by DOKL Date 5/14/92. Ref. (MaysTRI-PLEX Checked RD Sheet 1 of H
Accordiated	IGOBORN/MA Reviewed PCR

Evaluate the factor of safety of the Existing slope of the Rost Hide Pile ogainst shellow sloughing Objective =

Method :

1) Determine the steepest inclination of existing slope 2) Select the most representative soil parameter. 3) Perform infinite slope analyses outlined in Ref 3. for the strepest existing slope

1) Golder, 1992 Final Grading Plan. Drawing # 11-7 Proj # 903-6400 Rejuences : 2) Golder, 1992 Shope Stability Analysis." by DORL. Proj # 903-6400 Duncan & Bachignane, An Engineering Manual Jon Slope Stability Studies. University of Backeley. 1975 3) Golder, 1990, "Pre-Design Investigation Task S-2 Stability of Hide Piles, Interim Final Report," Proj # 893-6255 **グ**)

Golder	SUBJECT ISRT - A	East Hide Pile	stability
	Job No. 903-6400	Made by DOKL	Date 5/14/92
Associates	Ret. INDUSTRI - PLEY /	Checked RS	Sheet $\mathcal{Z}$ of $\mathcal{A}$
	WOBURN/MA	Reviewed Pen	-

The inclination of the existing slope was obtained from Refs 11 and 2. Shope Angle: (B) For pection F - F'  $\beta = 26°$ pection F - E  $\beta = 24°$ pection V - V  $\beta = 21°$ pection P - P  $\beta = 26°$ . The steepest dope is 26°

The properties of the surficial material ase obtained from Material Properties: Ret 4 and summarized as JollowA: 8 = 100 pef c'= 0  $\phi' = \lambda s'$ 

Calculations: 1) Dry Shope  $F.s = tan \phi' = tan \delta = 0.96 \\ tan \beta = tan \delta = 0.96 \\$ 

21 Perched Water Table leading to Seepage emerging from slope: Aosume acpage angle, 0, is 5° from the horizontal Aconding to Ref. 3.  $Y_u = \frac{Y_{w}}{Y} \frac{1}{(1 + tan \beta tan 0)}$  $= \frac{60.4}{100} \frac{1}{(1 + tan 26 tan 5)} = 0.60$  Section F-F' - Existing Conditions Circular - Long-Term and Perched Water Tables

\*

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1/9

### \*\* PCSTABL5M \*\*

by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTFE1.IN
Output Filename:	SECTFE1.OUT
Plotted Output Filename:	SECTFE1.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	F-F,	EXISTING	SLOPE	FILE	S
		ECTFE	1.IN					

### BOUNDARY COORDINATES

16	Тор	Boundaries
37	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	1.00	72.00	6.00	72.00	3
2	6.00	72.00	9.00	70.00	3
3	9.00	70.00	12.00	72.00	3
4	12.00	72.00	41.00	74.00	1
5	41.00	74.00	68.00	78.00	1
6	68.00	78.00	73.00	80.00	1
7	73.00	80.00	82.00	82.00	1
8	82.00	82.00	92.00	86.00	1
9	92.00	86.00	99.00	88.00	1
10	99.00	88.00	114.00	94.00	1
11	114.00	94.00	120.00	96.00	1
12	120.00	96.00	129.00	100.00	1
13	129.00	100.00	133.00	102.00	1
14	133.00	102.00	138.00	104.00	1
15	138.00	104.00	147.00	105.90	1
16	147.00	105.90	206.00	108.00	1
17	206.00	108.00	263.00	107.50	1
18	12.00	72.00	48.00	69.00	3
19	48.00	69.00	56.00	72.00	2
20	56.00	72.00	62.00	73.60	2
21	62.00	73.60	68.00	74.50	2
22	68.00	74.50	73.00	76.50	2
23	73.00	76.50	82.00	78.50	2
24	82.00	78.50	92.00	83.00	2
25	92.00	83.00	99.00	85.00	2
26	99.00	85.00	114.00	91.00	2
27	114.00	91.00	120.00	93.00	2
28	120.00	93.00	125.00	95.00	2
29	125.00	95.00	138.00	101.00	2
30	138.00	101.00	147.00	103.00	2

31	147.00	103.00	206.00	105.00	2
32	206.00	105.00	263.00	104.50	2
33	48.00	69.00	167.00	68.50	3
34	167.00	68.50	183.00	68.50	4
35	183.00	68.50	263.00	71.50	4
36	.00	62.00	48.00	62.00	4
37	48.00	62.00	167.00	68.50	4

3/9

#### ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	34.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	.0	1
4	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	9.00	70.00
2	75.50	77.00
3	178.00	80.00
4	263.00	82.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 10.00 ft. and X = 70.00 ft.

Each Surface Terminates Between X = 130.00 ft. and X = 160.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

1

5.00 ft. Line Segments Define Each Trial Failure Surface.

1/9

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -10.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 27 Coordinate Points

Point	X-Surf	Y-Surf			
No.	(ft)	(ft)			
1	22.11	72.20			
1	32.11	73.39			
2	37.00	72.55			
3	41.73	71.51			
	40.00	70.00			
5	56.96	70.42			
7	50.00	70.17			
/ 9	66 96	70.13			
0	71 94	70.20			
10	71.04	70.05			
10	91 76	71 03			
12	96 67	71.55			
13	91 53	72.00			
14	96 35	75 35			
15	101.11	76.88			
16	105.81	78.59			
17	110.44	80.49			
18	114.98	82.58			
19	119.44	84.84			
20	123.80	87.28			
21	128.07	89.89			
22	132.22	92.67			
23	136.26	95.62			
24	140.18	98.72			
25	143.98	101.98			
26	147.64	105.38			
27	148.19	105.94			
Circle	Center At X =	60.5 ; Y =	195.3	and Radius,	125.2
				•	
*	** 1.905	***			

Individual data on the 47 slices



### \*\* PCSTABL5M \*\*

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by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Run By:	DOKL
Input Data Filename:	SECTFE5.IN
Output Filename:	SECTFE5.OUT
Plotted Output Filename:	SECTFE5.PLT

PROBLEM DESCRIPTION ISRT: SECTION F-F, EXISTING SLOPE FILE S ECTFE5.IN

#### BOUNDARY COORDINATES

17	Тор	Boundaries
40	Total	Boundaries

Boundary	X-Left	Y-Left	X-Right	Y-Right	Soil Type
No.	(ft)	(ft)	(fť)	(fť)	Below Bnd
1	1.00	72.00	6.00	72.00	5
2	6.00	72.00	9.00	70.00	5
3	9.00	70.00	12.00	72.00	5
4	12.00	72.00	41.00	74.00	1
5	41.00	74.00	68.00	78.00	1
6	68.00	78.00	73.00	80.00	1
7	73.00	80.00	82.00	82.00	1
8	82.00	82.00	92.00	86.00	1
9	92.00	86.00	99.00	88.00	2
10	99.00	88.00	114.00	94.00	2
11	114.00	94.00	120.00	96.00	2
12	120.00	96.00	129.00	100.00	2
13	129.00	100.00	133.00	102.00	2
14	133.00	102.00	138.00	104.00	2
15	138.00	104.00	147.00	105.90	2
16	147.00	105.90	206.00	108.00	2
17	206.00	108.00	263.00	107.50	2
18	92.00	86.00	101.50	86.00	1
19	12.00	72.00	48.00	69.00	5
20	48.00	69.00	56.00	72.00	3
21	56.00	72.00	62.00	73.60	3
22	62.00	73.60	68.00	74.50	3
23	68.00	74.50	73.00	76.50	3
24	73.00	76.50	82.00	78.50	3
25	82.00	78.50	92.00	83.00	3
26	92.00	83.00	99.00	85.00	3
27	99.00	85.00	101.50	86.00	3
28	101.50	86.00	114.00	91.00	4
29	114.00	91.00	120.00	93.00	4
30	120.00	93.00	125.00	95.00	4

31	125.00	95.00	138.00	101.00	4
32	138.00	101.00	147.00	103.00	4
33	147.00	103.00	206.00	105.00	4
34	206.00	105.00	263.00	104.50	4
35	101.50	86.00	263.00	86.00	3
36	48.00	69.00	167.00	68.50	5
37	167.00	68.50	183.00	68.50	6
38	183.00	68.50	263.00	71.50	6
39	.00	62.00	48.00	62.00	6
40	48.00	62.00	167.00	68.50	6

19

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1

1

## ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Typ <b>e</b> No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	90.0	100.0	.0	25.0	.00	.0	2
3	100.0	125.0	.0	34.0	.00	.0	1
4	100.0	125.0	.0	34.0	.00	.0	2
5	120.0	120.0	.0	36.0	.00	.0	1
6	125.0	125.0	.0	37.0	.00	.0	1

2 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	9.00	70.00
3	178.00	80.00
4	263.00	82.00

Piezometric Surface No. 2 Specified by 2 Coordinate Points

Point	X-Water	Y-Water
No.	(ft)	(ft)
1	124.00	97.50
2	263.00	97.50

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified. 400 Trial Surfaces Have Been Generated.

. . . . . . . . . . . . . . . .

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 10.00 ft. and X = 70.00 ft.

.

Each Surface Terminates Between X = 130.00 ft. and X = 160.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -10.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 24 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	28.95	73.17
2	33.78	71.88
3	38.67	70.82
4 5	43.60 48.57	70.01 69.44
6	53.56	69.11
7	58.55	69.03
8	63.55	69.20
9	68.54	69.61
10	73.49	70.26
11	78.41	71.16
12	83.28	72.30
13	88.09	73 68
14	92.82	75.29
15	97.47	77.13
16 17 19	102.02 106.47	79.20 81.48 83 89
19	114.99	86.70
20	119.06	89.62
21	122.97	92.73
22	126.73	96.03
23 24	130.31	99.51 101.66

\*\*\* 1.911 \*\*\*

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Individual data on the 45 slices

			Water	Water	Tie	Tie	Eartho	quake	_
			Force	Force	Force	Force	Foi	rce Sui	rcharge
Slice	Width	Weight	Тор	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs(kg)							
1	2.9	124.4	.0	.0	.0	.0	.0	.0	.0
2	2.0	236.2	.0	46.2	.0	.0	.0	.0	.0
3	4.9	1095.2	.0	470.8	.0	.0	.0	.0	.0
4	2.3	752.3	.0	384.3	.0	.0	.0	.0	.0
5	2.6	1013.5	.0	536.6	.0	.0	.0	.0	.0
6	5.0	2455.4	.0	1297.2	.0	.0	.0	.0	.0
7	.5	288.9	.0	152.0	.0	.0	.0	.0	.0
8	4.5	2868.1	.0	1446.7	.0	.0	.0	.0	.0
9	2.4	1817.5	.0	868.7	.0	.0	.0	.0	.0
10	2.6	2055.1	.0	956.0	.0	.0	.0	.0	.0
11	3.4	2973.1	.0	1349.4	.0	.0	.0	.0	.0
12	1.6	1401.4	. 0	625.3	.0	.0	.0	.0	.0
13	4.4	4141.9	. 0	1826.5	.0	. 0	.0	. 0	. 0
14	5	512 9		221 7		.0	.0		
16	.5	A627 A	.0	19/3 0	.0	.0		.0	.0
16		511 7	.0	201 2	.0	.0	.0	.0	.0
10	.5	1705 4	.0	625 2	.0	.0	.0	.0	.0
Τĺ	T+0	E20 7	.0	101 4	.0	.0	.0	.0	.0
		229.7	.0	1124 2	.0	.0	.0	.0	.0
20	2.9	3250.8	.0	1134.2	.0	.0	.0	.0	.0
20	3.0	3968.8	.0	12//.3	.0	.0	.0	.0	.0
21	1.3	1410.2	.0	414.5	.0	.0	.0	.0	.0
22	4.8	5398.0	.0	1343.9	.0	.0	.0	.0	.0
23	3.9	4436.2	.0	795.0	.0	.0	.0	.0	.0
24	.8	923.8	605.7	126.8	.0	.0	.0	.0	.0
25	4.6	5030.8	3198.4	426.4	.0	.0	.0	.0	.0
26	1.2	1244.2	767.7	21.4	.0	.0	.0	.0	.0
27	.3	323.0	198.2	.0	.0	.0	.0	.0	.0
28	2.5	2514.7	1512.2	.0	.0	.0	.0	.0	.0
29	.5	524.1	294.1	.0	.0	.0	.0	.0	.0
30	4.4	4460.1	2211.7	.0	.0	.0	.0	.0	.0
31	4.3	4254.3	1642.7	.0	.0	.0	.0	.0	.0
32	3.1	2938.2	870.7	.0	.0	.0	.0	.0	.0
33	.1	82.8	21.3	76.8	.0	.0	.0	.0	.0
34	1.0	893.5	218.1	821.7	.0	.0	.0	.0	.0
35	4.1	3172.7	665.6	2914.4	.0	.0	.0	.0	.0
36	.9	619.5	102.9	565.0	.0	.0	.0	.0	.0
37	3.0	1669.5	170.3	1408.9	.0	.0	.0	.0	.0
38	1.0	480.7	.0	369.7	.0	.0	.0	.0	.0
39	1.0	405.7	.0	284.6	.0	.0	.0	.0	.0
40	1.2	398.0	.0	239.4	.0	.0	.0	.0	.0
41	.6	165.0	.0	79.9	.0	.0	.0	.0	.0
42	1.5	360.4	.0	96.8	.0	.0	.0	.0	.0
43	.8	134.2	.0	.0	.0	.0	.0	.0	.0
44	1.3	172.0	.0	.0	.0	.0	.0	.0	.0
45	2.0	103.6	.0	.0	. 0	_ 0	.0	.0	. 0
	2.0	20010							
1									
		Y		A	X I	S		F 5	Г

9/9

Section F-F' - Existing Conditions Non-Circular - Long-Term Water Table

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SECT F-F LONG TEAM G.W.T. (NON-CIRCULAR SURFACE) EXISTING CONDITION: F.S. = 2.3 (SECTFE2.IN) EHP



by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTFE2.IN
Output Filename:	SECTFE2.OUT
Plotted Output Filename:	SECTFE2.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	F-F,	EXISTING	SLOPE	FILE	S
		ECTFE	2.IN					

## BOUNDARY COORDINATES

16	Top	Boundaries
37	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	1.00	72.00	6.00	72.00	3
2	6.00	72.00	9.00	70.00	3
3	9.00	70.00	12.00	72.00	3
4	12.00	72.00	41.00	74.00	1
5	41.00	74.00	68.00	78.00	1
6	68.00	78.00	73.00	80.00	1
7	73.00	80.00	82.00	82.00	1
8	82.00	82.00	92.00	86.00	1
9	92.00	86.00	99.00	88.00	1
10	99.00	88.00	114.00	94.00	1
11	114.00	94.00	120.00	96.00	1
12	120.00	96.00	129.00	100.00	1
13	129.00	100.00	133.00	102.00	1
14	133.00	102.00	138.00	104.00	1
15	138.00	104.00	147.00	105.90	1
16	147.00	105.90	206.00	108.00	1
17	206.00	108.00	263.00	107.50	1
18	12.00	72.00	48.00	69.00	3
19	48.00	69.00	56.00	72.00	2
20	56.00	72.00	62.00	73.60	2
21	62.00	73.60	68.00	74.50	2
22	68.00	74.50	73.00	76.50	2
23	73.00	76.50	82.00	78.50	2
24	82.00	78.50	92.00	83.00	2
25	92.00	83.00	99.00	85.00	2
26	99.00	85.00	114.00	91.00	2
27	114.00	91.00	120.00	93.00	2
28	120.00	93.00	125.00	95.00	2
29	125.00	95.00	138.00	101.00	2
30	138.00	101.00	147.00	103.00	2

					3	1:3
31	147.00	103.00	206.00	105.00	2	1
32	206.00	105.00	263.00	104.50	2	
33	48.00	69.00	167.00	68.50	3	
34	167.00	68.50	183.00	68.50	4	
35	183.00	68.50	263.00	71.50	4	
36	.00	62.00	48.00	62.00	4	
37	48.00	62.00	167.00	68.50	4	

# ISOTROPIC SOIL PARAMETERS

# 4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angl <b>e</b> (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	34.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	• 0	1
4	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

X-Water (ft)	Y-Water (ft)	
9.00	70.00	
75.50	77.00	
178.00	80.00	
263.00	82.00	
	X-Water (ft) 9.00 75.50 178.00 263.00	

Trial Failure Surface Specified By 3 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	41.00	74.00
2	120.00	80.00
3	147.00	105.90
Spencer's	FOS	FOS
Theta	(Moment)	(Force)
(deg)	(Equil.)	(Equil.)
7.50	2.624	2.139
11.25	2.571	2.190
29.78	1.661	2.476
19.13	2.376	2.302

1

1

16.76	2.451	2.267
22.06	2.257	2.347
19.73	2.354	2.311
19.96	2.346	2.315
20.74	2.315	2.327
20.52	2.323	2.323

Factor Of Safety For The Preceding Specified Surface = 2.323 Spencer's Theta = 20.52 -1/3

Factor Of Safety Is Calculated By Spencer's Method of Slices

Slice No.	X Coord.	Y Coord.	L/H	Side Force (lbs)			
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	62.55 68.00 72.79 73.00 75.03 75.50 82.00 83.63 92.00 99.00 114.00 120.00 125.00 129.00 133.00 138.00 143.07 147.00	78.85 79.47 79.96 79.93 79.76 79.75 80.23 80.41 81.47 82.50 84.94 85.91 89.82 93.03 96.17 100.02 103.73 288.81	2.067 1.756 1.013 .979 .822 .797 .637 .586 .443 .427 .373 .369 .374 .386 .388 .408 .543 .000	207. 320. 468. 484. 639. 677. 1297. 1487. 2798. 4255. 8529. 10706. 7342. 5085. 3220. 1411. 313. 0.			
	Y	A	x	I S	F	т	
	.00	32.88	65.75	98.63	131.50	164.38	
x	.00 + - - - - -	+	*+ * **		+	+	
	32.88 + - - -		: * * *	•			
A	- 65.75 + - - -		* * * *	** ** V **			
x	- - 98.63 +	- - ** 8.63 + **					

\*\*\* Line of Thrust \*\*\*
		-		
		-		
		-		**
		-	S	**
		-		*
I	131.50	+		**
		-		**
		-		
		-		**
		-		
		-		
S	164.38	+	*	
-		-		
		-	W	
		-	*	
		-		
		-		
	197.25	+		
		-		
		-		**
		-		
		-		
		-		
ਸ	230.13	+		
•	230.13	-		
		-		
		-		
		-		
		-		
ጥ	263 00	+	* W	**
-	203.00		·· /	

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6/13

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--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTFE3.IN
Output Filename:	SECTFE3.OUT
Plotted Output Filename:	SECTFE3.PLT

PROBLEM DESCRIPTION ISRT: SECTION F-F, EXISTING SLOPE FILE S ECTFE3.IN

# BOUNDARY COORDINATES

16	Тор	Boundaries
37	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
	(/	()	(/	<b>v v</b>	
1	1.00	72.00	6.00	72.00	3
2	6.00	72.00	9.00	70.00	3
3	9.00	70.00	12.00	72.00	3
4	12.00	72.00	41.00	74.00	1
5	41.00	74.00	68.00	78.00	1
6	68.00	78.00	73.00	80.00	1
7	73.00	80.00	82.00	82.00	1
8	82.00	82.00	92.00	86.00	1
9	92.00	86.00	99.00	88.00	1
10	99.00	88.00	114.00	94.00	1
11	114.00	94.00	120.00	96.00	1
12	120.00	96.00	129.00	100.00	1
13	129.00	100.00	133.00	102.00	1
14	133.00	102.00	138.00	104.00	1
15	138.00	104.00	147.00	105.90	1
16	147.00	105.90	206.00	108.00	1
17	206.00	108.00	263.00	107.50	1
18	12.00	72.00	48.00	69.00	3
19	48.00	69.00	56.00	72.00	2
20	56.00	72.00	62.00	73.60	2
21	62.00	73.60	68.00	74.50	2
22	68.00	74.50	73.00	76.50	2
23	73.00	76.50	82.00	78.50	2
24	82.00	78.50	92.00	83.00	2
25	92.00	83.00	99.00	85.00	2
26	99.00	85.00	114.00	91.00	2
27	114.00	91.00	120.00	93.00	2
28	120.00	93.00	125.00	95.00	2
29	125.00	95.00	138.00	101.00	2
30	138.00	101.00	147.00	103.00	2

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31	147.00	103.00	206.00	105.00	2	,
32	206.00	105.00	263.00	104.50	2	
33	48.00	69.00	167.00	68.50	3	
34	167.00	68.50	183.00	68.50	4	
35	183.00	68.50	263.00	71.50	4	
36	.00	62.00	48.00	62.00	4	
37	48.00	62.00	167.00	68.50	4	

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# ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Typ <b>e</b> No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	34.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	.0	1
4	125.0	125.0	.0	37.0	.00	.0	1

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1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	9.00	70.00
2	75.50	77.00
3	178.00	80.00
4	263.00	82.00

Trial Failure Surface Specified By 3 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	41.00	74.00
2	120.00	85.00
3	157.00	106.26
Spenc <b>er`s</b>	FOS	FOS
Theta	(Moment)	(Force)
(deg)	(Equil.)	(Equil.)
10.00	2.286	1.981
15.00	2.184	2.003
24.81	1.480	2.049
18.16	2.075	2.017

16.77	2.129	2.011
20.42	1.957	2.027
18.61	2.055	2.019
18.82	2.045	2.020
19.46	2.013	2.023
19.28	2.022	2.022

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Factor Of Safety For The Preceding Specified Surface = 2.022 Spencer's Theta = 19.28

Factor Of Safety Is Calculated By Spencer's Method of Slices

Slice No.	X Coord.	Y Coord.	L/H	Side Force (lbs)		
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	68.00 73.00 82.00 85.89 92.00 99.00 114.00 120.00 125.00 129.00 133.00 138.00 147.00 151.60 157.00	80.60 80.40 81.55 82.23 82.77 84.05 87.14 88.36 90.80 92.77 94.77 97.38 102.13 104.30 809.53	11.815 1.259 .803 .598 .340 .333 .305 .283 .264 .241 .235 .301 .394 .000	28. 67. 217. 312. 799. 1552. 3944. 5222. 4185. 3403. 2655. 1776. 560. 208. 0.		
	Y	A	x	I S	F	Т
	.00	32.88	65.75	98.63	131.50	164.38
x	.00 + - - 32.88 +	+	*+-*- * **	+		+
			* * * *			
A	65.75 + - - -		* * W	* * *		
x	- - 98.63 + -			** **		
	-			**		

\*\*\* Line of Thrust \*\*\*



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# by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTFE4.IN
Output Filename:	SECTFE4.OUT
Plotted Output Filename:	SECTFE4.PLT

PROBLEM DESCRIPTION ISRT: SECTION F-F, EXISTING SLOPE FILE S ECTFE3.IN

# BOUNDARY COORDINATES

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16	Тор	Boundaries
37	Total	Boundaries

Boundary	X-Left	Y-Left	X-Right	Y-Right	Soil Type
No.	(ft)	(ft)	(fť)	(fť)	Below Bnd
1	1.00	72.00	6.00	72.00	3
2	6.00	72.00	9.00	70.00	3
3	9.00	70.00	12.00	72.00	3
4	12.00	72.00	41.00	74.00	ĩ
5	41.00	74.00	68.00	78.00	ĩ
6	68.00	78.00	73.00	80.00	ĩ
7	73.00	80.00	82.00	82.00	ī
8	82.00	82.00	92.00	86.00	ī
9	92.00	86.00	99.00	88.00	1
10	99.00	88.00	114.00	94.00	1
11	114.00	94.00	120.00	96.00	1
12	120.00	96.00	129.00	100.00	1
13	129.00	100.00	133.00	102.00	1
14	133.00	102.00	138.00	104.00	1
15	138.00	104.00	147.00	105.90	1
16	147.00	105.90	206.00	108.00	1
17	206.00	108.00	263.00	107.50	1
18	12.00	72.00	48.00	69.00	3
19	48.00	69.00	56.00	72.00	2
20	56.00	72.00	62.00	73.60	2
21	62.00	73.60	68.00	74.50	2
22	68.00	74.50	73.00	76.50	2
23	73.00	76.50	82.00	78.50	2
24	82.00	78.50	92.00	83.00	2
25	92.00	83.00	99.00	85.00	2
26	99.00	85.00	114.00	91.00	2
27	114.00	91.00	120.00	93.00	2
28	120.00	93.00	125.00	95.00	2
29	125.00	95.00	138.00	101.00	2
30	138.00	101.00	147.00	103.00	2

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31	147.00	103.00	206.00	105.00	2	
32	206.00	105.00	263.00	104.50	2	
33	48.00	69.00	167.00	68.50	3	
34	167.00	68.50	183.00	68.50	4	
35	183.00	68.50	263.00	71.50	4	
36	.00	62.00	48.00	62.00	4	·
37	48.00	62.00	167.00	68.50	4	

# ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	34.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	.0	1
4	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)		
1	9.00	70.00		
2	75.50	77.00		
3	178.00	80.00		
4	263.00	82.00		

Trial Failure Surface Specified By 3 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	73.00	80.00
2	120.00	85.00
3	147.00	105.90
Spencer <b>`s</b>	FOS	FOS
Th <b>eta</b>	(Moment)	(Force)
(deg)	(Equil.)	(Equil.)
10.00	2.337	1.952
15.00	2.255	1.993
29.16	1.237	2.128
19.29	2.134	2.031

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17.36	2.196	2.014
23.26	1.941	2.068
20.04	2.105	2.038
20.46	2.088	2.042
21.68	2.031	2.053
21.16	2.056	2.048
21.31	2.049	2.049

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Factor Of Safety For The Preceding Specified Surface = 2.049 Spencer's Theta = 21.31

Factor Of Safety Is Calculated By Spencer's Method of Slices

#### Slice Side Force Х Y No. Coord. Coord. L/H (lbs) 82.23 83.28 82.00 1 1.224 56. 89.15 .497 2 235. 3 92.00 83.41 .349 469. .363 1229. 4 99.00 84.67 5 114.00 87.75 .352 3929. 6 88.91 120.00 .355 5444. 7 125.00 92.14 3795. .350 8 94.75 .346 129.00 2675. 9 133.00 97.43 .342 1717. 10 138.00 100.91 .389 766. 11 141.74 103.41 .535 306. 12 147.00 364.78 .000 0. Y A Х Ι S F т .00 32.88 65.75 98.63 131.50 164.38 Х .00 +------\*-\_\_\_\_ ------+ -----\* \*\* 32.88 + Α 65.75 + Х 98.63 + \*\* S \*\*

\*\*\* Line of Thrust \*\*\*

Section E-E' - Existing Conditions Circular - Long-Term Water Table



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### \*\* PCSTABL5M \*\*

214

by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/8/92
Time of Run:	DAW
Run By:	DOKL CEOTEEL IN
Output Filename:	SECTEEL.IN
Dicted Output Filename.	SECTEEI.OUI
FIOLLed Output FITename.	SECTEDI.FDI

PROBLEM	DESCRIPTION	ISRT:	SECTION	E-Ε,	EXISTING	SLOPE	FILE	S
		ECTEE:	L.IN					

### BOUNDARY COORDINATES

13	Тор	Boundaries
34	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd	
1	25.00	70.50	66.00	72.00	3	
2	66.00	72.00	68.00	73.00	3	
3	68.00	73.00	69.00	74.00	1	
4	69.00	74.00	80.00	76.00	1	
5	80.00	76.00	92.00	78.00	1	
6	92.00	78.00	101.00	80.00	1	
7	101.00	80.00	114.00	86.00	1	
8	114.00	86.00	121.00	90.00	1	
9	121.00	90.00	145.00	98.00	1	
10	145.00	98.00	150.00	100.00	1	
11	150.00	100.00	170.00	104.00	1	
12	170.00	104.00	211.00	106.00	1	
13	211.00	106.00	325.00	108.00	1	
14	68.00	73.00	80.00	75.00	3	
15	80.00	75.00	90.00	75.20	2	
16	90.00	75.20	101.00	77.50	2	
17	101.00	77.50	114.00	83.50	2	
18	114.00	83.50	121.00	87.50	2	
19	121.00	87.50	150.00	97.00	2	
20	150.00	97.00	170.00	101.00	2	
21	170.00	101.00	211.00	103.00	2	
22	211.00	103.00	325.00	105.00	2	
23	80.00	75.00	120.00	73.00	3	
24	120.00	73.00	160.00	70.00	3	
25	160.00	70.00	188.00	68.50	3	
26	188.00	68.50	222.00	68.00	3	
27	222.00	68.00	325.00	68.30	3	
28	25.00	65.50	40.00	66.00	4	
29	40.00	66.00	70.00	66.00	4	
30	70.00	66.00	110.00	65.00	4	

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31	110.00	65.00	170.00	62.00	4	- 1 1
32	170.00	62.00	223.00	60.30	4	
33	223.00	60.30	267.00	60.00	4	
34	267.00	60.00	325.00	61.50	4	

#### ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

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Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	34.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	.0	1
4	125.0	125.0	• 0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 8 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	25.00	70.20
2	66.00	71.80
3	93.00	74.50
4	120.00	76.00
5	152.00	80.00
6	170.00	81.00
7	260.00	81.00
8	325.00	81.60

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 65.00 ft. and X = 110.00 ft.

Each Surface Terminates Between X = 150.00 ft. and X = 210.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

4/4

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -15.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 19 Coordinate Points

Point	t X-Surf	Y-Surf			
No.	(ft)	(ft)			
1	72.11	74.56			
2	76.91	73.17			
3	81.79	72.11			
4	86.75	71.41			
5	91.73	71.07			
6	96.73	71.08			
7	101.72	71.44			
8	106.67	72.16			
9	111.55	73.24			
10	116.35	74.65			
11	121.03	76.41			
12	125.57	78.49			
13	129.96	80.90			
14	134.16	83.61			
15	138.16	86.61			
16	141.93	89.89			
17	145.46	93.43			
18	148.73	97.21			
19	150.95	100.19			
Circle	Center At X =	94.1 ; Y =	141.1	and Radius,	70.1

\*\*\* 2.110 \*\*\*

Individual data on the 32 slices

			Water	Water	_Tie	_Tie	Earth	quake	
Slice	Width	Weight	Force Top	Force Bot	Force Norm	rorce Tan	Fo: Hor	rce Su: Ver	rcharge Load
No.	Ft(m)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(ky,
1	1.9	78.7	.0	.0	.0	.0	.0	.0	.0
2	2.9	468.7	.0	.0	.0	.0	.0	.0	.0
3	.9	231.7	.0	.0	.0	.0	.0	.0	.0
4	2.2	748.7	.0	49.2	.0	.0	.0	.0	.0

Sections P-P' and V-V' - Existing Conditions Circular - Long-Term Water Table

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# \*\* PCSTABL5M \*\*

218

by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/8/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTPE1.IN
Output Filename:	SECTPE1.OUT
Plotted Output Filename:	SECTPE1.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	P-P,	EXISTING	SLOPE	FILE	S
		ECTPE:	l.IN	-				

### BOUNDARY COORDINATES

15	Тор	Boundaries
27	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	12.00	71.00	38.00	72.00	3
2	38.00	72.00	43.00	74.00	3
3	43.00	74.00	45.00	74.50	2
4	45.00	74.50	55.00	76.00	1
5	55.00	76.00	70.00	76.00	1
6	70.00	76.00	81.00	78.00	1
7	81.00	78.00	83.00	80.00	1
8	83.00	80.00	91.00	84.00	1
9	91.00	84.00	93.00	86.00	1
10	93.00	86.00	102.50	90.00	1
11	102.50	90.00	110.00	94.00	1
12	110.00	94.00	125.50	100.00	1
13	125.50	100.00	134.50	102.00	1
14	134.50	102.00	159.00	104.00	1
15	159.00	104.00	210.00	104.00	1
16	45.00	74.50	81.00	75.00	2
17	81.00	75.00	83.00	77.00	2
18	83.00	77.00	96.00	83.00	2
19	96.00	83.00	99.00	85.00	2
20	99.00	85.00	128.00	97.20	2
21	128.00	97.20	159.00	101.00	2
22	159.00	101.00	210.00	101.00	2
23	43.00	74.00	140.00	70.00	3
24	140.00	70.00	210.00	70.00	3
25	12.00	66.20	42.50	67.50	4
26	42.50	67.50	149.00	60.20	4
27	149.00	60.20	210.00	60.20	4

4 Type(s) of Soil

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Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	31.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	.0	1
4	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 5 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)		
1	12.00	72.00		
2	26.00	72.00		
3	149.00	79.20		
4	158.50	80.00		
5	210.00	80.00		

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 60.00 ft. and X = 100.00 ft.

Each Surface Terminates Between X = 120.00 ft. and X = 170.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -15.0 deg. Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

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Failure Surface Specified By 14 Coordinate Points

Point	t X-Surf	Y-Surf			
No.	(ft)	(ft)			
1	66.32	76.00			
2	71.12	74.60			
3	76.04	73.75			
4	81.04	73.47			
5	86.03	73.74			
6	90.96	74.58			
7	95.76	75.97			
8	100.38	77.89			
9	104.75	80.32			
10	108.82	83.22			
11	112.53	86.57			
12	115.85	90.31			
13	118.72	94.40			
14	120.78	98.17			
Circle	Center At X =	81.1 ; Y =	117.7	and Radius,	44.2

\*\*\* 1.502 \*\*\*

Individual data on the 28 slices

			Water Force	Water Force	Tie Force	Tie Force	Eartho For	quake rce Sui	rcharge
Slice	Width	Weight	Top	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs (kq)	Lbs(kq)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)
1	3.7	177.8	.0	.Ō	.0	.0	.0	.0	.0
2	.3	26.8	.0	.0	.0	.0	.0	.0	.0
3	.7	92.6	.0	.0	.0	.0	.0	.0	.0
4	.1	16.1	.0	.1	.0	.0	.0	.0	.0
5	4.9	1206.8	.0	189.1	.0	.0	.0	.0	.0
6	.0	13.4	.0	2.9	.0	.0	.0	.0	.0
7	4.9	1983.3	.0	449.6	.0	.0	.0	.0	.0
8	.0	16.8	. 0	4.0	.0	.0	.0	.0	.0
9	.2	94.3	.0	21.6	.0	.0	.0	.0	.0
10	1.8	1012.2	.0	193.8	.0	.0	.0	.0	.0
11	3.0	2190.4	.0	333.7	.0	.0	.0	.0	.0
12	4.9	4257.3	.0	466.0	.0	.0	.0	.0	.0
13	. 0	39.5	.0	3.3	.0	.0	.0	.0	.0
14	2.0	1995.7	.0	127.3	.0	.0	.0	.0	
15	2 8	2951.1	.0	77.5	.0	.0	.0	.0	
16	2.0	257.3	.0	1.2	.0	.0	.0	.0	.0
17		89.5	.0		.0	.0	.0	.0	.0
10	2 0	3154.6	.0	.0	.0	.0	.0	.0	.0
19	1.4	1496.7	.0	.0	.0	.0	.0	.0	.0



### \*\* PCSTABL5M \*\*

by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/8/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTVE2.IN
Output Filename:	SECTVE2.OUT
Plotted Output Filename:	SECTVE2.PLT

PROBLEM	DESCRIPTION	ISRT: SECTIO	N V-V,	EXISTING	SLOPE	FILE	S
		ECTVE2.IN					

#### BOUNDARY COORDINATES

13	TOT	Boundaries
23	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	69.00	73.30	84.50	74.00	3
2	84.50	74.00	87.50	76.00	2
3	87.50	76.00	91.00	77.50	2
4	91.00	77.50	99.00	80.00	2
5	99.00	80.00	105.50	83.00	2
6	105.50	83.00	117.50	86.00	2
7	117.50	86.00	175.00	90.00	1
8	175.00	90.00	189.00	92.00	1
9	189.00	92.00	207.00	97.00	1
10	207.00	97.00	226.00	104.00	ī
11	226.00	104.00	229.00	105.00	ī
12	229.00	105.00	283.00	108.00	ī
13	283.00	108.00	336.00	108.00	ī
14	117.50	86.00	181.00	88.00	2
15	181.00	88.00	207.00	94.00	2
16	207.00	94.00	229.00	102.00	2
17	229.00	102.00	245.00	104.00	2
18	245.00	104.00	280.00	105.00	2
19	280.00	105.00	336.00	105.00	2
20	84.50	74.00	112.50	69.00	3
21	112.50	69.00	152.50	68.00	3
22	152.50	68.00	222.50	68.00	3
23	222.50	68.00	336.00	70.00	3

#### ISOTROPIC SOIL PARAMETERS

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	90.0	100.0	.0	25.0	.00	.0	1
2	100.0	125.0	.0	28.0	.00	.0	1
3	120.0	120.0	.0	36.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

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Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)		
1	69.00	71.50		
2	125.00	78.00		
3	291.00	82.00		
4	336.00	82.00		

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 160.00 ft. and X = 200.00 ft.

Each Surface Terminates Between X = 220.00 ft. and X = 260.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -10.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Point X-Surf Y-Surf No. (ft) (ft) 1 197.90 94.47 2 200.81 93.76 3 93.37 203.78 4567 206.78 93.29 209.77 93.55 212.72 94.12 215.58 95.00 8 218.34 96.19 9 220.95 97.67 99.43 10 223.38 101.43 11 225.61 103.66 12 227.62 104.82 13 228.45 Circle Center At X = 205.9; Y = 121.1 and Radius, 27.8

Failure Surface Specified By 13 Coordinate Points

\*\*\* 1.755 \*\*\*

Individual data on the 16 slices

			Water	Water	Tie	Tie	Earth	quake	
			Force	Force	Force	Force	For	rce Su	rcharge
Slice	Width	Weight	Тор	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs(kg)							
1	2.9	199.5	.Õ	.0	.0	.0	.0	.0	.0
2	3.0	570.5	.0	.0	.0	.0	.0	.0	.0
3	. 4	106.5	.0	.0	.0	.0	.0	.0	.0
4	2.6	764.0	.0	.0	.0	.0	.0	.0	.0
5	.2	73.1	.0	.0	.0	.0	.0	.0	.0
6	2.8	1048.2	.0	.0	.0	.0	.0	.0	.0
7	2.9	1304.4	.0	.0	.0	.0	.0	.0	.0
8	2.9	1366.8	.0	.0	.0	• 0	.0	•0	.0
9	2.8	1312.2	.0	.0	.0	.0	.0	.0	.0
10	2.6	1152.6	.0	.0	.0	.0	.0	.0	.0
11	2.4	908.1	.0	.0	.0	.0	.0	.0	.0
12	1.0	301.6	.0	.0	.0	.0	.0	.0	.0
13	1.2	307.3	.0	.0	.0	.0	·• 0	.0	.0
14	.4	79.3	.0	.0	.0	.0	.0	.0	.0
15	1.6	219.5	.0	.0	.0	.0	.0	.0	.0
16	.8	32.6	.0	.0	.0	.0	.0	.0	.0

Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	197.90	94.47
2	200.82	93.78
3	203.80	93.53

3/8

APPENDIX 12-C Remediated Slope Stability Calculations Section F-F' - Remediated Condition Circular - Long-Term Water Table Unit Weights of Fill and Hide Residue = 115 and 125 pcf Unit Weight of Fill and Hide Residue = 125 pcf

EHP SECTION F-F LONG TEAM G.W.T. (CIRCULAR SURFACE) REMEDIATED CONDITION: F.S. = 2.3 (SECTF1.IN)



# by Purdue University

# --Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTF1.IN
Output Filename:	SECTF1.OUT
Plotted Output Filename:	SECTF1.PLT

PROBLEM DESCRIPTION ISRT: SECTION F-F, REMEDIATED SLOPE FILE SECTF1.IN

#### BOUNDARY COORDINATES

1

- - - -

11	Тор	Boundaries
54	Total	Boundaries

Boundary	X-Left	Y-Left	X-Right	Y-Right	Soil Type
No.	(ft)	(ft)	(fť)	(fť)	Below Bnd
1	1.00	72.00	6.00	72.00	5
2	6.00	72.00	9.00	70.00	5
3	9.00	70.00	12.00	72.00	5
4	12.00	72.00	24.00	76.00	1
5	24.00	76.00	47.00	80.00	1
6	47.00	80.00	62.00	84.00	1
7	62.00	84.00	100.00	96.00	1
8	100.00	96.00	137.00	108.00	1
9	137.00	108.00	157.00	110.00	1
10	157.00	110.00	195.00	112.00	1
11	195.00	112.00	263.00	114.30	1
12	12.00	72.00	22.00	72.50	3
13	22.00	72.50	24.00	73.00	2
14	24.00	73.00	47.00	77.00	2
15	47.00	77.00	62.00	81.00	2
16	62.00	81.00	100.00	93.00	2
17	100.00	93.00	137.00	105.00	2
18	137.00	105.00	157.00	107.00	2
19	157.00	107.00	195.00	109.00	2
20	195.00	109.00	263.00	111.00	2
21	22.00	72.50	41.00	74.00	3
22	41.00	74.00	68.00	78.00	3
23	68.00	78.00	73.00	80.00	3
24	73.00	80.00	82.00	82.00	3
25	82.00	82.00	92.00	86.00	3
26	92.00	86.00	99.00	88.00	3
27	99.00	88.00	114.00	94.00	3
28	114.00	94.00	120.00	96.00	3
29	120.00	96.00	129.00	100.00	3
30	129.00	100.00	133.00	102.00	3

3	104.00	138.00	102.00	133.00	31
3	105.90	147.00	104.00	138.00	32
3	108.00	206.00	105.90	147.00	33
3	107.50	263.00	108.00	206.00	34
5	69.00	48.00	72.00	12.00	35
4	72.00	56.00	69.00	48.00	36
4	73.60	62.00	72.00	56.00	37
4	74.50	68.00	73.60	62.00	38
4	76.50	73.00	74.50	68.00	39
4	78.50	82.00	76.50	73.00	40
4	83.00	92.00	78.50	82.00	41
4	85.00	99.00	83.00	92.00	42
4	91.00	114.00	85.00	99.00	43
4	93.00	120.00	91.00	114.00	44
4	95.00	125.00	93.00	120.00	45
4	101.00	138.00	95.00	125.00	46
4	103.00	147.00	101.00	138.00	47
4	105.00	206.00	103.00	147.00	48
4	104.50	263.00	105.00	206.00	49
5	68.50	167.00	69.00	48.00	50
6	68.50	183.00	68.50	167.00	51
6	71.50	263.00	68.50	183.00	52
6	62.00	48.00	62.00	.00	53
6	68.50	167.00	62.00	48.00	54

3/5

# ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	.0	.0	.00	.0	1
2	125.0	125.0	.0	33.0	.00	.0	1
3	90.0	100.0	.0	25.0	.00	.0	1
4	100.0	125.0	.0	34.0	.00	.0	1
5	120.0	120.0	.0	36.0	.00	.0	1
6	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	9.00	70.00
2	75.50	77.00
3	178.00	80.00
4	263.00	82.00

1

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1

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A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

.....

1

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 10.00 ft. and X = 70.00 ft.

Each Surface Terminates Between X = 130.00 ft. and X = 160.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -20.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	22.63	75.54
2	27.32	73.81
3	32.10	72.32
4	36.94	71.08
5	41.84	70.08
6	46.78	69.32
7	51.75	68.82
8	56.75	68.57
9	61.75	68.57
10	66.74	68.83
11	71.72	69.33
12	76.66	70.09
13	81.56	71.09
14	86.40	72.34
15	91.17	73.84
16	95.86	75.57
17	100.46	77.54
18	104.95	79.73
19	109.32	82.15
20	113.57	84.79
21	117.68	87.64

22	121.64	90.69			
23	125.44	93.94			
24	129.07	97.38			
25	132.52	100.99			
26	135.79	104.78			
27	138.41	108.14			
Circle Ce	enter At X =	59.2 ; Y =	167.6	and Radius,	99.0

515

\*\*\* 2.316 \*\*\*

Individual data on the 55 slices

			Water	Water	Tie	Tie	Eartho	quake	
			Force	Force	Force	Force	Foi	rce Sui	ccharge
Slice	Width	Weight	Тор	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs(kg)							
1	1.4	78.8	.0	.0	.0	.0	.0	.0	.0
2	3.3	742.5	.0	.0	.0	.0	.0	.0	.0
3	.5	168.4	.0	.0	.0	.0	.0	.0	.0
4	1.8	746.2	.0	.0	.0	.0	.0	.0	.0
5	2.2	1164.1	.0	.0	.0	.0	.0	.0	.0
6	.3	148.5	.0	.9	.0	.0	.0	.0	.0
7	4.8	3381.0	.0	305.7	.0	.0	.0	.0	.0
8	4.1	3620.2	.0	641.4	.0	.0	.0	.0	.0
9	.8	827.9	.0	172.3	.0	.0	.0	.0	.0
10	4.9	5369.9	.0	1246.6	.0	.0	.0	.0	.0
ר י	.2	257.8	.0	64.2	.0	.0	.0	.0	.0
	1.4	1704.5	.0	428.8	.0	.0	.0	.0	.0
т3	1.6	2085.2	.0	528.0	.0	.0	.0	.0	.0
14	1.7	2299.7	.0	582.3	.0	.0	.0	.0	.0
15	4.2	6342.7	.0	1585.5	.0	.0	.0	.0	.0
16	.7	1200.4	.0	297.5	.0	.0	.0	.0	.0
17	5.0	8548.2	.0	2084.9	.0	.0	.0	.0	.0
18	.3	454.0	.0	109.3	.0	.0	.0	.0	.0
19	4.7	8938.1	.0	2099.0	.0	.0	.0	.0	.0
20	.9	1792.7	.0	410.7	.0	.0	.0	.0	.0
21	. 4	698.9	.0	158.8	.0	.0	.0	.0	.0
22	3.7	7585.1	.0	1683.8	.0	.0	.0	.0	.0
23	1.3	2691.8	.0	583.6	.0	.0	.0	.0	.0
24	2.0	4307.6	.0	910.4	.0	.0	.0	.0	.0
25	.5	1021.3	.0	211.8	.0	.0	.0	.0	.0
26	1.2	2507.3	.0	513.1	.0	.0	.0	.0	.0
27	4.9	10752.2	• 0	2032.1	.0	.0	.0	• 0	.0
28	. 4	983.5	.0	172.4	.0	.0	.0	.0	.0
29	4.4	9740.0	.0	1552.5	.0	.0	.0	• 0	• 0
30	4.8	10456.2	.0	1340.8	.0	.0	.0	.0	.0
31	.8	1798.2	.0	192.3	.0	.0	.0	.0	.0
32	3.9	8232.7	.0	688.7	• 0	.0	.0	.0	.0
33	3.1	6518.6	.0	298.5	.0	.0	• 0	.0	.0
34	1.0	2032.0	.0	39.1	.0	.0	.0	.0	.0
35	.5	919.8	.0	8.8	.0	.0	.0	.0	.0
36	. 4	848.2	.0	2.9	.0	.0	.0	.0	.0
37	4.1	7975.0	.0	.0	.0	.0	.0	.0	.0
38	4.4	8175.5	.0	.0	.0	.0	.0	.0	.0
20	4.2	7421.7	.0	.0	.0	.0	.0	.0	.0
	. 4	718.2	.0	.0	.0	.0	.0	.0	.0
<b>41</b>	3.7	5869.5	.0	.0	.0	.0	.0	.0	.0
42	2.3	3423.0	.0	.0	.0	.0	.0	.0	.0
43	1.6	2267.1	.0	.0	.0	.0	.0	.0	.0
44	3.4	4198.1	.0	.0	.0	.0	.0	.0	.0

Unit Weight of Fill and Hide Residue = 115 pcf

EHP SECTION F-F LONG TEAM G.W.T. (CIRCULAR SURFACE) - REMEDIATED CONDITION: F.S. = 2.3 (SECTF2.IN)



# by Purdue University

# --Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/11/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTF2.IN
Output Filename:	SECTF2.OUT
Plotted Output Filename:	SECTF2.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	F-F,	REMEDIATED	SLOPE	FILE
		SECT	F2.IN				

# BOUNDARY COORDINATES

1

11	Top	Boundaries
54	Total	Boundaries

Boundary	X-Left	Y-Left	X-Right	Y-Right	Soil Type
No.	(ft)	(ft)	(fť)	(fť)	Below Bnd
1	1.00	72.00	6.00	72.00	5
2	6.00	72.00	9.00	70.00	5
3	9.00	70.00	12.00	72.00	5
4	12.00	72.00	24.00	76.00	1
5	24.00	76.00	47.00	80.00	1
6	47.00	80.00	62.00	84.00	1
7	62.00	84.00	100.00	96.00	1
8	100.00	96.00	137.00	108.00	1
9	137.00	108.00	157.00	110.00	1
10	157.00	110.00	195.00	112.00	1
11	195.00	112.00	263.00	114.30	1
12	12.00	72.00	22.00	72.50	3
13	22.00	72.50	24.00	73.00	2
14	24.00	73.00	47.00	77.00	2
15	47.00	77.00	62.00	81.00	2
16	62.00	81.00	100.00	93.00	2
17	100.00	93.00	137.00	105.00	2
18	137.00	105.00	157.00	107.00	2
19	157.00	107.00	195.00	109.00	2
20	195.00	109.00	263.00	111.00	2
21	22.00	72.50	41.00	74.00	3
22	41.00	74.00	68.00	78.00	3
23	68.00	78.00	73.00	80.00	3
24	73.00	80.00	82.00	82.00	3
25	82.00	82.00	92.00	86.00	3
26	92.00	86.00	99.00	88.00	3
27	99.00	88.00	114.00	94.00	3
28	114.00	94.00	120.00	96.00	3
29	120.00	96.00	129.00	100.00	3
30	129.00	100.00	133.00	102.00	3

31	133.00	102.00	138.00	104.00	3
32	138.00	104.00	147.00	105.90	3
33	147.00	105.90	206.00	108.00	3
34	206.00	108.00	263.00	107.50	3
35	12.00	72.00	48.00	69.00	5
36	48.00	69.00	56.00	72.00	4
37	56.00	72.00	62.00	73.60	4
38	62.00	73.60	68.00	74.50	4
39	68.00	74.50	73.00	76.50	4
40	73.00	76.50	82.00	78.50	4
41	82.00	78.50	92.00	83.00	4
42	92.00	83.00	99.00	85.00	4
43	99.00	85.00	114.00	91.00	4
44	114.00	91.00	120.00	93.00	4
45	120.00	93.00	125.00	95.00	4
46	125.00	95.00	138.00	101.00	4
47	138.00	101.00	147.00	103.00	4
48	147.00	103.00	206.00	105.00	4
49	206.00	105.00	263.00	104.50	4
50	48.00	69.00	167.00	68.50	5
51	167.00	68.50	183.00	68.50	6
52	183.00	68.50	263.00	71.50	6
53	.00	62.00	48.00	62.00	6
54	48.00	62.00	167.00	68.50	6

3/5

# ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	.0	.0	.00	.0	1
2	125.0	125.0	.0	33.0	.00	.0	1
3	90.0	100.0	.0	25.0	.00	.0	1
4	92.0	115.0	.0	34.0	.00	.0	1
5	120.0	120.0	.0	36.0	.00	.0	1
6	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	9.00	70.00
2	75.50	77.00
3	178.00	80.00
4	263.00	82.00

1

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

4/5

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 10.00 ft. and X = 70.00 ft.

Each Surface Terminates Between X = 130.00 ft. and X = 160.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -20.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 27 Coordinate Points

Point	X-Surf	Y-Surf				
No.	(ft)	(ft)				
1	22.63	75.54				
2	27.32	73.81				
3	32.10	72.32				
4	36.94	71.08				
5	41.84	70.08				
6	46.78	69.32				
7	51.75	68.82				
8	56.75	68.57				
9	61.75	68.57				
10	66.74	68.83				
11	71.72	69.33				
12	76.66	70.09				
13	81.56	71.09				
14	86.40	72.34				
15	91.17	73.84				
16	95.86	75.57				
17	100.46	77.54				
18	104.95	79.73				
19	109.32	82.15				
20	113.57	84.79				
21	117.68	87.64				
-	Circle Ce	nter At X =	59.2 ; Y =	167.6	and Radius,	99.0
---	-----------	-------------	------------	-------	-------------	------
	27	138.41	108.14			
	26	135.79	104.78			
	25	132.52	100.99			
	24	129.07	97.38			
	23	125.44	93.94			
	22	121.64	90.69			

5/5

\*\*\* 2.316 \*\*\*

Individual data on the 55 slices

			Water	Water	Tie	Tie	Earth	quake	
			Force	Force	Force	Force	Foi	rce Su	rcharge
Slice	Width	Weight	Тор	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs(kg)							
1	1.4	78.8	.0	.0	.0	.0	.0	.0	.0
2	3.3	742.5	.0	.0	.0	.0	.0	.0	.0
3	.5	168.4	.0	.0	.0	.0	.0	.0	.0
4	1.8	746.2	.0	.0	.0	.0	.0	.0	.0
5	2.2	1164.1	.0	.0	.0	.0	.0	.0	.0
6	.3	148.5	.0	.9	.0	.0	.0	.0	.0
7	4.8	3381.0	.0	305.7	.0	.0	.0	.0	.0
8	4.1	3620.2	.0	641.4	.0	.0	.0	.0	.0
9	.8	827.9	.0	172.3	.0	.0	.0	.0	.0
10	4.9	5369.9	.0	1246.6	.0	.0	.0	.0	.0
11	.2	257.8	.0	64.2	.0	.0	.0	.0	.0
	1.4	1704.5	.0	428.8	.0	.0	.0	.0	.0
~~	1.6	2078.8	.0	528.0	.0	.0	.0	.0	.0
14	1.7	2281.0	.0	582.3	.0	• 0	.0	.0	.0
15	4.2	6248.1	.0	1585.5	.0	• 0	.0	.0	.0
16	.7	1176.9	.0	297.5	.0	.0	.0	.0	.0
17	5.0	8352.5	.0	2084.9	.0	• 0	.0	.0	.0
18	.3	442.4	.0	109.3	.0	.0	.0	.0	.0
19	4.7	8699.9	.0	2099.0	.0	.0	.0	.0	.0
20	.9	1743.1	.0	410.7	.0	.0	.0	.0	.0
21	. 4	679.4	.0	158.8	.0	.0	.0	.0	.0
22	3.7	7358.4	.0	1683.8	.0	.0	.0	.0	.0
23	1.3	2604.4	.0	583.6	.0	.0	.0	.0	.0
24	2.0	4165.0	.0	910.4	.0	.0	.0	.0	.0
25	.5	987.5	.0	211.8	.0	.0	.0	.0	.0
26	1.2	2424.5	.0	513.1	.0	.0	.0	.0	.0
27	4.9	10403.7	.0	2032.1	.0	.0	.0	.0	.0
28	. 4	952.2	.0	172.4	.0	.0	.0	.0	.0
29	4.4	9420.4	.0	1552.5	.0	.0	.0	.0	.0
30	4.8	10092.1	.0	1340.8	.0	.0	.0	.0	.0
31	.8	1733.8	.0	192.3	.0	.0	.0	.0	.0
32	3.9	7943.5	.0	688.7	.0	.0	.0	.0	.0
33	3.1	6301.0	.0	298.5	.0	.0	.0	.0	.0
34	1.0	1966.3	.0	39.1	.0	.0	.0	.0	.0
35	• 5	890.1	.0	8.8	.0	.0	.0	.0	.0
36	. 4	820.9	.0	2.9	.0	.0	.0	.0	.0
37	4.1	7720.3	.0	.0	.0	.0	.0	.0	.0
38	4.4	7919.6	.0	.0	.0	.0	.0	.0	.0
39	4.2	7200.6	.0	.0	.0	.0	.0	.0	.0
	.4	697.7	.0	.0	.0	.0	.0	.0	.0
~ +	3.7	5715.1	.0	.0	.0	.0	.0	.0	.0
42	2.3	3347.3	.0	.0	.0	.0	.0	.0	.0
43	1.6	2224.3	.0	• 0	.0	.0	.0	.0	.0
44	3.4	4139.0	.0	.0	.0	.0	.0	.0	.0

Section P-P' - Remediated Conditions Circular - Long-Term Water Table Unit Weights of Fill and Hide Residue = 115 and 125 pcf Unit Weight of Fill and Hide Residue = 125 pcf



. 14

## \*\* PCSTABL5M \*\*

by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/7/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTP1.IN
Output Filename:	SECTP1.OUT
Plotted Output Filename:	SECTP1.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	P-P,	REMEDIATED	SLOPE	FILE

# BOUNDARY COORDINATES

1

6	Тор	Boundaries
38	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	12.00	69.50	15.40	71.20	5
2	15.40	71.20	17.00	72.00	1
3	17.00	72.00	55.00	80.00	1
4	55.00	80.00	127.00	104.00	1
5	127.00	104.00	147.50	108.00	1
6	147.50	108.00	210.00	108.00	1
7	15.40	71.20	27.50	71.50	5
8	27.50	71.50	55.00	77.00	2
9	55.00	77.00	127.00	101.00	2
10	127.00	101.00	147.50	105.00	2
11	147.50	105.00	210.00	105.00	2
12	27.50	71.50	38.00	72.00	5
13	38.00	72.00	43.00	74.00	5
14	43.00	74.00	45.00	74.50	4
15	45.00	74.50	55.00	76.00	3
16	55.00	76.00	70.00	76.00	3
17	70.00	76.00	81.00	78.00	3
18	81.00	78.00	83.00	80.00	3
19	83.00	80.00	91.00	84.00	3
20	91.00	84.00	93.00	86.00	3
21	93.00	86.00	102.50	90.00	3
22	102.50	90.00	110.00	94.00	3
23	110.00	94.00	125.50	100.00	3
24	125.50	100.00	134.50	102.00	3
25	134.50	102.00	159.00	104.00	3
26	159.00	104.00	210.00	104.00	3
27	45.00	74.50	81.00	75.00	4
28	81.00	75.00	83.00	77.00	4
29	83.00	77.00	96.00	83.00	4
30	96.00	83.00	99.00	85.00	4

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31	99.00	85.00	128.00	97.20	4
32	128.00	97.20	159.00	101.00	4
33	159.00	101.00	210.00	101.00	4
34	43.00	74.00	140.00	70.00	5
35	140.00	70.00	210.00	70.00	5
36	12.00	66.20	42.50	67.50	6
37	42.50	67.50	149.00	60.20	6
38	149.00	60.20	210.00	60.20	6

## ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

L

L

1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	.0	.0	.00	.0	1
2	125.0	125.0	.0	33.0	.00	.0	1
3	90.0	100.0	.0	25.0	.00	.0	1
4	100.0	125.0	.0	31.0	.00	.0	1
5	120.0	120.0	.0	36.0	.00	.0	1
6	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 5 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	12.00	72.00
2	26.00	72.00
3	149.00	79.20
4	158.50	80.00
5	210.00	80.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 50.00 ft. and X = 60.00 ft.

Each Surface Terminates Between X = 150.00 ft. and X = 170.00 ft. Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -10.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 23 Coordinate Points

1

Point No.	X-Surf (ft)	Y-Surf (ft)		
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	51.58 56.48 61.42 66.39 71.39 76.39 81.38 86.36 91.32 96.25 101.12 105.94 115.36 119.94 124.42 128.79 133.05 137.17 141.16	79.28 78.29 77.53 77.00 76.71 76.65 76.83 77.24 77.89 78.77 79.88 81.22 82.78 84.56 86.57 88.78 91.21 93.84 96.66 99.68		
22 23	148.69	106.25		
Circle Cer	nter At X =	75.1 ; Y =	182.9 and Radius	, 106.3
***	2.189	***		
Indiv	vidual data c	on the 42	slices	

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Water Water Tie Tie

Earthquake

Unit Weight of Fill and Hide Residue = 115 pcf



1/4

## \*\* PCSTABL5M \*\*

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by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date: Time of Run:	5/7/92
Run By:	DOKL
Input Data Filename:	SECTP2.IN
Output Filename:	SECTP2.OUT
Plotted Output Filename:	SECTP2.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	P-P,	REMEDIATED	SLOPE	FILE
		-					

# BOUNDARY COORDINATES

L

6	Тор	Boundaries
38	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	12.00	69.50	15.40	71.20	5
2	15.40	71.20	17.00	72.00	1
3	17.00	72.00	55.00	80.00	1
4	55.00	80.00	127.00	104.00	1
5	127.00	104.00	147.50	108.00	1
6	147.50	108.00	210.00	108.00	1
7	15.40	71.20	27.50	71.50	5
8	27.50	71.50	55.00	77.00	2
9	55.00	77.00	127.00	101.00	2
10	127.00	101.00	147.50	105.00	2
11	147.50	105.00	210.00	105.00	2
12	27.50	71.50	38.00	72.00	5
13	38.00	72.00	43.00	74.00	5
14	43.00	74.00	45.00	74.50	4
15	45.00	74.50	55.00	76.00	3
16	55.00	76.00	70.00	76.00	3
17	70.00	76.00	81.00	78.00	3
18	81.00	78.00	83.00	80.00	3
19	83.00	80.00	91.00	84.00	3
20	91.00	84.00	93.00	86.00	3
21	93.00	86.00	102.50	90.00	3
22	102.50	90.00	110.00	94.00	3
23	110.00	94.00	125.50	100.00	3
24	125.50	100.00	134.50	102.00	3
25	134.50	102.00	159.00	104.00	3
26	159.00	104.00	210.00	104.00	3
27	45.00	74.50	81.00	75.00	4
28	81.00	75.00	83.00	77.00	4
29	83.00	77.00	96.00	83.00	4
30	96.00	83.00	99.00	85.00	4

31	99.00	85.00	128.00	97.20	4
32	128.00	97.20	159.00	101.00	4
33	159.00	101.00	210.00	101.00	4
34	43.00	74.00	140.00	70.00	5
35	140.00	70.00	210.00	70.00	5
36	12.00	66.20	42.50	67.50	6
37	42.50	67.50	149.00	60.20	6
38	149.00	60.20	210.00	60.20	6

#### ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

L

1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	.0	.0	.00	.0	1
2	125.0	125.0	.0	33.0	.00	.0	1
3	90.0	100.0	.0	25.0	.00	.0	1
4	92.0	115.0	.0	31.0	.00	.0	1
5	120.0	120.0	.0	36.0	.00	.0	1
6	125.0	125.0	.0	37.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 5 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	12.00	72.00
2	26.00	72.00
3	149.00	79.20
4	158.50	80.00
5	210.00	80.00

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 50.00 ft. and X = 60.00 ft.

Each Surface Terminates Between X = 150.00 ft. and X = 170.00 ft.

4/4

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -10.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

Failure Surface Specified By 23 Coordinate Points

No. (ft) (ft) 1 51.58 79.28 2 56.48 78.29 3 61.42 77.53 4 66.39 77.00 5 71.39 76.71 6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106	Point	t }	<-Surf	¥٠	-Surf					
<pre>1 51.58 79.28 2 56.48 78.29 3 61.42 77.53 4 66.39 77.00 5 71.39 76.71 6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106</pre>	No.		(ft)		(ft)					
<pre>1 51.58 79.28 2 56.48 78.29 3 61.42 77.53 4 66.39 77.00 5 71.39 76.71 6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106</pre>	-									
2 56.48 78.29 3 61.42 77.53 4 66.39 77.00 5 71.39 76.71 6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106	1		51.58		79.28					
3 $61.42$ 77.53 4 $66.39$ 77.00 5 71.39 76.71 6 76.39 76.65 7 $81.38$ 76.83 8 $86.36$ 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106	2		56.48		78.29					
<pre>4 66.39 77.00 5 71.39 76.71 6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 **** 2.206 ***</pre>	3		61.42	•	77.53					
5 71.39 76.71 6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	4		66.39	•	77.00					
6 76.39 76.65 7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	5		71.39	-	76.71					
7 81.38 76.83 8 86.36 77.24 9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	6		76.39	•	76.65					
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	7		81.38	•	76.83					
<pre>9 91.32 77.89 10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	8		86.36	•	77.24					
<pre>10 96.25 78.77 11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	9		91.32	•	77.89					
<pre>11 101.12 79.88 12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	10		96.25	•	78.77					
12 105.94 81.22 13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	11	1	101.12	•	79.88					
<pre>13 110.69 82.78 14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	12	1	105.94	1	81.22					
<pre>14 115.36 84.56 15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	13	1	110.69	1	82.78					
<pre>15 119.94 86.57 16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	14	1	115.36	1	84.56					
<pre>16 124.42 88.78 17 128.79 91.21 18 133.05 93.84 19 137.17 96.66 20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***</pre>	15	]	19.94	ł	86.57					
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	16	1	124.42	1	88.78					
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	17	1	28.79		91.21					
$\begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$	18	]	133.05		93.84					
20 141.16 99.68 21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	19	1	37.17		96.66					
21 145.00 102.88 22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	20	1	41.16		99.68					
22 148.69 106.25 23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	21	1	45.00	1	02.88					
23 150.43 108.00 Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	22	· 1	48.69	10	06.25					
Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106	23	1	50.43	1	08.00					
Circle Center At X = 75.1 ; Y = 182.9 and Radius, 106 *** 2.206 ***	25	-		<b>•</b> •						
*** 2.206 ***	Circle	Center	At X =	= 75.3	1 ; Y	Ξ	182.9	and	Radius,	106.3
	Ŀ	* * *	2.206	***						

Individual data on the 42 slices

Section V-V' - Remediated Conditions Circular - Long-Term Water Table Unit Weights of Fill and Hide Residue = 115 and 125 pcf Unit Weight of Fill and Hide Residue = 125 pcf



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: 14

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by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/8/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTV2.IN
Output Filename:	SECTV2.OUT
Plotted Output Filename:	SECTV2.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	<b>V−V</b> ,	REMEDIATED	SLOPE	FILE
		SECT	V2.IN				

# BOUNDARY COORDINATES

-

5	Тор	Boundaries
33	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	69.00	75.00	96.50	84.30	1
2	96,50	84.30	131.00	92.00	1
3	131.00	92.00	228.00	108.00	1
4	228.00	108.00	242.00	110.00	1
5	242.00	110.00	336.00	110.00	1
6	70.00	72.00	74.50	73.50	5
7	74.50	73.50	97.00	81.30	2
8	97.00	81.30	105.50	83.00	2
9	105.50	83.00	117.50	86.00	4
10	117.50	86.00	132.00	89.00	2
11	132.00	89.00	229.00	105.00	2
12	229.00	105.00	245.00	107.00	3
13	245.00	107.00	336.00	107.00	3
14	117.50	86.00	175.00	90.00	3
15	175.00	90.00	189.00	92.00	3
16	189.00	92.00	207.00	97.00	3
17	207.00	97.00	226.00	104.00	3
18	226.00	104.00	229.00	105.00	3
19	117.50	86.00	181.00	88.00	4
20	181.00	88.00	207.00	94.00	4
21	207.00	94.00	229.00	102.00	4
22	229.00	102.00	245.00	104.00	4
23	245.00	104.00	280.00	105.00	4
24	280.00	105.00	336.00	105.00	4
25	74.50	73.50	84.50	74.00	5
26	84.50	74.00	87.50	76.00	4
27	87.50	76.00	91.00	77.50	4
28	91.00	77.50	99.00	80.00	4
29	99.00	80.00	105.50	83.00	4
30	84.50	74.00	112.50	69.00	5

31	112.50	69.00	152.50	68.00	5
32	152.50	68.00	222.50	68.00	5
33	222.50	68.00	336.00	70.00	5

#### ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

1

1

-----

1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	.0	.0	.00	.0	1
2	125.0	125.0	.0	33.0	.00	.0	1
3	90.0	100.0	.0	25.0	.00	.0	1
4	100.0	125.0	.0	28.0	.00	.0	1
5	120.0	120.0	.0	36.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

X-Water	Y-Water			
(ft)	(ft)			
69.00	71.50			
125.00	78.00			
291.00	82.00			
336.00	82.00			
	X-Water (ft) 69.00 125.00 291.00 336.00			

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 70.00 ft. and X = 180.00 ft.

Each Surface Terminates Between X = 230.00 ft. and X = 260.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

3/4

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

4/4

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	70.00	75.34
2	79.81	73.39
3	89.70	71.93
4	99.65	70.94
5	109.64	70.44
6	119.64	70.43
7	129.63	70.90
8	139.58	71.85
9	149.48	73.29
10	159.30	75.20
11	169.01	77.59
12	178.59	80.45
13	188.02	83.77
14	197.28	87.54
15	206.35	91.75
16	215.20	96.40
17	223.82	101.48
18	232.18	106.97
19	234.97	109.00

Circle Center At X = 115.0; Y = 276.5 and Radius, 206.1

\*\*\* 2.804 \*\*\*

Individual data on the 44 slices

			Water	Water	Tie	Tie	Earth	quake	
			Force	Force	Force	Force	For	rce Su	rcharge
Slice	Width	Weight	Тор	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs(kg)	Lbs(k̄g)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)
1	6.2	1251.9	.0	.0	.0	.0	.0	.0	.0
2	2.1	978.7	.0	.0	.0	.0	.0	.0	• ^
3	1.5	881.8	.0	.0	.0	.0	.0	.0	•
4	2.4	1723.5	.0	.0	.0	.0	.0	.0	.0
5	2.3	1932.7	.0	42.6	.0	.0	.0	.0	.0
6	2.4	2301.0	.0	136.2	.0	.0	.0	.0	.0
7	.6	639.3	.0	51.0	.0	.0	.0	.0	.0
8	2.2	2427.0	.0	232.2	.0	.0	.0	.0	.0

Unit Weight of Fill and Hide Residue = 115 pcf



1/4

# \*\* PCSTABL5M \*\*

2/4

by Purdue University

--Slope Stability Analysis--Simplified Janbu, Simplified Bishop or Spencer's Method of Slices

Run Date:	5/8/92
Time of Run:	
Run By:	DOKL
Input Data Filename:	SECTV3.IN
Output Filename:	SECTV3.OUT
Plotted Output Filename:	SECTV3.PLT

PROBLEM	DESCRIPTION	ISRT:	SECTION	V-V,	REMEDIATED	SLOPE	FILE
		SECT	V3.IN	-			

# BOUNDARY COORDINATES

5	Тор	Boundaries
33	Total	Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	69.00	75.00	96.50	84.30	1
2	96.50	84.30	131.00	92.00	1
3	131.00	92.00	228.00	108.00	1
4	228.00	108.00	242.00	110.00	1
5	242.00	110.00	336.00	110.00	1
6	70.00	72.00	74.50	73.50	5
7	74.50	73.50	97.00	81.30	2
8	97.00	81.30	105.50	83.00	2
9	105.50	83.00	117.50	86.00	4
10	117.50	86.00	132.00	89.00	2
11	132.00	89.00	229.00	105.00	2
12	229.00	105.00	245.00	107.00	3
13	245.00	107.00	336.00	107.00	3
14	117.50	86.00	175.00	90.00	3
15	175.00	90.00	189.00	92.00	3
16	189.00	92.00	207.00	97.00	3
17	207.00	97.00	226.00	104.00	3
18	226.00	104.00	229.00	105.00	3
19	117.50	86.00	181.00	88.00	4
20	181.00	88.00	207.00	94.00	4
21	207.00	94.00	229.00	102.00	4
22	229.00	102.00	245.00	104.00	4
23	245.00	104.00	280.00	105.00	4
24	280.00	105.00	336.00	105.00	4
25	74.50	73.50	84.50	74.00	5
26	84.50	74.00	87.50	76.00	4
27	87.50	76.00	91.00	77.50	4
28	91.00	77.50	99.00	80.00	4
29	99.00	80.00	105.50	83.00	4
30	84.50	74.00	112.50	69.00	5

1

31	112.50	69.00	152.50	68.00	5
32	152.50	68.00	222.50	68.00	5
33	222.50	68.00	336.00	70.00	5

## ISOTROPIC SOIL PARAMETERS

5 Type(s) of Soil

1

1

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	120.0	.0	.0	.00	.0	1
2	125.0	125.0	.0	33.0	.00	.0	1
3	90.0	100.0	.0	25.0	.00	.0	1
4	92.0	115.0	.0	28.0	.00	.0	1
5	120.0	120.0	.0	36.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 4 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)		
1	69.00	71.50		
2	125.00	78.00		
3	291.00	82.00		
4	336.00	82.00		

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

400 Trial Surfaces Have Been Generated.

20 Surfaces Initiate From Each Of 20 Points Equally Spaced Along The Ground Surface Between X = 70.00 ft. and X = 180.00 ft.

Each Surface Terminates Between X = 230.00 ft. and X = 260.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

Restrictions Have Been Imposed Upon The Angle Of Initiation. The Angle Has Been Restricted Between The Angles Of -45.0 And -5.0 deg.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

\* \* Safety Factors Are Calculated By The Modified Bishop Method \* \*

4/4

Failure Surface Specified By 19 Coordinate Points

Point	X-Surf	Y-Surf
No.	(ft)	(ft)
1	70.00	75.34
2	79.81	73.39
3	89.70	71.93
4	99.65	70.94
5	109.64	70.44
6	119.64	70.43
7	129.63	70.90
8	139.58	71.85
9	149.48	73.29
10	159.30	75.20
11	169.01	77.59
12	178.59	80.45
13	188.02	83.77
14	197.28	87.54
15	206.35	91,75
16	215.20	96.40
17	223.82	101.48
18	232.18	106.97
19	234.97	109.00

Circle Center At X = 115.0; Y = 276.5 and Radius, 206.1

\*\*\* 2.756 \*\*\*

Individual data on the 44 slices

			Water	Water	Tie	Tie	Earth	quake	
			Force	Force	Force	Force	Foi	rce Su	rcharge
Slice	Width	Weight	Тор	Bot	Norm	Tan	Hor	Ver	Load
No.	Ft(m)	Lbs(kg)	Lbs(k͡g)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)	Lbs(kg)
1	Ġ.Ż	1251.9	.Ō	. Ō	.0	.0	.0	.0	.0
2	2.1	978.7	.0	.0	.0	.0	.0	.0	.0
3	1.5	881.8	.0	.0	.0	.0	.0	.0	• ^
4	2.4	1723.5	.0	.0	.0	.0	.0	.0	•
5	2.3	1932.7	.0	42.6	.0	.0	.0	.0	.0
6	2.4	2281.9	.0	136.2	.0	.0	.0	.0	.0
7	.6	627.9	.0	51.0	.0	.0	.0	.0	.0
8	2.2	2368.4	.0	232.2	.0	.0	.0	.0	.0

APPENDIX 12-D Soil Erosion Calculations

-

Golder	SUBJECT Soll Erosign	
Associates	Job No. 90 3-67 (210) Made by NLK Ret. JSRT/Woburn/Mass Reviewed MM	Date 12/12/11 Sheet 1 of 8
Objective ; estimat	e the amount of soil loss on	the steepest

slope section of the cover on the East Hide Pile

Method: calculate the average annual erosion using the

 $A = R \times K \times L 5 \times C \times P$ 

where A = aug, annual soil loss, tons/acre

R= rainfall and runoff crossivity index K= soil crodibility factor, tons/acre LS = slope /ength - sterphess factor C = cover management factor P = crosson control practice factor

Golder		il Erosicn		
Associates	JOB NO. 403-1 Ref. ISRT/hav	Checked V44 T	Date 12,12, Sheet 2	91 of 8 -1
Calculations: slope sequ	nents '			
1	10% 510pe	20 ft. long		
2	33°% 5)0pe	100 ft. long		

3 20% slope 20 fl. brg - assume also to have

33% Slope to simplify calls and to be conservative

therefore model as 2 equal segments each of 20 for cryin and add soil loss from remaining 100 foot segment at 33% slope

$$LS_{eff} = (0.87 \times 0.71 + 60 \times 1.29)/2 = 4.18$$
  
for the two equal contents  $A = R \times K \times LS \times C \times P$   
= 125 × 0.24 × 4.18 × 0.004 × 1.0 (masface (1))  
= 0.50 (tonsface/yr)  
for remaining 100 feet  $A = R \times K \times LS \times C \times P$   
= 125 × 0.24 × 9.67 × 0.004 × 1.0 (tonsface/yr)  
= 1.16 (tonsface/yr)

total A = (0.50 + 1.16) / compare for) = 1.66 (tonsperfy-) < 2(tonspace/yr) ... calculated soil (oss is less than permitted value stated in RDAP Not only is erosion objectionable in itself but erosion can degrade the cover and seriously reduce its effectiveness.

## Evaluate Erosion Potential

ne ver

Step 19

The USDA universal soil loss equation (USLE) is a convenient tool for use in evaluating erosion potential. The USLE predicts average annual soil loss as the product of six quantifiable factors. The equation is:

# A = R K L S C P

where A = average annual soil loss, in tons/acre

- R = rainfall and runoff erosivity index
- K = soil erodibility factor, tons/acre
- L = slope-length factor
- S = slope-steepness factor
- C = cover-management factor

P = practice factor

The data necessary as input to this equation are available to the evaluator in a figure and tables included below. Note that the evaluations in Step 8 on soil composition and Steps 25-32 on vegetation all impact on the evaluation of erosion also.

Factor R in the USLE can be calculated empirically from climatological data. For average annual soil loss determinations, however, R can be obtained directly from Figure 20. Factor K, the average soil loss for a given



Figure 20. Average annual values of rainfall-erosivity factor R.<sup>11</sup>

37

from reference I

soil in a unit plot, pinpoints differences in erosion according to differences in soil type. Long-term plot studies under natural rainfall have produced K values generalized in Table 5 for the USDA soil types.

	Organ	ic matter c	ontent
Texture class	<u>•0.5%</u>	2% V	<u> </u>
Sand Fine sand Very fine sand	0.05 .16 .42	0.03 .14 .36	0.02 .10 .28
Loamy sand Loamy fine sand Loamy very fine sand	.12 .24 .44	.10 .20 .38	.08 .16 .30
Sandy loam Fine sandy loam Very fine sandy loam	.27 .35 .47	.24 .30 .41	.19 .24 .33
Loam	• 38	. 34	.29
Silt loam	.48	.42	• 33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	• 37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13-0.29	

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES<sup>11</sup>

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

The evaluator must next consider the shape of the slope in terms of length and inclination. The appropriate LS factor is obtained from Table 6. A nonlinear slope may have to be evaluated as a series of segments, each with uniform gradient. Two or three segments should be sufficient for most engineered landfills, provided the segments are selected so that they are also of equal length (Table 6 can be used, with certain adjustments). Enter Table 6 with the total slope length and read LS values corresponding to the percent slope of each segment. For three segments, multiply the chart LS values for the upper, middle, and lower segments by 0.58, 1.06, and 1.37, respectively. The average of the three products is a good estimate of the

(7 £1						Slope leng	th (fect)					
% Slope	25	50	75	100	150	200	300	400	500	600	800	1000
0.5	0.07	0.08	0.09	0.10	011	012	0.14	0.15	0.16	0.17	0.19	0.20
1	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.20	0.21	0.22	0.24	0.26
2	0.13	0.16	0.19	0.20	0.23	0.25	0.28	0.31	0.33	0.34	0.38	0.40
3	0.19	0.23	0.26	0.29	0.33	0.35	0.40	0.44	0.47	0.49	0.54	0.57
4	0.23	0.30	0.36	0.40	0.47	0.53	0.62	0.70	0.76	0.82	0.92	1.0
5	0.27	0.38	0.46	0.54	0.66	0.76	0.93	1.1	1.2	1.3	1.5	1.7
6	0.34	0.48	0.58	0.67	0.82	0.95	1.2	1.4	1.5	1.7	1.9	2.1
8	0.50	0.70	0.86	0.99	1.2	1.4	1.7	2.0	2.2	2.4	2.8	3.1
10	0.69	0.97	1.2	1.4	1.7	1.9	2.4	2.7	3.1	3.4	3.9	4.3
12	0.90	1.3	1.6	1.8	2.2	2.6	3.1	3.6	4.0	4.4	5.1	5.7
14	1.2	1.6	2.0	2.3	2.8	3.3	4.0	4.6	5.1	5.6	6.5	7.3
16	1.4	2.0	2.5	2.8	3.5	4.0	4.9	5.7	6.4	7.0	8.0	9.0
18	1.7	2.4	3.0	3.4	4.2	4.9	6.0	6.9	7.7	8.4	9.7	11.0
20	2.0	2.9	3.5	4.1	5.0	5.8	7.1	8.2	9.1	10.0	12.0	13.0
25	3.0	4.2	5.1	5.9	7.2	8.3	10.0	12.0	13.0	14.0	17.0	19.0
30	4.0	5.6	6.9	8.0	9.7	11.0	14.0	16.0,	18.0	20.0	23.0	25.0
40	6.3	9.0	11.0	13.0	16.0	18.0	22.0	25.0	28.0	31.0	1	
50	8.9	13.0	15.0	18.0	22.0	25.0	31.0					
60	12.0	16.0	20.0	23.0	28.0							·
	L	L	L	L	l	L	L	L	l	1	1	L

TABLE 6. VALUES OF THE FACTOR LS FOR SPECIFIC COMBINATIONS OF SLOPE LENGTH AND STEEPNESS<sup>11</sup>

Values given for slopes longer than 300 feet or steeper than 18% are extrapolations beyond the range of the research data and, therefore, less certain than the others.

overall effective LS value. If two segments are sufficient, multiply by 0.71 and 1.29.

Factor C in the USLE is the ratio of soil loss from land cropped under specified conditions to that from clean-tilled, continuous fallow. Therefore, C combines effects of vegetation, crop sequence, management, and agricultural (as opposed to engineering) erosion-control practices. On landfills, freshly covered and without vegetation or special erosion-reducing procedures of cover placement, C will usually be about unity. Where there is vegetative cover or significant amounts of gravel, roots, or plant residues or where cultural practices increase infiltration and reduce runoff velocity, C is much less than unity. Estimate C by reference to Table 7 for anticipated cover management, but also consider changes that may take place in time. Meadow values are usually most appropriate. See Reference 1 for additional guidance.

Factor P in the USLE is similar to C except that it accounts for additional erosion-reducing effects of land management practices that are superimposed on the cultural practices, e.g., contouring, terracing, and contour strip-cropping. Approximate values of P, related only to slope steepness,

from reference 1

TABLE A1-3 VALUES OF THE TOPOGRAPHIC FACTOR "LS"

1	60.0	23 218 23 218 23 218	32 23 25	33 35 54 54 54 54 54 54 54 54 54 54 54 54 54	61 87 87 87	8
	50.0	81428	20 21 23 15	26 35 26 26 26	<b>6</b> 88869	2
	49.0	8852U	445555	288828	800 - 38 800 - 38 800 - 38	21
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	25.0	0.5.5.5 6.5.5 6.5	67778	12008	16 16 22 22	24 speculat
	20.0	2.68 3.06 4.26	8 8 9 7 7 8 8 8 9 9 7 9 8 8 9 9 7 8	5.5 6.0 10 10 10	122213	17 es are s
	18.0	2.2 2.2 3.0 3.5	6444 0.01.63.	8.0 5.0 8.0 8.0 8.0	9.2 10.3 11.3 12.2	14.0 estimat
	16.0	2.6 2.7 2.6 2.6 2.6 2.6 2.6 2.6 2.6 2.6 2.6 2.6		0.449 0.449 0.490	7.6 8.5 9.3 10.1	11.6 1 1055
	14.0	0.4.8 8.7.8 8.7.4	0.989.0 9.098.0 9.09.0		6.2 8.2 9.3 9.3	9.3 t. sof
	12.0	.8] .4 .1.2 .6 .1.6	02-5- 5-5-5-0 5-5-5-0	2.5 2.6 3.6 4.2	6.9 6.9 6.9	7.4 Percen
	10.0	1.0	5.9.9.7.8	2.1	5.2 2,5 2,5 2,5 2,5 2,5 2,5 2,5 2,5 2,5 2,	5.6 ds 24
ope (S	8.0	44 63 77 89 89 89	60 <u>0</u> 00	2.1.2	2.86.4.2.3	3.0 excer
ent S	6.0	30 52 67	71 77 80 82	. 85 . 90 . 95 . 1.2	2.0 2.0 2.0 2.0	2.2 f slope
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Revised April 1987

from reference 2

Universal Soil Loss Equation

6/8

# GENERALIZED VALUES OF FACTOR C FOR STATES EAST OF THE ROCKY MOUNTAINS<sup>11</sup> TABLE 7.

	Producti	vity level	
Crop, rotation, and management	High	Mod.	
	C	value	
Base value: continuous fallow, tilled up and down slope	1.00	1.00	
CORN			
C, RdR, fall TP, conv	0.54	0.62	
C, RdR, spring TP, conv	.50	.59	
C, RdL, fall TP, conv	.42	.52	
C, RdR, we seeding, spring TP, conv	.40	.49	
C, RdL, standing, spring TP, conv	.38	.48	
C-W-M-M, RdL, TP for C, disk for W	.039	.074	
C-W-M-M, RdL, TP for C, disk for W	.032	.061	
C, no-till pl in c-k sod, 95-80% rc	.017	.05	
COTTON			
Cot, conv (Western Plains)	0.42	0.49	
Cot. conv (South)	.34	.40	
MEADOW			
Grass & Logume mix	0.004	0.01	
Alfalfa, lespedeza or Sericia	.020		
Sweet clover	.025		
SORGHUM, GRAIN (Western Plains)			
RdL, spring TP, conv	0.43	0.53	
No-till p1 in shredded 70-50% rc	.11	.18	
D D I DEANS D DAI Anting TD CONV	0.44	0.54	
D, NUL, Spilly JF, CONV	43	0.54 KI	
C-D, Frannuary, Why R. no-till of		21	
o, no un pr C.B. no. till nl. fall ebred C etailee	18	20	
Co, norum pi, nan anneu C starks			
WHEAT	0.28		
W-F, fall 1 Patter W	0.38	1	
w-r, studdie muich, DUU los rc	.52		
w-r, stubble mulch, 1000 lbs rc	.21	1	
		1	

B - soybeans	F - fallow
C - corn	M - grass & legume hay
c-k - chemically killed	pl - plant
conv - conventional	W - wheat
cot - cotton	we - winter cover
lbs rc - pounds of crop residue per acre ren % rc - percentage of soil surface covered b	naining on surface after new crop seeding
70-50% rc - 70% cover for C values in first colu	mn; 50% for second column
RdR - residues (corn stover, straw, etc.) re	moved or burned

- residues (corn stover, straw, etc.) removed or burned

RdL - all residues left on field (on surface or incorporated)

TP - turn plowed (upper 5 or more inches of soil inverted, covering residues)

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from reference 1

7/8

are listed in Table 8. These values are based on rather limited field data, but P has a narrower range of possible values than the other five factors.

	-		Land slope (percer	nt)	
Practice	1.1-2	2.1-7	7.1-12	12.1-18	18.1-24
		·	(Factor P)	*	·
Contouring (P <sub>C</sub> )	0.60	0.50	0.60	0.80	0.90
Contour strip cropping (Psc)					
R-R-M-M	0.30	0.25	0.30	0.40	0.45
R-W-M-M	0.30	0.25	0.30	0.40	0.45
R-R-W-M	0.45	0.38	0.45	0.60	0.68
R-W	0.52	0.44	0.52	0.70	0.90
R-O	0.60	0.50	0.60	0.80	0.90
Contour listing or ridge planting					
(P <sub>c1</sub> )	0.30	0.25	0.30	0.40	0.45
Contour terracing $(P_t)^2$	<sup>3</sup> 0.6/√n	0.5/√n	0.6/√n	0.8/√n	0.9/√n
No support practice	1.0	1.0	1.0	1.0	1.0

TABLE 8. VALUES OF FACTOR P<sup>11</sup>

<sup>1</sup> R = rowcrop, W = full-seeded grain, O = spring-seeded grain, M = meadow. The crops are grown in rotation and so arranged on the field that rowcrop strips are always separated by a meadow or winter-grain strip.

<sup>2</sup> These  $P_t$  values estimate the amount of soil eroded to the terrace channels and are used for conservation planning. For prediction of off-field sediment, the  $P_t$  values are multiplied by 0.2.

 $^{3}$  n = number of approximately equal-length intervals into which the field slope is divided by the terraces. Tillage operations must be parallel to the terraces.

Example: An owner/operator proposes to close one section of his small landfill with a sandy clay subsoil cover having the surface configuration shown in Figure 21. The factor R has been established as 200 for this locality. The evaluator questions anticipated erosion along the steep side and assigns the following values to the other factors in the USLE after inspecting Tables 5 through 8:

K = 0.14 LS = 8.3 C = 1.00 P = 0.90

The rate of erosion for the steep slope of the landfill is calculated as follows:

A = 200 (0.14 tons/acre) (8.3) (1.00) (0.90)= 209 tons/acre

This erosion not only exceeds a limit recommended by the permitting authority but also indicates a potential

from reference ]

APPENDIX 12-E Settlement Calculations

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**One-Dimensional Calculations** 

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# Golder Associates

SUBJECT THE MAN	2. DE SETTLEMENT	or billion Plan
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DE ITLEMENT, OF HIDE PILES
OBJECTIVE ESTIMATE SETTLEMENTSAND MAXIMUM DIFFERENTAL
DRAINAGE GRADIENTS.
Assumptions:
A PORTAL CELE D HI RELATINELY FRAM CELEINF MALL
2 MALEADH STRESS ANORENENT THEOLIGHANT SUCCESS
MAJERIALS: AND FILL AND HIDE RESIDUE
(VALID FOR WIDE LOAD)
CALCULADOUS
= 35 ft Security Fickness of Fill # Hide Recipule   Security E-E'
2. MAXIMUM RATE OF CHIANGE OF THICKNESS FIG. 6.2
S. MAXIMUM PHICKNESS OF SUFFICIEN MILTERS
= 4 ft
LOADING!
BACKFILL (max) = 3Ft x 125pcf = 375 psf
735 hef
$\beta \in Thement - AB = C \in H/(1+e) (loc - D = 1)$
$\int SETTLEMENT - \Delta S = \int C H/(1+C_s) \left( \log \frac{P_0 T M_s}{P_s} \right)$
UHERE C = compression index p = Derpurchen. province
JETTLEMENT - AB = (= H/(1+e)) (log p) UHERE C = compression index p = Juerbuilden pro line C = initial upid ratio Ag = stress incremente
$\frac{3}{4} = \frac{3}{4} = \frac{3}$

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CASE 1 - MAX HEGHT OF HURET CASE 1 - MAX HEGHT OF HURET CHILDE ABOUEWAND D.3 22	REILUR - 3= 1.5 200 73: 1.1 175 735	<u>AA</u> (9 0.54 0,47	
CASE 1 - MAX HEGHT OF HIDET CASE 1 - MAX HEGHT OF HIDET CHIEREN SUCFICIAL 0.5- 4. FILLEHIDE (ABOUEWT) 0.3 22 FILLEHIDE (ABOUEWT) 0.3 13	A HE 1775 psf HE 1775 psf HE 1775 735 1.1 1775 735 1.1 3560 735	<u>AA</u> (9 0.54 0.47 <u>0.15</u>	
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# Golder Associates

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Schmertmann Method

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<b>)</b>	Surficial Maria	0,35	ا ا ا	5.4	78.4	196
೭	ST-1	0.38	9	5.8	52	129
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4	57-2	<b>اک</b> رز	7	6.2	73.7	107.5
5	ST-2	0,51	10	6.2	62	155
is a	FILL # HIDEResidue	0.38	12	5.8	70	174
7	Full Hide Residue	0.38	10	5,8	58	175
8	Fill & HideResidue	0.22	19	7.8	912	228

\* Robertson & CAMPANELLA (1984) + Schmertmonn (1978)

CALCULATE IZD according to Schmermann (1978)  $I_{2p} = 0.5 + 0.1 \left(\frac{Ap}{J_{2p}}\right)^{1/2}$ DP = Vouer x tover + Vfill x thin = 120 pcf (3ft), + (125 pcf) (3ft) - 735 psf J' @ B/2 Assume axisymmetric B= 325 ft (augualue of kength & width of crest of EHP) B/2- 162.5 fl

Golder Associates	SUBJECT <u>SETTLEME</u> Job No. 763-0400 Ref.	Made by J.C. Checked VELT Reviewed MELL	EHP) Dete ///7/9/ Sheet - of 16
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$\frac{5}{20}^{\prime} = 10$	0(2,5 <sup>-</sup> )+ (125 <sup>-</sup> )(23, <u>-</u> (120-62.4) (9) + (17	5)+(125-62.4)(7.5) 25-62.4)(8)+(150	+ -62.4)(112.5)
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BOREHOLE # 12



LAYER	50	2c	Ε	DOPTH TO CELTER	I,	$\left(\frac{T_{2}}{2}\right)$ 02
1	6	78.4	196	3	0.11	0.0034
2	5.5	52	129	8.75	0,125	0.0053
3	5 Í	56	140	14	0,14	0,005
#	4.5	-13.4	108.5	18.75	0.15	0.006Z
5	5.5	62	155	23.75	0.165	0.0058
6	5-	70	174	29	0,18	0.0032
7	5.5	58	145	34.25	0 . 19 5	0.0074
8	1,3	91.Z	228	36.7	0,2	0.0011
					ZI (I)AZ	0.0394

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BOREHOLE #12

 $S_d = C_i C_2 \Delta p \mathcal{Z}(\frac{T_1}{E}) \Delta z_i$ 

Schmertmann (1970)

C,= 1.0 - 0,5 (00/10) 10,5

CI IS AN EMBEDDMENT CORRECTION FACTOR. IT IS CONSERVATIVE TO TAKE CI = 1

 $C_{2} = 1 + 0.2 \log(\frac{t}{a_{1}})$ t= 30 years =  $1 + 0.2 \log(\frac{30}{31})$ = 1.5

Ap= 735 pg

Sd= (1)(1.5) (735 - 200 ) (0,0394) = 0.0217ft = 0.26 in

						<b></b>		E: 696,263				ENETRA		RIETANC		1
DEPTH & FEET	BORING METHOD	DESCRIPTION	Lecs	GRAPHIC LOG	ELEV DEPTH	NUMBER	TYPE	BLOWS / B in	N	RECIATT	10 2 W/ 10 2	X0 30 4	NTENT, I	PERCENT	NG 80	PIEZOMETER OR STANOPIPE INSTALLATION
0	•	9.0-2.5 ft. Compact, moderate to dusky brown, I-SAND, some sit, few roots, possible hairs, (SM). FiLL	8.4		108.10	` 1	80	2,5,9,5	14	70	-					
5		2.5-36.9 ft. Compact, black with occasional light-gray patches, m-I SAND, little to some silt to clayey silt, hair and hair clumps, few micas, occasional clumps of root mass, (SM to SP-SM). F&L AND HIDE RESIDUE			2.50	\$T-1	TO	SHELBY TUBE		<b>90</b>						
	•	Sample saturated at 30.5 ft. Water level at approximately 26.0 ft. after hole stood for 2 days.				*	00	4,8,4,4	•	80						
10						15 9		A330	10	100						
		• •														
15						\• `) •	∞	2,3,4,4	7	100						
5						ST-5	то	SHELBY TUBE		100 1						
~						\$ 5	80	6,3,5,5	10	80	•					
25																
							00	27,5.7,7	12	25	•					
30						,	00	2,4,6,8	10	100	-					
35																
		OUTWASH SAND	4_		71.20	<b>[</b> •	80	7,8,11,21	18	75						
		AUGER REFUSAL AT 37.3 FT. BELOW GROUND SURFACE.			37.30											

cause the encountered conditions were core reads, and as changes in material types d brition test. A total of 65 test data points wi lions. A summary of the field measurement form	The correlation between q, and N was may sume 12-in. (30-cm) length as the N values w	6 in. (15 cm) to the 18 in. (38 cm) penetratio	The data resulting from this work was exp sus the mean grain diameter and was americ	and data points (solid circles) by Robertson an	in Fig. 1. The data points from this work a	and triangles for the hydraulic and natural a indeand by a in ka/cm <sup>2</sup> (see Tables ) and 2)	Examination of the relationship in Fig. 1 sh	ertson and Campanella (3) curve represents a	letter agrace and a source around the areas ou could indicate either that correlation relation	because of inherent variabilities in both type	of some other soil property that is not comp	graum channeder. The envire duck book in Table in the state the second book and the second book and the second sec	I ugare use possible dependence of the 9,/N of The results were incructative.	Another plot was developed to evaluate t	4./N on the fines content. For that purpose,		10 - 1 autr cur - 1115 (1444 mm							=	•	\$ 					0.00 0.00 0.01 ( 0.01 0.01 0.01 0.01 0.0		FIG. 1Variation of c./N with line
				•													•																
Manya or e tents. It for other a for the and typt-	ation be-		-{·		2	<b>.</b> .		1	2 X	∎		5 18	£ 9	7	Б		BR	1 A 1	<b>7</b> a	51	<del>۲</del> ج		21	8 8	3			9			)] ]]		
as cley lumps or asing the tests. It a made for other tage fines for the utural sand typi-	e correlation be-		2		51 5			3		X7 III		5 <b>k</b> 7 st	5 S	K F	5					21			2   R		z;	2	20 E 10	6.7 6					
es each as chy lumps or re performing the tests. It d studies made for other e percentage fines for the cas the satural sand typi-	ed in the correlation be- m		2 6	() Tes Lamba 5			() Test London 6			41(1) 31(2) 100						() The London ()				5 7 7		() Test Learner 9			2		20 4.2						
imparities such as circly humps of wed before performing the tests. It study and studies made for other ci site, the percentage faces for the 10, whereas the natural sand typi-	et included in the correlation be-			() Tel Lantes 5	2		()) Test Lorentza 6									(f) The Landson (						(h) Tara Lamina 9	R			1974 IN 1974	N 11 NG				مد قدم الارتخاص المراجعة المراجعة مراجعة المراجعة المرا	the at least for anythe to be used and from, and a or formed of all	
Labe 1. Impendes such as cay ample of ere removed before performing the tests. It ofh this study and studies made for other her project site, the percentage faces for the by about 10, whereas the satural send typi- mitmi.	s were not included in the correlation be- s 2 Reministra Data						10 () Test London 6									() The lamins (						() Turk (accurate 9					N N N N	41,114 162 163 163 16	الله من الله الله الله الله الله الله الله الل		فه استعدد عمل قدد دبدور. 21 میساییدی اد زند میدشد. معبور در مما ادب بردور. 21 میدفود اد قد متعاندا شدیر ایروی می	conducted when an lown for earlyin to be used with lower, using their constitute to Kornes, et al.	<b>30</b> 0
nown un same 1. supremues auch as city autipe of and" were armoved before performing the tests. It I from both this study and studies made for other the greater project site, the percentage fines for the is typically about 10, whereas the aatural sand typi- fines content.	er counts were not included in the correlation be- TARE 2 American Dan			dan 1 () () () () () () () () () () () () ()			2 110 (f) Test Loweline 6									dien 3 (f) Their Leastern (						Atom 4 Andrew 1 Andrew 1					NA 42 W	413(14) MOD 16.7 40	. An etheth (1) and 1) dark damin mine (1) and a damin mini (1) house (1).	ann and to depth is the proved mades for gath dat and and a birds an and	یداد. میله بدادی است. عمل قدید دیبرد. X میسایست اه ایه میدشد. مسیر زمانی است. عمل اده بردید. X میدخش به قد معدشها قسیر است.	is, er (i) 377 combrind wing av konn for angeler to be ward with line, anlag It oden construed something to Konnes, et al.	200
where a moven in taken 1. Experiment were as any number of "drifter's stud" were removed before performing the tests. It shed that from both this study and studies made for other thome of the greeter project site, the percentage fines for the fill stud is typically about 10, whereas the natural send typi- bout 20% fines content.	ally, blow counts were not included in the correlation be- TARE 2Producto Dan			(s) That Lacadan 1 (s) That Lacadan 5 (s)												ti Test Jacoban 3 (9) Test Jacoban 8						(A) Test Leasters 4 (A) Test Leasters 9						41,31,4 MOD 16.7 40	الإسلام ما 1972. An stands (1) and 10 deck denis minut and allowin marked and allowin	it b president and to depti is the sample marker for gain den andjung, which an and-	ده. 17 میشودند مقد یدانه است. عط قده دیدید. H همسیسف ی ان همشها همین Adriad ملک مادی است. عط اده بنجید H مندمقط ی قد شمایط شمیر است.	iling to Konnes, en cit SFT conducted when an lown for narpha to be und with Ban, unlay wreps und 18 when convert constant to Konnes, et al.	

BOREHOLE #2

FROM KASIN, et al (1986)

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Golder		SUBJECT SETTLEMENT CALCULATIONS IEHPI											
Assoc	iates	Job No. 703-64 Ref.	700 Ma Chi Ren	de by RAC acked UESA wewad NER	Date //. Sheet /C	17/9, od / g							
BOREHOU	£ #13												
LAYER	SAMPLE ID	Dsu	λ	24N*	9c	E=2.59							
1	S-2	0.2	17	4.8	81.6	224							
2	5-2	0.2	17	4.8	81.6	204							
3			>100	_	_								
4	ST-2	0.35	14	5.6	78.4	196							
ح	_		2100	-		_							
6	BH-13 Buik	ک که ()	28	6.6	184.8	410 2							
7	BHI3 BAK	0,58	27	6.6	178.2	145.5							
8		-	185	_	_								

\* Robertson and Componelly (1984) \* Schmertmann (1978)

Calculate 
$$I_{2p}$$
 according to Schmertmann (1974)  
 $I_{2p} = 0.5 + 0.1 \left(\frac{\Delta p}{J_{2p}}\right)^{1/2}$   
 $\Delta p = \delta_{cover} \lambda t_{cover} + \delta_{R,11} \lambda \xi_{H,11}$   
 $= 120 pcf(3) + (125)\chi(3)$   
 $= 735 psf$ 

J'ap @ B/a

Assume axisymmetric B= 325 ft (aug. of length and width of creat of EHP'

B/2=162.5 ft.





\* ASSUME IncomPRESSIBLE

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0,8

Z(72)02 0.0141

Golder	SUBJECT SETTLEME	SUBJECT SETTLEMENT CALCULATIONS (EHP)										
Associates	Rel.	Checked USER Reviewed MUL	Sheet 13 of 14									
BOREHOLL + 13		••••• • • •										
SJ - C	,C2 0p之(王)0元	Schme	er tmann (1970)									
C,= ,	$-0.5(\frac{-1}{AP}) \stackrel{?}{=} 0.5$											
$C_{1}$	IS AN EMBEDDHENT SERVATIVE TO TAKE	- CORRECTION FACT C;=1	ur It u									

 $C_{2} = i + 0, \& \log_{0}(\frac{\pi}{0.1})$ =  $1 + 0.2 \log_{0}(\frac{\pi}{0.1})$ t= 30 years = 1.5

$$S_d = (1)(1.5)(735_{psf} \times \frac{500}{2000})(0.0171)$$
  
= 0.0078 ft = 0.097 in

#### 14/16 **RECORD OF BOREHOLE 13** PROJECT: INDUSTRI-PLEX SHEET: 1 OF 1 BORING DATE: 05/29/90 DATUM: MSL PROJECT LOCATION: WOBURN BORING LOCATION: N: 554,730 E: 696,356 PROJECT NUMBER: 893-6255 SOL PROFILE BAMPLES PENETRATION RESISTANCE 3 BLOWS/FT 88 DEPTH SCOT PIEZOMETER ğ OR NUMBER ELEV NECAT 808 **GRAPHIC** Ĕ STANDPIPE 1 DESCRIPTION BLOWS / N WATER CONTENT, PERCENT INSTALLATION i in 10 20 20 40 80 80 70 80 80 DEPTH 109.10 0.00 ٥ 0.0-35.5 ft. Compact, black with occasional light-gray pockets, f-SAND, little to some silt to clayey silt, few oobbles and f-gravel, hair and hair clumps, occasional clumps of root mass, (SM to SP-SM). FILL AND HIDE RESIDUE. ļ 17 1 DO 2.7.10.21 75 Water encountered at approximately 37.0 ft. at end of drilling. 5 2 00 8,9,8,7 17 80 SHELBY TUBE 81-1 TO 30 10 3 00 6,100/.1\* 83 Þ 100 15 ų, 00 \$.7.7.7 14 70 4 SM to 88 SHELBY TUBE 51.2 TO 80 SM 20 5 DO 100/0 9 100 25 24 . 8 DO 11,13,15,20 28 60 30 3 1 7 00 9,14,13,23 27 100 NOTES: 1.) Recovered shelby tube sample placed in jar to TO-1. 35.5-56.2 R. Dense, black, m-I SAND, 35 73.60 72.58 36.20 72.18 37.00 little Forevel, trace silt, possible few hairs, (SP). OUTWASH SAND ? .... SP DO 18,80,125 185 100 38.2-37.0 R. Weathered bedrock. BORING TERMINATED AT 37.0 FT. BELOW GROUND SURFACE.

DRILL PIG: Mobile 8-57 ATV

DRILLING CONTRACTOR: Geologic DRILLER: T. Paquette

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## **Golder Associatés**

LOGGED: RJI CHECKED: JEW DATE: 05/31/90

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			1		¥	R	3 6	K 14	u	51	а	••		2	* 4	2 8	B	2	*	•	, <b>z</b>	2 2		*	: E	22	• 1	r N	2		Ĩ	9	*		· -	onally, I		noted t
			K		×	R	5 1	K 18	u.	Lonion 4	4			3	<b>K</b> 4	2		2	¥		, 2	<b>#</b> 14			Least 2	<b>K</b> 2	• 1	<b>K</b> 9	4	*		9	2		T		d is typi	
			3		3	ē.	<b>3</b> 1	i 9			5	•	. 2	×	81	ĨØ			*		13	I	ä	- F		ž 2	=	5	6	•		3	ļ			contenț. Inte were	cally abou	
	e II e			197e	tale a	52	Ę z	:2	2		¥ 6°	2010	19.	Ę	22			i i	1 i e	5 E	•	• •	·	Į	13	• •		Į	5	-		B	ł		i i i i i i i i i i i i i i i i i i i	not includ	t 10, when	
	5		ł	Ş	5	51	5 5	13	2)IC	572	128		3	×	ŝŧ	13	274	3	3	99	2	ĕš	6	e)j	Ē	1 1 1 1	S		• 1	•	sī	3	5	Ē	ł		the particular	
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			រែ	8	Ŧ		5 3		3		X	2 C		8		19		4		× X	¥	Ħ ŭ				¥ ¥	1		U			2	<b>.</b>		·			

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ET # KC

results, such as changes in material types discovered during the pene-iration test. A total of 65 test data points were selected for the correlacause the encountered conditions were considered to invalidate the test ions. A summary of the field measurements is given in Table 2.

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213

6-in. (15-cm) to the 18-in. (38-cm) penetration levels of the sampler. same 12-in. (30-cm) length as the N values were recorded, i.e., from the The correlation between q, and N was made by averaging q, over the

sus the mean grain diameter and was superimposed on the average curve und triangles for the hydraulic and natural sands, sespectively, and are und data points (solid circles) by Robertson and Campanella (3), as shown n Fig. 1. The data points from this work are denoted by open circles ndexed by 4 in kg/cm² (see Tables 1 and 2). The data resulting from this work was expressed in terms of 4./N ver

grain diameter. The entire data bank in Table 2 was analyzed to invesertson and Campanella (3) curve represents a good average for the study of some other soil property that is not completely defined by the mean could indicate either that correlation relationships are difficult to obtain the results were incondusive. ight the possible dependence of the  $q_i/N$  on the numerical value of  $q_i$ secure of inherent variabilities in both types of tests or that the effect ite, significant scatter around the mean curve is evident. Such scatter Evansionation of the relationship in Fig. 1 shows that although the Rob

Another plot was developed to evaluate the possible dependence of p./N on the fines content. For that purpose, we have utilized only that





0.0139 ft / 140 ft = 0.0099 % = 0.01%



APPENDIX 12-F Drainage Layer Calculations

Golder	SUBJECT HELP M	odel 5	[MULAT	IONS	
Associates	Job No. 903-6400 Ret.	Made by 12 Checked & Reviewed	bach.	Date / Sheet /	18/91 of 23
DBJECTI	VE :			••• •••• • • • • • • • • • • • • • • •	
Model Using Morein Liver below	the East Hido the HELP mode ium head on (FML). The the growd	pile ; to be in the shift of th	eternin eternin erible required	to ren to ren	<ul> <li></li> &lt;</ul>
Methodol	<u>097</u> i				
CAS	A - ROD Coved		42+tical 12 " 4 50:1 + 50:1 + 570 5 24:0 5570 5 5570 5 5570 5 5570 5 5570 5 5570 5 5570 5 5570 5 5570 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	hick (R hick (R hick (R hick (R hick (R hick Jon hick Jon h	AN LEART OD COUER) XE 6 Nace leart I Conta I VIO I COU Dut Co Cout Co
CASE	e model was sum the drainage armeability of animum slope of 150 used to 2	La Jeden La Jer un IXIO-2 C Conserve Maximum	mine the her the misec or the trans brane netice	he this Lis us borrier Hiso, t a + 1 + m	ickwees in Rob v J_ A lazer the the
	<u> </u>		Ve-tical verioe CASE Latiral 12" this SB Sh 260 3t. Barner 1 1204	Pe-cold owne in Fe Drainage K Pe Drainage Armuage	Lics Later oput es Later Lewgth Die some
	he model was r. readed for the dr in manifationed		Berner H siput renive H ren if rechts.	es car the parma	e 12 cale. The hickness

Colder		Madel Simul	<u>کر می ج</u>
Golder Associates	Job No. 963 -6400 Ref.	Made by Are Checked For Reviewed Ach	Date 1-18-74 Sheet 2 of 23
Results r	Cases 2 + 3	2.	
praineat	hyper Thicknee ity (calsed) (20)	Thickwess (2	(JM3 reada GI) (C
2 1 1 1 1 1	-3 102	. 12	107
CASE SXI	- <sup>2</sup> \2	12	18.6
ie fea TRT A CASE 3	GEOCOMPOS	ETE:	
	XXXX	r -> 14" soil Def Leter Bar	al Porrolation Larger Mick tarture VF b with Soil Data al Drainage lagger Relow For Lagger - Samp as care KFL
The Da	geocomposite u ta Jor thickwe colectwical Fabri	ill be modelbd ss & Trasmis ics Report (121 a	using published rsinity from 1) for TEX-NORT.
•	thickness(b) 5.1	m= :51cm= . 2 (	wches
	Transmissivity (7	$(1) = .001 m^2$	Sec
		= 10 em7	ددر
:	$\begin{array}{c} \mathbf{z} \mathbf{F}  \mathbf{T} = \mathbf{K} \times \mathbf{b} \\ \mathbf{K} = \mathbf{T} / \mathbf{b} \end{array}$	$= \frac{10  \mathrm{cm}^2/\mathrm{sec}}{\mathrm{s}  \mathrm{cm}} =$	19.6 cm/sec

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SUBJECT HELP MODEL Simulations Golder Jab No. 9 03 - 6408 Made by 100 Date 1-18-91 Associates Checked Oran Ref. Sheet a 23 Reviewed OTHER ENPOT PARAmetes SOR Geocomposite: Porosity = . & volluol Wilting paint = . 02 vol (vol ( warst possible is) Field Capacity = . 03 vollool (must be > willing 40,-2+) The HELP model indicates a head on the FUL of 10.5" Conservation was quite the slope longth and leaked fuctor as discossed previously. The vertical percolation was increased from the 12" (ROD cover) to 18" to provide additional cover over the geocomposite CASE 4 A sinulation was run to model the geocomposite as a soil to check the result of CASE 3. The vertical percolation & barner 50,1 layor parameter rencia the same as CASE 3. Scale the soil thickness & permeability to equal the transmissivity of the geocomposite ose a thickwess of 12" = 30.48 cm T= Kb K= T = 10 cm²/sec = . 328 cm/sec The default soil data for type the war ser for the other soil perameterse The HELP model indicates a head on the FML of 5.0" Conservation was given to slape longth A Leakage Fuctor as previously Discussed.

Golder	SUBJECT HELP	SUBJECT HELP MODEL Simulations								
Associates	Job No. ら0フーを408 Ref.	Made by N.S. Checked OB Reviewed Man	Date 1-15-9 Sheet 4 of 23							
		- <b>-</b>								

Cases 1 and 2 indicate that a substantial thickness of soil or very high permeability is required to maintain a head below the ground surface with a grounder draining + layer. A geocomposite maintains a head below the ground surface and has a minimal theckness.

TABLE 4. DEFAULT UNVEGETATED, UNCOMPACTED SOIL CHARACTERISTICS

5/23

SOII	. TEXTU	RE	POPOSITY	FIELD	WILTING	SAT. HYD.
HELP	USDA	USCS	(VOL/VOL)	(VOL/VOL)	(VOL/VOL)	(CH/SEC)
1	CoS	GS	0.417	0.045	0.018	1.0E-02
2	S	SW	0.437	0.062	0.024	5.8E-03
3	FS	SM	0.457	0.083	0.033	3.1E-03
4	LS	SM	0.437	0.105	0.047	1.7E-03
5	LFS	SM	0.457	0.131	0.058	1.0E-03
6	SL	SM	0.453	0.190	0.085	7.2E-04
7	FSL	SM	0.473	0.222	0.104	5.2E-04
8	L	HL.	0.463	0.232	0.116	3.7E-04
9	SiL	NL	0.501	0.284	0.135	1.9E-04
10	SCL	SC	0.398	0.244	0.136	1.2E-04
11	CL	CL	0.464	0.310	0.187	6.4E-05
12	SiCL	CL	0.471	0.342	0.210	4.2E-05
13	SC	СН	0.430	0.321	0.221	3. 3E-05
14	SiC	СН	0.479	0.371	0.251	2. 5E-05
15	С	СН	0.475	0.378	0.265	1.7E-05
16	Liner	Soil	0.430	0.366	0.280	1.0E-07
17	Liner	Soil	0.400	0.356	0.290	1.0E-08
18	Mun.	laste	0.520	0.294	0.140	2.0E-04
19		USER	SPECIFIED S	OIL CHARACT	ERISTICS	
20		USER	SPECIFIED S	OIL CHARACT	ERISTICS	

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From "GEOTECHNICK FABRICS REPORT" Dec. 1987

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r	1		Dimension	al Properties		Transmissivity			
	]						ASTM D	716-874	
1			Width/	Thickness	Crush Strength	Gentertile	10 kPa (1.45 pei)	100 kPa (14.5 pei)	
Product Name	Structure <sup>ry</sup>	Polymer Composition	Length m (ft)	ASTM D1777m mm (mile)	ASTM D1621 kPa (pel)	Product W attached	M²/S (gel/min/It)	M <sup>4</sup> /S (gel/min/it)	

## **Contech Construction Products Inc.**

C-112	geonet with Inminated geotexule	polyethylene	1.6/7.6,30.5 (5.2/25,100)	5.6 (220)	•	Trevira 1112	~	•
C-114	geonet with laminated geotextile	polyethylene	1.6/7.6,30.5 (5.2/25,100)	5.6 (220)	<b>8</b> 2	Trevira 1114	-	-
C-212	geonet with Inminated geotextile	polyethylene	1.67.6.30.5 (5.2/25,100)	5.6 (220)	•	Trevirs 1112	~	
C-214	geonet with Inminued geotextile	polyethylene	1.67.6,30.5 (5.2/25,100)	5.6 (220)	200	Trevira 1114	**	RA .
STRIPDRAIN 100	cumpated core	HDPE	.30,.46,.61,.76, .91/122 (1,1,5,2,2,5, 3/400)	25.4 (1000)	379 (55)	Trevina 1114	5.11 (24.7)	4.66 (22.5)
STRIPDRAIN 75	Computed core & israinated geotextile	HDPE	.55,1.1/55 (1.8,3.6/180)	19.1 (750)	276 (40)	Trevira 1114	.62 (3)	.41 (2)

#### **Conwed Plastics**

LXE-9000	thermoformed act	polyethylene	1.2/30.5 (4/100)	15.2 (600)	280 (40)	various	7.4 (35.8)**	6.6 (31.9) <sup>p</sup>
XBSI 10	geonal	polyethylenc	2.1/91.4 (6.9/300)	6.1 (240)	>900 (130)	various	3.4 (16.4)**	3.0 (14.5)*
X88210	geonet	polyethylenc	2.1/91.4 (6.9/300)	4.1 (160)	>900 (130)	various	1.9 (9.2)**	1.8 (8.7) <sup>p</sup>
XB4310	geoust	polyethylene	2.1/91.4 (6.9/300)	4.8 (190)	>900 (130)	various	2.7 (13.0)**	2.6 (12.6) <sup>p</sup>
XB43LSCN	geoast	polysthylene	2.1/91.4 (6.9/300)	\$.1 (200)	>900 (130)	various	2.6 (12.6) <sup>A D</sup>	2.6 (12.6) <sup>p</sup>
X85410	geoust	polyethylene	2.1/67.1 (6.9/220)	7.6 (360)	>900 (130)	various	4.3 (20.8)* 0	4.3 (20.8) <sup>p</sup>

#### Fluid Systems Inc.

TEX-NET TN1001	gecast composite	polyethylene	(7.5/250)	5.7 (225)	>900 (130)	Trevira 1120 <sup>4</sup>	.0015	.0015	
TEX-NET TN3001	goonal composite	polyatkylcac	(7.5/300)	5.1 (200)	>900 (130)	Trevira 1120°	.0012	.0012	
TEX-NET TN3001CN	ground composite	polyethylene	(7.5/300)	5.1 (200)	<900 (130)	Trevira 1120 <sup>e</sup>	.0010	.0010	←
TEX-NET TN4001	groast composite	polyethylene	(7.5/250)	6.9 (270)	<900 (130)	Trevira 1120*	.0025	.0025 •	

#### Greenstreak Inc.

Deck Drain	composite single-side core	polystyrene	1.2/3.0 (4/10)	9.6 (380)	958 (139)	Amoco 1198 woven polypropylene	1.5-4.8 (7-23)f	1.2-4.6 (6-22) <sup>c</sup>
Sheet Dinin	composite single-side care	polystyreae	1.2/3.0 (4/10)	9.6 (380)	717 (104)	Amoco 9140 NP polypropylane	1.2-3.9 (6-19) <sup>c</sup>	1-3.7 (3-18) <sup>c</sup>
Sheet Drain HS	composite single-side core	polystyrese	1.2/3.0 (4/10)	5.3 (210)	1199 (174)	Amoco 9140 NP polypropylaas	.3-1.1 (1.3-5.2)*	.2-10 (1.1-4.9) <sup>c</sup>

(A) 48 kPs ~ 6.9 psi \*\* Available on both sides

[C] Gradient range of .1 - 1.0 [D] Gradient of .25

All values were requested to be minimum average roll values and all claims are the responsibility of the manufacturer. All product data are intended as a guide. Geotechnical Fabrics Report recommends you contact manufacturers before making any specifying/purchasing decisions.

903-6402 123 1-18-91 7/28

CASE 1

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ISRT WOBURN

GOOD GRASS

LAYER 1

## VERTICAL PERCOLATION LAYER

THICKNESS	-	12.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1907 VOL/VOL
WILTING POINT	-	0.0849 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2183 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0030239999760 CM/SEC

## LAYER 2

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## LATERAL DRAINAGE LAYER

THICKNESS	=	102.00 INCHES
POROSITY	-	0.4170 VOL/VOL
FIELD CAPACITY	-	0.0457 VOL/VOL
WILTING POINT	-	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1606 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.001000000475 CM/SEC
SLOPE	-	5.00 PERCENT
DRAINAGE LENGTH	<b>*</b> ·	260.0 FEET

DARRIER SUID DINER WIIN FLEAIDDE MEMORANE DIN	BARRIER	SOIL	LINER	WITH	FLEXIBLE	MEMBRANE	LINE
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THICKNESS	=	0.06 INCHES
POROSITY	=	0.4000 VOL/VOL
FIELD CAPACITY	=	0.3563 VOL/VOL
WILTING POINT	=	0.2901 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4000 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.0000000

# GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	= 60.10
TOTAL AREA OF COVER	= 43560. SQ FT
EVAPORATIVE ZONE DEPTH	= 24.00 INCHES
UPPER LIMIT VEG. STORAGE	= 10.4400 INCHES
INITIAL VEG. STORAGE	= 3.7728 INCHES
SOIL WATER CONTENT	INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR BOSTON MASS

MAXIMUM LEAF AREA INDEX	=	3.30
START OF GROWING SEASON (JULIAN DATE)	-	127
END OF GROWING SEASON (JULIAN DATE)	-	290

## NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
	4 <b>-</b> - <b>-</b> - <b>-</b> -				
29.60	30.70	38.40	48.70	58.50	68.00
73.50	71.90	64.60	54.80	45.20	33.30

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

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	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44 3.06	3.64 3.53	4.56 3.18	3.49 3.34	3.45 4.78	3.53 5.26
STD. DEVIATIONS	1.96 1.44	1.72 1.38	1.85 1.94	1.44 1.39	1.41 2.06	1.67
RUNOFF						
TOTALS	0.000	0.000 0.000	0.001 0.000	0.008 0.000	0.000 0.000	0.000 0.002
STD. DEVIATIONS	0.000 0.000	0.000 0.000	0.004 0.000	0.036 0.000	0.000 0.000	0.000 0.006
EVAPOTRANSPIRATION						
TOTALS	0.894 3.251	1.265 3.099	2.231 2.816	2.627 1.769	2.625 1.259	4.616 0.903
STD. DEVIATIONS	0.179 1.262	0.188 1.279	0.261 0.935	0.691 0.525	0.722 0.222	0.927 0.143
LATERAL DRAINAGE F	ROM LAYER	2				
TOTALS	1.4415 1.4215	1.4096 1.3165	1.6601 1.1880	1.6369 1.1636	1.6095 1.1495	1.486 1.349
STD. DEVIATIONS	0.3480 0.3181	0.3505 0.2865	0.4357 0.2540	0.4865 0.2384	0.4104 0.2057	0.362 0.262
PERCOLATION FROM L	AYER 3					
TOTALS	0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.000
STD. DEVIATIONS	0.0000	0.0000 0.0000	0.0000 0.0000	0.0000 0.0000	0.0000	0.000
*****	*******	*******	*******	*******	*******	******
*****	********	******	*******	*******	******	*****
AVERAGE ANNUAL TOTA	LS & (STD	. DEVIAT	IONS) FO	R YEARS	1 THRO	DUGH
		(IN	CHES)	(ເບ	. FT.)	PERCE
PRECIPITATION		45.27	( 4.848)	) 10	54343.	100.00
RUNOFF		0.011	( 0.036)	)	40.	0.02

9/23

EVAPOTRANSPIRATION	27.356	( 2.699)	99303.	60.42
LATERAL DRAINAGE FROM LAYER 2	16.8319	( 3.7774)	61100.	37.18
PERCOLATION FROM LAYER 3	0.0000	( 0.0000)	0.	0.00
CHANGE IN WATER STORAGE	1.074	( 3.495)	3900.	2.37

PEAK DAILY VALUES FOR YEARS 1 THROUGH 20 ----(INCHES) (CU. FT.) 3.45 12523.5 PRECIPITATION RUNOFF 0.162 586.4 LATERAL DRAINAGE FROM LAYER 2 0.1153 418.6 PERCOLATION FROM LAYER 3 0.0000 0.0 HEAD ON LAYER 3 113.6 3.10 11253.0 SNOW WATER MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4309 MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0524

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FINAL WATER	STORAGE AT	END OF YEAR 20	
 LAYER	(INCHES)	(VOL/VOL)	
<b>1</b>	2.53	0.2108	
2	37.77	0.3703	
3	0.02	0.4000	

10/23

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## SNOW WATER 0.00

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CASE 2

903-6400

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1-12-91

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ISRT					
WOBURN					
1-18-91	1				

GOOD GRASS

LAYER 1

#### VERTICAL PERCOLATION LAYER

THICKNESS	-	12.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1907 VOL/VOL
WILTING POINT	=	0.0849 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2180 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0030239999760 CM/SEC

#### LAYER 2

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#### LATERAL DRAINAGE LAYER

-	12.00 INCHES
=	0.4170 VOL/VOL
=	0.0457 VOL/VOL
=	0.0200 VOL/VOL
-	0.0770 VOL/VOL
-	0.050000007451 CM/SEC
-	5.00 PERCENT
=	260.0 FEET

LAYER 3

#### BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER THICKNESS 0.06 INCHES

POROSITY FIELD CAPACITY WILTING POINT INITIAL SOIL WATER CONTENT SATURATED HYDRAULIC CONDUCTIVITY = LINER LEAKAGE FRACTION

0.4000 VOL/VOL 0.3563 VOL/VOL 0.3903 VOL/VOL 0.2901 VOL/VOL 0.4000 VOL/VOL 0.0000000100000 CM/SEC 0.00000000 -

#### GENERAL SIMULATION DATA \_\_\_\_\_

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SCS RUNOFF CURVE NUMBER 60.10 -TOTAL AREA OF COVER = 43560. SQ FT EVAPORATIVE ZONE DEPTH 24.00 INCHES -UPPER LIMIT VEG. STORAGE -10.4400 INCHES INITIAL VEG. STORAGE -3.3789 INCHES SOIL WATER CONTENT INITIALIZED BY PROGRAM.

#### CLIMATOLOGICAL DATA -----

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR BOSTON MASS

MAXIMUM LEAF AREA INDEX = 3.30START OF GROWING SEASON (JULIAN DATE) = 127 END OF GROWING SEASON (JULIAN DATE) = 290

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
		*****			
29.60	30.70	38.40	48.70	58.50	68.00
73.50	71.90	64.60	54.80	45.20	33.30

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC	
PRECIPITATION							
TOTALS	3.44	3.64	4.56	3.49	3.45	3.53	
	3.06	3.53	3.18	3.34	4.78	5.26	
STD. DEVIATIONS	1.96	1.72	1.85	1.44	1.41	1.67	
	1.44	1.38	1.94	1.39	2.06	2.02	

RUNOFF							(4/
TOTALS	0.000	0.000	0.001	0.000	0.000	0.000	
STD. DEVIATIONS	0.000	0.000	0.003	0.000 0.000	0.000	0.000	
EVAPOTRANSPIRATION							
TOTALS	0.901 3.117	1.271 3.060	2.235 2.791	2.626 1.761	2.618 1.272	<b>4.1</b> 69 0.913	
STD. DEVIATIONS	0.184 1.198	0.189 1.210	0.260 0.956	0.700 0.542	0.731 0.233	0.995 0.144	
LATERAL DRAINAGE FR	OM LAYER	2					
TOTALS	3.2135 0.0826	2.5116	2.8040 0.3017	1.4960 0.6967	0.7374 2.2933	0.4943 3.7608	
STD. DEVIATIONS	1.3316 0.1830	1.5998 0.1131	1.4928 0.5751	1.3609 0.7404	0.5200 1.6222	0.7414 1.5855	
PERCOLATION FROM LA	YER 3						
TOTALS	0.0000	0.0000 0.0000	0.0000 0.0000	0.0000	0.0000	0.0000	
STD. DEVIATIONS	0.0000	0.0000	0.0000 0.0000	0.0000	0.0000	0.0000	
**************************************	********* S & (STD.	DEVIATI	********* (ONS) FOR	********* YEARS	1 THRC	******** 9UGH 20	
		(INC	CHES)	(CU.	FT.)	PERCENT	-
PRECIPITATION		45.27	( 4.848)	164	4343.	100.00	
RUNOFF		0.003	( 0.007)		11.	0.01	
EVAPOTRANSPIRATION		26.735	( 2.631)	97	7049.	59.05	
LATERAL DRAINAGE FR Layer 2	OM	18.4429	( 4.7906)	) 60	5948.	40.74	
PERCOLATION FROM LA	YER 3	0.0000	( 0.0000)	)	0.	0.00	
CHANGE IN WATER STO	RAGE	0.092	( 1.088)		335.	0.20	

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15/23

PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.5
RUNOFF	0.018	65.3
LATERAL DRAINAGE FROM LAYER 2	0.3165	1148.9
PERCOLATION FROM LAYER 3	0.0000	0.0
HEAD ON LAYER 3	18.6	
SNOW WATER	3.10	11253.0
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3790	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0523	

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<u> </u>	FINAL WATER	STORAGE AT	END OF YEAR 20	
	LAYER	(INCHES)	(VOL/VOL)	
	1	2.53	0.2108	
	2	2.68	0.2233	
	3	0.02	0.4000	
	SNOW WATER	0.00		

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CASE 3

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ISRT Woburn 1-18-91	
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GOOD GRASS

LAYER 1

### VERTICAL PERCOLATION LAYER

THICKNESS	**	18.00 INCHES
POROSITY	-	0.4530 VOL/VOL
FIELD CAPACITY	-	0.1907 VOL/VOL
WILTING POINT	-	0.0849 VOL/VOL
INITIAL SOIL WATER CONTENT	E	0.2218 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0030239999760 CM/SEC

## LAYER 2

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## LATERAL DRAINAGE LAYER

THICKNESS	-	0.20 INCHES	
POROSITY	=	0.8000 VOL/VOL	
FIELD CAPACITY	-	0.0300 VOL/VOL	
WILTING POINT	=	0.0200 VOL/VOL	
INITIAL SOIL WATER CONTENT	-	0.0391 VOL/VOL	
SATURATED HYDRAULIC CONDUCTIVITY	*	19.600003814697 CM/S	SEC
SLOPE	-	5.00 PERCENT	
DRAINAGE LENGTH	=	260.0 FEET	

LAYER 3

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POROSITY	-	0.4000 VOL/VOL
FIELD CAPACITY	=	0.3563 VOL/VOL
WILTING POINT		0.2901 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.4000 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	-	0.0000000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	= 60.10
TOTAL AREA OF COVER	= 43560. SQ FT
EVAPORATIVE ZONE DEPTH	= 18.00 INCHES
UPPER LIMIT VEG. STORAGE	= 8.1540 INCHES
INITIAL VEG. STORAGE	= 3.8242 INCHES
SOIL WATER CONTENT	INITIALIZED BY PROGRAM.

## CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR BOSTON MASS

MAXIMUM LEAF AREA INDEX = 3.30 START OF GROWING SEASON (JULIAN DATE) = 127 END OF GROWING SEASON (JULIAN DATE) = 290

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
	~~~~~ <u></u>	() () () () () () () () () () () () () (	الله الله الله الله الله الله الله الله		
29.60	30.70	38.40	48.70	58.50	68.00
73.50	71.90	64.60	54.80	45.20	33.30

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	3.64	4.56	3.49	3.45	3.53
	3.06	3.53	3.18	3.34	4.78	5.26
STD. DEVIATIONS	1.96	1.72	1.85	1.44	1.41	1.67
	1.44	1.38	1.94	1.39	2.06	2.02

17/23

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RINOFF	
RONOLL	

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*						
TOTALS	0.000 0.000	0.000 0.000	0.002 0.000	0.000 0.000	0.000 0.000	0.000 0.002
STD. DEVIATIONS	0.000	0.000	0.007	0.000	0.000	0.000 0.006
EVAPOTRANSPIRATION						··••.
TOTALS	0.899 3.183	1.270 3.093	2.278 2.841	2.688 1.805	2.696 1.271	4.431 0.911
STD. DEVIATIONS	0.181 1.237	0.190 1.276	0.255 0.975	0.705 0.533	0.741 0.231	0.961 0.144
LATERAL DRAINAGE FRO	M LAYER	2				
TOTALS	2.7672 0.0446	2.5445 0.0138	2.4116 0.2210	1.2799 0.5794	0.6128 2.6960	0.4751 4.2391
STD. DEVIATIONS	1.7261 0.1294	1.7211 0.0426	1.5448 0.4785	1.3091 0.7289	0.4994 1.9596	0.7530 2.2174
PERCOLATION FROM LAY	ER 3					
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 0.0000
STD. DEVIATIONS	0.0000 0.0000	0.0000	0.0000 0.0000	0.0000 0.0000	0.0000	0.0000
*****	******	******	******	*******	******	*******

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AVERAGE ANNUAL TOTALS &	(STD.	DEVIATI	[0]	NS) FOR	YEARS	1 7	HROUGH 20
		(INC	:HI	ES)	(CU.	FT.)	PERCENT
PRECIPITATION		45.27	(	4.848)	164	343.	100.00
RUNOFF		0.004	(	0.011)		14.	0.01
EVAPOTRANSPIRATION		27.364	(	2.698)	99	331.	60.44
LATERAL DRAINAGE FROM LAYER 2		17.8849	(	4.6650)	64	922.	39.50
PERCOLATION FROM LAYER	3	0.0000	(	0.0000)	)	0.	0.00
CHANGE IN WATER STORAGE		0.021	(	0.790)		76.	0.05

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PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
RECIPITATION	3.45	12523.5
UNOFF	0.030	109.9
ATERAL DRAINAGE FROM LAYER 2	1.7169	6232.4
ERCOLATION FROM LAYER 3	0.0000	0.0
EAD ON LAYER 3	10.5	
NOW WATER	3.10	11253.0
AXIMUM VEG. SOIL WATER (VOL/VOL)	0.3679	1
INIMUM VEG. SOIL WATER (VOL/VOL)	0.0846	

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FINAL WATER	STORAGE AT B	END OF YEAR 20	
LAYER	(INCHES)	(VOL/VOL)	
1	4.22	0.2343	
2	0.02	0.1063	
3	0.02	0.4000	
SNOW WATER	0.00		

CASE 4

G03-6400 MT 1-18-91

20/2

ISRT Woburn 1-18-91

GOOD GRASS

## LAYER 1

### VERTICAL PERCOLATION LAYER

THICKNESS	=	18.00 INCHES
POROSITY	-	0.4530 VOL/VOL
FIELD CAPACITY	-	0.1907 VOL/VOL
WILTING POINT	=	0.0849 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.2218 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.0030239999760 CM/SEC

### LAYER 2

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### LATERAL DRAINAGE LAYER

THICKNESS	=	12.00 INCHES
POROSITY	-	0.4170 VOL/VOL
FIELD CAPACITY	-	0.0457 VOL/VOL
WILTING POINT	-	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	-	0.0470 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.3300000131130 CM/SEC
SLOPE	-	5.00 PERCENT
DRAINAGE LENGTH	-	260.0 FEET

LAYER 3

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POROSITY	-	0.4000 VOL/VOL
FIELD CAPACITY	-	0.3563 VOL/VOL
WILTING POINT	=	0.2901 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4000 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	-	0.0000000100000 CM/SEC
LINER LEAKAGE FRACTION	-	0.0000000

### GENERAL SIMULATION DATA

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SCS RUNOFF CURVE NUMBER 60.10 -TOTAL AREA OF COVER -43560. SQ FT EVAPORATIVE ZONE DEPTH 18.00 INCHES UPPER LIMIT VEG. STORAGE -8.1540 INCHES INITIAL VEG. STORAGE -3.8245 INCHES SOIL WATER CONTENT INITIALIZED BY PROGRAM.

### CLIMATOLOGICAL DATA

### SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND SOLAR RADIATION FOR BOSTON MASS

MAXIMUM LEAF AREA INDEX = 3.30 START OF GROWING SEASON (JULIAN DATE) = 127 END OF GROWING SEASON (JULIAN DATE) = 290

### NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.60	30.70	38.40	48.70	58.50	68.00
73.50	71.90	64.60	54.80	45.20	33.30

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 20

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.44	3.64	4.56	3.49	3.45	3.53
	3.06	3.53	3.18	3.34	4.78	5.26
STD. DEVIATIONS	1.96	1.72	1.85	1.44	1.41	1.67
	1.44	1.38	1.94	1.39	2.06	2.02

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TOTALS	0.000	0.000 0.000	0.002	0.000	0.000	0.000 0.002
STD. DEVIATIONS	0.000 0.000	0.000	0.007 0.000	0.000	0.000	0.000
VAPOTRANSPIRATION						
TOTALS	0.899 3.183	1.270 3.093	2.277 2.841	2.687 1.805	2.696 1.270	4.431 0.911
STD. DEVIATIONS	0.181 1.237	0.190 1.276	0.255 0.975	0.704 0.533	0.741 0.231	0.961 0.144
ATERAL DRAINAGE FR	OM LAYER	2				
TOTALS	2.7401 0.0415	2.5595 0.0174	2.4584 0.2146	1.2806 0.5599	0.6296 2.6263	0.4858 4.2665
STD. DEVIATIONS	1.6298 0.1167	1.7343 0.0575	1.5592 0.4699	1.3223 0.7332	0.5127 1.9852	0.7544 2.2919
ERCOLATION FROM LA	YER 3					
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000 0.0000
STD. DEVIATIONS	0.0000 0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
/ERAGE ANNUAL TOTAL	******** S & (STD	. DEVIATI	ONS) FOR	********* YEARS	1 THRC	)UGH 20
VERAGE ANNUAL TOTAL	******** S & (STD	. DEVIATI (INC	ONS) FOR	YEARS	1 THRC FT.)	UGH 20 PERCENT
PRECIPITATION	******** S & (STD	. DEVIATI (INC 45.27	ONS) FOR HES) ( 4.848)	YEARS (CU. 16	1 THRC FT.) 4343.	DUGH 20 PERCENT 100.00
TERAGE ANNUAL TOTAL PRECIPITATION	******** S & (STD	. DEVIATI (INC 45.27 0.004	ONS) FOR (HES) (4.848) (0.011)	YEARS (CU. 16	1 THRC FT.) 4343. 14.	DUGH 20 PERCENT 100.00 0.01
**************************************	******** S & (STD	. DEVIATI (INC 45.27 0.004 27.363	ONS) FOR HES) ( 4.848) ( 0.011) ( 2.699)	YEARS (CU. 16	1 THRC FT.) 4343. 14.	DUGH 20 PERCENT 100.00 0.01 60.44
VERAGE ANNUAL TOTAL PRECIPITATION RUNOFF EVAPOTRANSPIRATION ATERAL DRAINAGE FR LAYER 2	******** S & (STD 	DEVIATI (INC 45.27 0.004 27.363 17.8801	CONS) FOR HES) ( 4.848) ( 0.011) ( 2.699) ( 4.6743	YEARS (CU. 16 9	1 THRO FT.) 4343. 14. 9327. 4905.	DUGH 20 PERCENT 100.00 0.01 60.44 39.49
ERAGE ANNUAL TOTAL RECIPITATION UNOFF VAPOTRANSPIRATION ATERAL DRAINAGE FR LAYER 2 ERCOLATION FROM LA	******** S & (STD OM YER 3	. DEVIATI (INC 45.27 0.004 27.363 17.8801 0.0000	CONS) FOR HES) ( 4.848) ( 0.011) ( 2.699) ( 4.6743 ( 0.0000	YEARS (CU. 16 ) 6	1 THRO FT.) 4343. 14. 9327. 4905. 0.	DUGH 20 PERCENT 100.00 0.01 60.44 39.49 0.00

PEAK DAILY VALUES FOR YEARS	1 THROUGH	20
	(INCHES)	(CU. FT.)
PRECIPITATION	3.45	12523.5
RUNOFF	0.030	109.9
LATERAL DRAINAGE FROM LAYER 2	0.9907	3596.3
PERCOLATION FROM LAYER 3	0.0000	0.0
HEAD ON LAYER 3	5.0	
SNOW WATER	3.10	11253.0
AXIMIM VEG. SOII. WATER (VOI./VOI.)	0.3432	
	0.0102	

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\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*

$\smile$	FINAL WATER	STORAGE AT	END OF YEAR 20	
	LAYER	(INCHES)	(VOL/VOL)	
	1	4.22	0.2343	
	2	0.69	0.0579	
	3	0.02	0.4000	
	SNOW WATER	0.00		

•

# APPENDIX 12-G Drainage Channel and Culvert Calculations

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Golder	SUBJECT EAST HIDE PILE - DEANNAGE CHANNIEL				
Associates	Job No. 913-6-10,220 Ref.	Made by A.C. Checked A.C. Reviewed / C.M.	Date 7/16 191 Sheet 1 of 25		

OBJECTIVE: TO DESIGN A DRAINAGE CHANNEL FOR SURFACE WATER ON THE EAST HIDE PILE

METHOD :

- 1) USE QUICK TR.55 TO DETERMINE THE MAXIMUM FLOW IN THE CHANNEL BASED ON A 24 hr-100 yr STORM
- 2) USE THE MAXIMUM FLOW TO DETERMINE THE SIZE AND SHAPE OF THE CHANNEL, MAXIMUM DEPITIOF FLOW AND LINING MATERIAL
- 3) FOLLOW THE GUIDELINES SET FORTH IN THE "MATIONAL COOPERATIVE FIGHWAI RESEARCH PROGRAM REPORT NO 108" TO DETERMINE MANNING'S 'N' AND MAXIMUM STONE SIZE.
- 4) MAXIMUM VELOCITIES FOR A GIVEN MAXIMUM RIPHIP SIZE SHALL BE BASED ON CURVE 16-1, page 16-20 OF THE ENGINEERING FIELD MANUAL.
- 5) RIPRAP THICKNES SHALL BE THE MAXIMUM STONE SIZE FLUS A LATER OF 10 OUNCE NONWOURN GEOTEXTLE AS REFERENCED IN REPORT NOTES OF THE MATCHAL HANDBOOK OF CONSERVATION PRACTICES.
- 6) DETERMINE CULVERT SIZES BASED ON CONCRETE PIPE DESIGN MANUAL.

REFERENCES

- 1. NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT 108, TENTATIVE DESIGN PROCEDURE FOR RIPRAP LINED CHANNELS, ALVING ANDERSON, AMREEK S PAINTAL AND JOHN T DAVENPORT, 1970.
- 2. REPORT 468 , NATIONAL HANDBOOK OF CONSERVATION PRACTICES
- 3. JOIL CONSERVATION SERVICES ENGINEERING FIELD MANUAL.

CALCULATIONS:

CALCULATIONS FOLLOW

Golder	SUBJECT EAST HOF PI	LE DRAINACE CHANNE	с
	JOD NO. 903-6400,220	Made by GAL	Date 7/12171
<b>Associates</b>	Ref.	Checked Hat	Sheet 7 of 25
		Reviewed RCR	

ASSUMPTIONS:

- CN VALUES

CN=95 FOR PROPOSED COVER CN=79 FOR EXISTING CONDITIONS

REACH IA - IE - CHANNEL SECTION FROM CREST TO SOUTHERN EDGE OF EAST HIDE PILE

REACH 2A-2C - CHANNEL SECTION ALONG NORTHEAST EIGE OF PILE

REACH 2D-2F - CHANNEL SECTION ALONG NORTHERN EDGE OF PILE

Golder	SUBJECT DRAINAGE CURDINEL CAURY STOKE						
	Job No. 9,03.41	00.220 Mad	le by	Date 5-11-191			
Associates	Ref. East Hour	Puic Rev	iewed <i>MR</i>	Sheet 3 of 25			
BUTCHIE TO DETE EAST CHOCEDIRE: USE / (See	RHINE THE ARI HOE PILE A PLANIMETER E FIGURE IM	TO FIND BAGP 13	THE AFFAS	CF I THRUGH			
AREA	Area , ({{{}^2})	Area 2	Avg Area (fe <sup>+</sup> )	Aug. Area (acre)			
Ţ	30341	30136	30,264	0.69			
<u>II</u>	48283	48321	48,302	1.1			

8-36 323 8,390 0.19

43,226

0,99

43323

 Image: State
 535994
 56033
 56,014
 1,29

 IMI
 7944
 7905
 7,945
 0,13

43129

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I

NOTE: ALIGNMENT OF DRAINAGE CHANNEL AND CULVERT ALONG 3/7/91) NORTHEAST EDGE OF EAST HIDE PILE HAS BEEN MODIFIED, THE NEW ALIGNMENT AS SHOWN ON SHEET 12-1 SLIGHTLY DECREASES DRAINAGE AREAS THE AND V THUS THIS ANALYSIS IS CONSERVATIVE.

Project ISRT THAT HAR PALE	ву <u>БА</u>	C	Date <u>5/17/</u>	<u>11</u>
Location $(1)_{\alpha} = (\alpha) = f^{\alpha} + \frac{1}{2} + \frac$	Checke	ed	Date <u>and a</u>	
Circle one: Present Developed		<u></u>		
Circle one: T <sub>c</sub> T <sub>t</sub> through subarea				
NOTES: Space for as many as two segments per flow worksheet.	type o	can be us	ed for each	
Include a map, schematic, or description o	of flo∵	segments AREA T	•	
Sheet flow (Applicable to T <sub>c</sub> only) Segment	ID	1		
1. Surface description (table 3-1)		SHOOTH SU	AIFACE OIL	
2. Manning's roughness coeff., n (table 3-1)		0.011	0.011	
3. Flow length, L (total L $\leq$ 300 ft)	ft	147	125	
4. Two-yr 24-hr rainfall, P <sub>2</sub>	in	3,3	3,3	
5. Land slope, s	ft/ft	0.075	0.28	<b></b>
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2 0.5 s^{0.4}}$ Compute $T_t$	hr	0.016	+ 0.007	= 0.024
Shallow concentrated flow Segment	ID			
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s		<u> </u>	
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr		+	-
Channel flow Segment	ID			
12. Cross sectional flow area, a	ft <sup>2</sup>			
13. Werted perimeter, p <sub>w</sub>	ft			
14. Hydraulic radius, $r = \frac{a}{p}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft		,L	<b></b>
19. $T_t = \frac{L}{3600 V}$ Compute $T_t$	hr		+	•
20. Watershed or subarea $T_c$ or $T_t$ (add $T_t$ in step	s 6, 11	i, and 19	) hi	0.024

(210-VI-TR-55, Second Ed., June 1986)

Project ISRT / FAST HODE PILS	By: <u></u>	R	Date <u>5/17</u>	191
Location Doplars 122	Check	edi	Date	<u></u>
Circle one: Present Developed Circle one: T <sub>c</sub> T <sub>t</sub> through subarea	<u> </u>	:		·
NOTES: Space for as many as two segments per fl	ow type	can be us	ed for each	
Worksneet. Include a map, schematic, or description	n of flo∵	segnents		-
Sheet flow (Applicable to T <sub>c</sub> only) Segme	ent ID	22	~b	1
<ol> <li>Surface description (table 3-1)</li> </ol>	•	DENSE	a Broks	
2. Manning's roughness coeff., n (table 3-1) .	•	0.8	0.15	
3. Flow length, L (total $L \leq 300$ ft)	. ft	95	205	
4. Two-yr 24-hr rainfall, P <sub>2</sub>	. in	3.3	3,3	
5. Land slope, s	. ft/ft	0.057	0.049	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2 0.5 s}$ Compute $T_t \dots$	. hr	0 387	+ 0.199	3.586
Shallow concentrated flow Segme	ent ID	20	adtre	(A)
7. Surface description (paved or unpaved)	•	INFLC.	UNEAUST	-
8. Flow length, L	. ft	30	145	
9. Watercourse slope, s	. ft/ft	2.15	0,155	_
10. Average velocity, V (figure 3-1)	. ft/s	6.25	6.3	
11. $T_t = \frac{L}{3600 V}$ Compute $T_t$	. hr	0.0013	+ 0.0054	- 1.0077
Channel flow Segme	ent ID			
12. Cross sectional flow area, a	. ft <sup>2</sup>			
13. Wetted perimeter, p <sub>w</sub>	. ft			
14. Hydraulic radius, $r = \frac{a}{p}$ Compute r	. ft	 		
w 15. Channel slope, s	. ft/ft	L		
16. Manning's roughness coeff., n	•			
Ile Flev level I	. IC/S	<u> </u>	+	1
10. Flow length, L Compute T	. It		+	┥╻┌───
$t = \frac{3600 \text{ V}}{3600 \text{ V}}$	. hr	L	J L	┛ ┝━━━━
20. Watershed or subarea $T_c$ or $T_t$ (add $T_t$ in st	eps 6, 1	1, and 19	)	nr [

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Project ISRT / FAT MOR DUS	By <u>A</u>	<u>n1</u>	Date _	<11191
LocationOut	Checke	ed <u>22</u>	Date_	1 dy 11
Circle one: Present Developed		···		
Circle one: T <sub>c</sub> T <sub>t</sub> through subarea		<u> </u>		
NOTES: Space for as many as two segments per flow worksheet.	type o	an be us	ed for	each
Include a map, schematic, or description of	of flow	segnents	•	
Sheet flow (Applicable to Touchu)		<u> </u>	<u></u>	
Siert How (Applicable to 1 <sub>c</sub> only) Segment	10		+	
I. Surface description (table 3-1)			+	
<ol> <li>Manning's roughness coeff., n (table 3-1)</li> </ol>				
3. Flow length, L (total L $\leq$ 300 ft)	ft			
4. Two-yr 24-hr rainfall, P <sub>2</sub>	in			
5. Land slope, s	ft/ft			
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2 s^{0.4}}$ Compute $T_t$	hr		+	] = []
Shallow concentrated flow Segment	: ID	20	_	
7. Surface description (paved or unpaved)		UNAL FO		
8. Flow length, L	ft	125		
9. Watercourse slope, s	ft/ft	0.104		
10. Average velocity, V (figure 3-1)	ft/s	5.25		
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr	0.0046	+	= 0.0006
Channel flow Segment	ID.		1	
12. Cross sectional flow area, a	ft <sup>2</sup>			
13. Wetted perimeter, p <sub>y</sub>	ft			
14. Hydraulic radius, $r = \frac{a}{P_{}}$ Compute r	ft		<u> </u>	
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft		<u> </u>	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr		+	] = []
20. Watershed or subarea $T_c$ or $T_t$ (add $T_t$ in step	os 6, 11	, and 19	)	hr 0.6

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Project SRT FAST HOL DUG	Ву	<u>n</u>	Date <u>Shala</u>	<u>/_</u>
Location Weight 14	Checke	ed	Date	·
Circle one: Present Developed Circle one: T <sub>c</sub> T <sub>t</sub> through subarea				_
NOTES: Space for as many as two segments per flo worksheet.	ow type o	an be use	d for each	
Include a map, schematic, or description	of flo∵	segments.		
Sheet flow (Applicable to T only) Same	at ID	- <u></u> 	Ī	
$\frac{1}{c} = \frac{1}{c} = \frac{1}$		SHOOTH S	URFACE	
2 Manning's roughness coeff n (table 3-1)	•	A OLI		
2. Remaining a roughness coeff., in (radie $5-7$ ).		13-		
5. Flow length, $E$ (local $E \leq 500$ ff)	, IL 18	1-22		
5 land close o	. IN f+/f-	A ki		
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2 0.5 0.4}$ Compute $T_t$	hr	0.012	+	= 0.CIZ
Shallow concentrated flow Segme	nt ID			
7. Surface description (paved or unpaved)				
8. Flow length, L	. ft			
9. Watercourse slope, s	. ft/ft			
10. Average velocity, V (figure 3-1)	. ft/s			
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	. hr		+	-
Channel flow Segme	nt ID			
12. Cross sectional flow area, a	. ft <sup>2</sup>			
13. Wetted perimeter, p	. ft			
14. Hydraulic radius, r = a Compute r	. ft			
<sup>r</sup> w 15. Channel slope, s	. ft/ft			
16. Manning's roughness coeff., n				1
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	. ft/s			
18. Flow length, L	. ft	ļ,	l	
19. $T_t = \frac{L}{3600 V}$ Compute $T_t$	. hr		+	=
20. Watershed or subarea T or T (add T in st	eps 6, 11	, and 19)	h	r 0.012

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Project ISAT France 26	By 🖉	<u>90</u>	Date <u>5-/,</u>	91
Location Workers 1413	Check	ed	Date	<u>, </u>
Circle one: Present Developed Circle one: T <sub>c</sub> T <sub>t</sub> through subarea	<u> </u>			
NOTES: Space for as many as two segments per flow worksheet.	type (	can be us	ed for each	
Include a map, schematic, or description o	of flo∵	segments	•	
		<u>APC</u>		1
Sheet flow (Applicable to T <sub>c</sub> only) Segment	: ID	4		
1. Surface description (table 3-1)		GE. S		1
2. Manning's roughness coeff., n (table 3-1)		0.15		1
3. Flow length, L (total L $\leq$ 300 ft)	ft	250		1
4. Two-yr 24-hr rainfall, P <sub>2</sub>	in	3.3		-
5. Land slope, s	ft/ft	0.16	<u></u>	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2}$ Compute $T_t$ ,	hr	0.146	+	= 0,146
Shallow concentrated flow Segment	: ID			
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr		+	] -
Channel flow Segment	ID.			]
12. Cross sectional flow area, a	ft <sup>2</sup>			
13. Wetted perimeter, p	ft			
14. Hydraulic radius, $r = \frac{a}{p}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr		+	] = []
20. Watershed or subarea T or T (add T in step	os 6, 11	l, and 19	)h	r 0.146

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Project	By	R	Date <u>5-1141</u>	<u>.</u>
Location <u>Norman</u> 14	Checke	id <u></u> i	Date	<u>11</u>
Circle one: Present Developed			······································	
Circle one: T <sub>c</sub> T <sub>t</sub> through subarea				
NOTES: Space for as many as two segments per worksheet.	flow type o	an be us	ed for each	
Include a map, schematic, or descripti	ion of flow	segments <u>AP</u>	-AI	_
Sheet flow (Applicable to T <sub>c</sub> only) Seg	gment ID	5		
<ol> <li>Surface description (table 3-1)</li> </ol>	• • • •	SHOOTH S BULF SI	URCAI <b>G</b>	
2. Manning's roughness coeff., n (table 3-1)	)	0.011		
3. Flow length, L (total L $\leq$ 300 ft)	ft	2-13		
4. Two-yr 24-hr rainfall, P <sub>2</sub>	in	5.3		
5. Land slope, s	ft/ft	0.185		
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute $T_t \dots$	hr	0.016	] + [	• 0.0i6
Shallow concentrated flow Seg	gment ID			
7. Surface description (paved or unpaved)	• • • •			Į
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1)	ft/s			
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t \dots$	hr		+	] = [
Channel flow Seg	ment ID			]
12. Cross sectional flow area, a	ft <sup>2</sup>			
13. Wetted perimeter, p <sub>w</sub>	ft			
14. Hydraulic radius, $r = \frac{a}{p}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n	• • • •			
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s			
18. Flow length, L	ft		<u> </u>	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t \dots$	hr		+	-
20. Watershed or subarea T_ or T_ (add T_ in	steps 6, 11	, and 19	)h	r 0.016

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Worksheet 3: Time of concentration (	T <sub>c</sub> ) or travel t	ime (T <sub>t</sub> )	10/2:
Project _ 3RT IF IST MOT PILS	By MC	Date <u>5/14/91</u>	
Location 10000000 Mg	Checked 20	Date 51121/91	
Circle one: Present Developed Circle one: T <sub>c</sub> T <sub>t</sub> through subarea	··· '		<u> </u>
NOTES: Space for as many as two segments per flow worksheet.	type can be use	ed for each	
Include a map, schematic, or description o	of flow segments	· 1	
Sheet flow (Applicable to T <sub>c</sub> only) Segment	ID 6	RCVE	
1. Surface description (table 3-1)	EN E		
2. Manning's roughness coeff., n (table 3-1)	0.011		
3. Flow length, L (total L $\leq$ 300 ft)	ft <u>275</u>		
4. Two-yr 24-hr rainfall, P <sub>2</sub>	in <u>3,3</u>		
5. Land slope, s	ft/ft 0.061		
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute $T_t$	hr 0.028	+ 0,028	
Shallow concentrated flow Segment	ID		
7. Surface description (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity, V (figure 3-1)	ft/s		
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr	+ =	
Channel flow Segment	ID		
12. Cross sectional flow area, a	ft <sup>2</sup>		
13. Wetted perimeter, p	ft		
14. Hydraulic radius, $r = \frac{a}{r}$ Compute r	ft		
<sup>P</sup> w 15. Channel slope, s	ft/ft		
16. Manning's roughness coeff., n			
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		
18. Flow length, L	ft		•
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute $T_t$	hr	+	
20. Watershed or subarea $T_c$ or $T_t$ (add $T_t$ in step	s 6, 11, and 19)	) hr 0.028	Ì

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### Figure 3-1.--Average velocities for estimating travel time for shallow concentrated flow.

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3.2

### Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute  $T_t$ :

$$T_{t} = \frac{0.007 (nL)0.8}{(P_{2})0.5 s0.4}$$
 [Eq. 3-3]

## Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n¹
Smooth surfaces (concrete, asphalt, gravel, or	
bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses <sup>2</sup>	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: <sup>3</sup>	
Light underbrush	0.40
Dense underbrush	0.80

<sup>4</sup>The n values are a composite of information compiled by Engman (1986).

<sup>3</sup>Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

<sup>3</sup>When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

### where

- $T_t = travel time (hr),$
- n = Manning's roughness coefficient (table 3-1),
- L = flow length (ft),
- $P_2 = 2$ -year, 24-hour rainfall (in), and
- s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

### Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

#### **Open channels**

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.



## TR-55 TABULAR DISCHARGE METHOD

Project : I County : M Subtitle: E	SRT Niddlesex Sast Hide Pile	State: MA	User: RAC Checked:	Date: 07-16-91 Date:
Total water	shed area: 0.	001 sq mi Rainfall	type: III Freq	uency: 100 years
Area(sq mi) Rainfall(in Curve numbe Runoff(in) Tc (hrs) TimeToOutle Ia/P (Used)	I 0.00 0.00 0.02 0.10 0.02 0.10	Suba	reas	
Time Total (hr) Flow	I	Subarea Contributio	on to Total Flow	(cfs)
11.0011.3011.6011.9112.0212.1312.2412.34	0 0 1 2 3 P 4P 4			
12.4       2         12.5       2         12.6       1         12.7       1         12.8       1         13.0       1         13.2       0         13.4       0	2 2 1 1 1 1 0 0			
13.6013.8014.0014.3014.6015.0015.5016.00	0 0 0 0 0 0 0			
16.5 0 17.0 0 17.5 0 18.0 0 19.0 0 20.0 0 22.0 0 26.0 0 P - Peak F1	0 0 0 0 0 0 0			

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VERSION 1.11

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Projection ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) (	ct : ISR' y : Mide tle: Eas	r dlesex t Hide Pil	Sta	ate: MA	User: Checked:	RAC	Date: 07-16-93 Date:	L 
Total	watersh	ed area:	0.002 sq m	i Rainfal	l type: III	Freq	uency: 100 years	
Area( Rainfa Curve Runoff Tc (h TimeTc Ia/P	sq mi) all(in) number f(in) rs) (Used) pOutlet (Used)	II 0.00 6.6 79 4.22 0.60 0.50 0.00 0.08 0.10		Sub	areas			
Time (hr)	Total - Flow	II	Subarea	Contribut	ion to Total	Flow	(cfs)	
$11.0 \\ 11.3 \\ 11.6 \\ 11.9 \\ 12.0 \\ 12.1 \\ 1^{2}.2 \\ 3$	0 0 0 1 1 2	0 0 0 1 1 2						
12.4 12.5 12.6 12.7 12.8 13.0 13.2 13.4	2 3P 3 2 2 1 1	2 3P 3 2 2 1 1						
13.6 13.8 14.0 14.3 14.6 15.0 15.5 16.0	1 0 0 0 0 0 0	1 0 0 0 0 0 0						
$ \begin{array}{c} 16.5 \\ 17.0 \\ 17.5 \\ 18.0 \\ 19.0 \\ 0 \\ 26.0 \\ \end{array} $	0 0 0 0 0 0 0							
P - Pe	eak Flow							

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Project : ISRT County : Midd Subtitle: East	llesex Hide Pile	State: MA	User: RAC Checked:	Date: 07-16-91 Date:
Total watershe	d area: 0.00	0 sq mi Rainfall	type: III Free	quency: 100 years
Area(sq mi) Rainfall(in) Curve number Runoff(in) Tc (hrs) TimeToOutlet Ia/P (Used)	III 0.00 6.6 95 6.01 0.10 0.00 0.02 0.10	Subai	reas	
Time Total (hr) Flow	III	ubarea Contributio	on to Total Flow	(cfs)
11.0011.3011.6011.9012.0012.11P12.2112.31	0 0 0 1 P 1 1			
12.4       1         12.5       0         12.6       0         12.7       0         12.8       0         13.0       0         13.2       0         13.4       0	1 0 0 0 0 0 0 0			
13.6013.8014.0014.3014.6015.0015.5016.00	0 0 0 0 0 0 0 0			
16.5       0         17.0       0         17.5       0         18.0       0         19.0       0         20.0       0         22.0       0         26.0       0	0 0 0 0 0 0 0 0			

### TR-55 TABULAR DISCHARGE METHOD

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Total watershed area: 0.002 sq mi Rainfall type: III Frequency: 100 years ----- Subareas IV . Area(sq mi) 0.00 Rainfall(in) 6.6 Curve number 79 Runoff(in) 4.22 Tc (hrs) 0.15 (Used) 0.10 TimeToOutlet 0.00 Ia/P 0.08 (Used) 0.10 Time Total ------ Subarea Contribution to Total Flow (cfs) ------(hr) Flow IV 12.42212.52212.61112.71112.81113.01113.20013.400 13.60013.80014.00014.30014.60015.00015.50016.000 22.0 0 0 0 26.0 0

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## TR-55 TABULAR DISCHARGE METHOD

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Project : County : Subtitle:	ISRT Midd East	lesex Hide Pi	Sta le	te: MA	User: R Checked: _	AC Date: Date:	07-16-91
Total wate	ershe	d area:	0.002 sq mi	Rainfall	type: III	Frequency: 1	00 years
Area(sq m Rainfall( Curve num Runoff(in Tc (hrs) TimeToOut Ia/P (Use	- in) ber ) let ed)	V 0.00 6.6 95 6.01 0.10 0.00 0.02 0.10		Suba		Flow (cfs)	
Time Tot (hr) Flo	al w	v	Subarea	Contributi	on to Total	FIOW (CIS) -	
11.0 11.3 11.6 11.9 12.0 12.1 12.2 12.3	0 1 3 4 6 10P 8	0 1 3 4 6 10P 8					-
12.4 12.5 12.6 12.7 12.8 13.0 13.2 13.4	5 4 3 2 1 1 1	5 4 3 2 2 1 1 1					
13.6 13.8 14.0 14.3 14.6 15.0 15.5 16.0	1 1 1 1 1 0 0	1 1 1 1 0 0					
16.5 17.0 17.5 18.0 19.0 20.0 22.0 26.0		0 0 0 0 0 0 0					

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## TR-55 TABULAR DISCHARGE METHOD

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jeo nty Subti	ct : ISR' y : Mide tle: Eas	T dlesex t Hide Pi	le	Stat	e: MA	User: Checked:	RAC	Date: Date:	07-16-91
Total	watersh	ed area:	0.000 s	sq mi	Rainfall	type: III	Freq	uency: 10	0 years
Area(s Rainfa Curve Runoff Tc (hr TimeTc Ia/P	sq mi) all(in) number f(in) rs) oOutlet (Used)	VI 0.00 6.6 95 6.01 0.10 0.00 0.02 0.10			Suba	Leas			
Time (hr)	Total - Flow	VI	Suba	area C	ontributio	on to Total	Flow	(cfs)	
11.0 11.3 11.6 11.9 12.0 12.1 1 <sup>2</sup> .2 3	0 0 0 1 P 1 1	0 0 0 1 1 1 1							
12.4 12.5 12.6 12.7 12.8 13.0 13.2 13.4	1 0 0 0 0 0 0	1 0 0 0 0 0 0							
13.6 13.8 14.0 14.3 14.6 15.0 15.5 16.0	0 0 0 0 0 0	0 0 0 0 0 0 0							
$ \begin{array}{c} 16.5 \\ 17.0 \\ 17.5 \\ 18.0 \\ 19.0 \\ 0 \\ 0 \\ 26.0 \\ \end{array} $		0 0 0 0 0 0 0							
P - Pe	eak Flow								

rainage Channel		May 17,1991	August 6,1991
East Hide Pile Di	903-6400.220	Date created:	Date revised:

Mannings equation

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velocity (ft/s)	3.4	6.2	7.3	5.6	6.3	2.8	5.5	7.0	4.5	3.6	2.7
Qmax (cfs)	8.0	9.4	8.2	8.3	9.4	5.3	6.1	17.6	16.9	17.6	16.7
required discharge (cfs)	7	2	7	7	7	S	5	16	16	16	16
design depth (ft)	0.70	0.50	0.40	0.50	0.50	0.60	0.40	0.50	0.70	0.85	0.42
Manning's n	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035
riprap D50 (ft)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
channel slope (ft/ft)	0.018	0.087	0.153	0.069	0.088	0.014	0.085	0.094	0.026	0.014	0.014
base width (ft)	2	0	2	2	2	2	2	4	4	4	14
side slope 2	2	2	2	2	2	2	2	2	2	0	2
side ANNEL slope 1	N	2	0	2	0	2	0	2	0	5	s 2
CH	1A	18	<u>0</u>	<u>0</u>	μ	2A	2B	SC	2D	2E	tran

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16-20

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Golder	SUBJECT CULVERT	CALCULATIONS- EH	5
Associates	Job No. 913-6-101.220 Ref.	Made by the C Checked Fills	Date 7/35/7/ Sheet 10 of 25
		Reviewed R.R	

OBJECTIVE: TO DETERMINE THE SIZE OF THE CONCRETE CULVERTS BASED UPON THE MAXIMUM EXPECTED FLOW.

METHOD : USE THE PROCEDURE OUTLINED IN CONCRETE DESIGN MANUAL FOR THE SELECTION OF CULVERT SIZE.

REFERENCE : CONCRETE DESIGN MANJUAL, Prepared by AMERICAIN CONCRETE PIPE ASSOCIATION, FEBRUARY 1985

ASSUMPTIONS :

- 1) CULVERT I IS LOCATED AT THE SOUTHEAST EDGE OF THE EAST HIDE PILE
- 2) CULVERT 2 IS LOCATED AT THE NORTHEAST EDGE OF THE EAST HIDE PILE
- 3) EXPECTED MAXIMIM FLOW 15 BASEDOND THE 241 Hour, 100 YEAR STOPIN RAINFALL + 6.6 IN

Golder	SUBJECT CULVERT CALCULAT	101US-EHP
	Job No. 93-6-100.228 Made by RA	$C$ <b>Date</b> $\frac{1}{7}$ <b>Date</b> $\frac{1}{7}$
Associates	Ref. Checked ALK Reviewed	R Sheet 23 of 25

CALCULATONS:

CULVERT <u>1</u> USE CULVERT CADACITY CHARTS Q = 7 efs L = 53 feet So = 6.6 % HW = 1.5 ft ASSUME CONCRETE CULVERT, 18 INCH DAME FR FROM FIG. 44 TNLET CONTROL HW = 1.45 ft OUTLET CONTROL HW = 1.75 ft HW = 1.7 ft = 0.066 (53 ft) = -1.8

INLET HEADWATER IS CREATER THAN OUTLET HEADWATER, THEREFORE INLET CONTROL GOVERNS AN 18 INCH DIAMETER WILL BE ADEQUATE

CULVERT 2 USE CULVERT CAPACITY CHARTS Q = 5 CES L = 154 FL SJ = 17 % HW = 1.5 FL Assume CONCRETE CULVERT, 18 INCH DIAMETER FROM Fig 44 INLET CONTROL HW = 1.2 FL OUTLET CONTROL HW + SJL = 1.7 FL

Golder	SUBJECT CULUERT	CALCHLADOUS- EH	5
	Job No. 903 6-100.220	Made by RAC	Date 7/25/91
Associates	Ret.	Checked ALK	Sheet 34 of 25
		Reviewed PER	

CALCULATIONS (CONE'd)

CUTLET CONTROL

HW= 1.7 ft- 154ft(0.17) = -24.5 ft

INLET HEADWATER IS GREATER THAN OUTLET HEADWATER, THEREFORE INLET CONTROL GOVERNS. AN 10 INCH DIAMETER WILL BE ADEQUATE



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APPENDIX 12-H Access Road Calculations

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Golder Associates	SUBJECT East Hide Pile Gravel Access Road Job No. 903-6400 Made by DOKL Date 5/19/92 Ret. INDUSTRI-PLEX Checked PCN Sheet 1 of 4 WOBURN/MA Reviewed PCC PSP Sheet 1 of 4
Objective =	To determine the material cross-section of a gravel access road to gas treatment plant at the East Hide Pile
Method =	1) Determine the wheel load 2) Estimate the CBR of the subgrade and subbase material 3) Estimate the thickness of the gravel layer and subbase layer from Figure 1 based on the values of CBR of the subbase and subgrade layers.

Rejevences : 1) Dureau of Minus Information Circular IC 8758, 1977. 2) Golder 1990 Pre-Design Investigation Task S-4, Foundation Data, Interim Final Report, Industri-Plex Site, Woburn MA Sept.

Golder	SUBJECT East Hide Pile Gravel Access Road			
Associates	Jab No. 903-6400 Ret. INDUSTRI - PLEX /WOBURN/MA	Made by SORL Checked PCN Reviewed PCC FSI	Date 5/19/92 Sheet 2 of 4	

Assumptions : 1)

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and	its	cargo	o is	8° +	ono.	
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- 2) Underlying Doil: coarse to fine Dand with Some gravel, Dilt, repples and copples (taken from Ref. 2) From Fig I, CBR of the subgrade is estimated to be about 15.
- 3) Subbase fill is a mixture of sand gravel and fines. From Fig 1. CBR of subbase material is estimated to be 40.
- 4) Surface course is AASHTO #57 stone From Fig I CBR of the surface cour is estimated to be about 60
- 5) Minimum road section thickness in 16 inches to meet cover requirement.

Golder	SUBJECT East Hide Pile Gravel Access Road			
Associates	JOB NO. 903-6400 Ret. INDUSTRI-PLEX. IWOBURN / MA	Made by BOKL Checked PCN Reviewed PCC (Sf	Date 5/19/92 Sheet 3 of 14	

Calculations = 1) Maximum weight of truck and its cargo is 8 tono. wheel load = 8 x 2000 1b = 4000 1b. 4 wheel 2) Required suppose thickness For subgrade with CBR of 15. From Fig 1, the minimum subpase thickness is 5.5 in ≈ 6 inches. 31 Required sur Jace course thickness For Auphase with CBR of 40. From Fig I, the minimum our Jace course thickness is 3 inches 4) Minimum required section thickness is 16 inches in Use 13 inches of road subbase fill under 3 inches of AASHTO #57 surface course Use Geotextile to underlie fill section


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LAANGES FOR SOIL TYPES ARE APPROXIMATE; BASE DESIGNS ARE ON ACTUAL TEST REGULTS

FIGURE 1 - CBR curves.

relation to subgrade characteristics. To be completely accurate, it necessitates CBR tests to precisely determine the bearing capabilities of both subgrade and subbase materials. These tests can be conducted by a soil-testing laboratory at relatively minimal cost simply by submitting samples of the subgrade and subbase materials.

The curves of figure 18 depict subbase thickness requirements for a wide range of CBR test values. To serve as a general indication of the subbase thicknesses required for various subgrade soil types, ranges of bearing ratios

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# CHAPTER 13

# STREAM AND WETLAND SEDIMENTS REMEDIATION

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#### CHAPTER 13

#### STREAM AND WETLAND SEDIMENTS REMEDIATION

# 13.1 INTRODUCTION

This chapter outlines the remedial actions selected for the stream and wetland sediments which contain Arsenic, Lead and/or Chromium above Consent Decree Action Levels within the boundaries of the Site.

Wetlands within the project Site were delineated and described in a previous report by Wetlands Management Specialists, Inc. (WMS, 1986). Figure 13-1 shows the Wetlands Location Map, reproduced from Figure 1 of the WMS report, and the present Site boundary. The WMS report covered a study area larger than the present Site and identified the wetlands with numbers from one through nine. Some of the wetlands were further designated with suffixes A, B, C, etc. Thirteen of the wetlands shown on Figure 1 of the WMS report are located within the present Site limits. These are: 1C, 2A, 2B, 3A, 3B, 3C, 3D, 3E, 7A, 7B, 7C, 8, and part of 6A. 13.2 REMEDIAL DESIGN WORK PLAN REQUIREMENTS

The Remedial Design Work Plan (RDWP; Golder, 1990) requires the 100% Design Report to provide the following information:

"Development of final sediment excavation methodology, sections for wetlands revitalization, additional remediation and/or revitalization techniques, and monitoring plan" (p. 57)

In accordance with this requirement, this chapter discusses the remedial actions for each specific stream and wetland for which the sediments need to be remediated and the associated designs for the remediation are provided. Mitigation of wetlands impacts due to sediment remediation is discussed in Chapter 14.

# 13.3 CONSENT DECREE REQUIREMENTS

The Consent Decree (USEPA, 1989a) briefly explains the work to be performed and establishes in the RDAP the requirements for remediation of sediments. Sediments within streams and wetlands where there are "no odoremitting Hazardous Substances (e.g. hide wastes),...shall dredge the Hazardous Substances or remove them by another method shown to be environmentally protective and approved by the EPA in consultation with the Commonwealth" (p. 5).

The RDAP mandates an in-situ cover for areas with sediments containing Arsenic, Lead, and/or Chromium at or above Consent Decree action levels, hide and residues. stipulating activities that these capping will be consistent with other technical requirements of the RDAP (p.6).

Following the criteria described above and the extent of Arsenic, Lead and/or Chromium above Consent Decree action levels shown in Sheets 11-2A through 2D, seven of the WMSdelineated wetlands (1C, 2A, 3B, 7A, 7B, 7C, and 8) have sediments that require remediation. In order to refine the extent of remediation in Wetlands 3B and 8, a limited program of supplementary sediment sampling was carried out in June 1991 and the results are presented as Appendix 13-A. In addition to these seven wetlands there are two channels in which the sediments also must be remediated. These are the New Boston Street Drainway, including the culverted portion and the channel connecting the culvert to Wetland 8, and the channel draining into the New Boston Street Drainway from the west.

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Although Wetland 3B does include some sediment containing lead in excess of ROD action levels, remediation of this wetland is not to occur at the specific direction of the USEPA (USEPA letter dated March 4, 1992 to ISRT).

The nine streams and wetlands with sediments that are to be remediated are shown on Sheet 13-1. The guidelines for the remediation of the stream and wetland sediments are discussed in the following sections.

Finally, the RDAP requires that excavated sediments be "consolidated in other areas of the Site which contain such Hazardous Substances and which will be covered as part of the approved remedial action" (p. 5). 13.4 STREAM SEDIMENTS REMEDIATION

This section discusses the guidelines for remediation of stream sediments. Wetlands 2A and 7C that are elongated in shape and have flow patterns typical of streams are also included in this section. Including these two wetlands, the streams that require sediment remediation are:

- The Western Branch of the Aberjona River (Wetland 2A);
- The Atlantic Avenue Drainway (Wetland 7C);
- The New Boston Street Drainway, including the culverted portion and the channel connecting the culvert to Wetland 8; and
- The channel draining into the New Boston Street Drainway from the west.

Additionally, the culverts associated with the Western Branch of the Aberjona River, the Atlantic Avenue Drainway, and the New Boston Street Drainway will be cleaned.

#### 13.4.1 Remediation Requirements for Stream Sediments

The streams on the Site have several functions. These functions are the collection of stormwater from surrounding drainage areas, the conveyance of stormwater from upstream, and the storage of backwaters during a storm.

The remedy for streams sediments must allow satisfactory performance of these functions. Additionally, the following criteria were considered in the selection of the remedy:

- Ability to perform in accordance with their design objectives for a minimum of 30 years;
- Satisfactory performance under varying groundwater conditions and to prevent sediment transport via groundwater seepage toward the stream;

- Prevention of surface water from contacting sediments and, possibly, transporting them downstream;
- Minimization of storage capacity losses;
- Satisfactory performance under variable weather conditions;
- Maintenance of discharge capacity so that peak discharges can be conveyed without increasing the flood potential;
- Prevention of erosion;
- Minimization of excavation of hide residues; and,
- Continued ability to collect runoff from the surrounding drainage areas.

# 13.4.2 Selected Remedies

The first stream sediment remedy, for streams containing Arsenic, Lead and/or Chromium at or above Consent Decree action levels, in the absence of hide residues, consists of a gravel/cobble cap to be placed after dredging the sediments. A minimum of 16 inches of sediments, is to be dredged followed by placement of a 16 ounce nonwoven geotextile and a 16 inch gravel/cobble cap with a  $d_{50}$  of 3 inches (see Detail C on Sheet 13-2). This remedy has been selected for the channel draining into the New Boston Street Drainway from the west, the northern portion of the New Boston Street Drainway, and the Atlantic Avenue Drainway. Although the northern portion of the New Boston Street Drainway and the channel draining from the west contain some hide residues, this remedy is being applied to these streams under the direction of the USEPA in order to minimize impacts upon this portion of the industrial park. The Atlantic Avenue Drainway has also been determined to contain hide residues at some locations, but will also receive this remediation in order to preserve its current hydrologic conditions and allow it to function as the

#### **Golder Associates**

recharge basin. The design for the Atlantic Avenue Drainway is presented in Chapter 9.

The second stream sediment remedy, for streams containing Arsenic, Lead and/or Chromium at or above Consent Decree action levels and hide residues, utilizes the same cover but with the minimum amount of dredging consistent with maintaining storm flow capacity. The decision to dredge hide residues in this manner was made to comply with requests from the Agencies. The cover in such locations will comprise a 16 ounce non-woven geotextile overlain by a 16 inch thick gravel/cobble cap. This remedy will be implemented in the following areas:

- The western portion of the Western Branch of the Aberjona River (Wetland 2A); and,
- The portion of the New Boston Street Drainway adjacent to Wetland 8.

The gravel/cobble lined channels are to have a minimum base width of 4 feet and side slopes of one to one or flatter. The base width of each channel is indicated in Sheet 13-1. At locations where the gravel/cobble lined channels will sections culverts, transition connect to have been incorporated to match the designed channel bottom width to the dimensions of the culvert (see Detail 1 on Sheet 13-3). These transition sections are 6 feet in length and maintain the channel's one to one side slope. Six foot long transitions have also been designed to smoothly vary the channel width when required (see Detail 1 on Sheet 13-2). Transitioning between gravel/cobble lined streams and existing stream beds has been provided (see Detail 2 on Sheet 13-3).

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	_	_	_	_	_	

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The third stream sediment remedy consists of culvertization. This remedy has been selected only for the portion of the Western Branch of the Aberjona River adjacent to the East Central Hide Pile where regrading of the hide pile slope, for stabilization reasons, does not allow other solutions. A 24 inch diameter reinforced concrete pipe will be bedded in a 6 inch minimum layer of AASHTO No. 57 coarse aggregate, and backfilled with previously excavated material (see Detail 4 on Sheet 13-3).

The fourth stream sediment remedy selected is the cleaning, by means of flushing, of culverts connecting channels which require remediation.

Table 13-1 summarizes these remedies as applied to the stream sediments requiring remediation.

# 13.5 WETLAND SEDIMENTS REMEDIATION

The wetlands in which sediment remediation is to be undertaken are 1C, 7A, 7B and 8, as identified on Sheet 13-1. For these wetlands, there are two possible situations. First, where Arsenic, Lead and/or Chromium concentrations exceed Consent Decree action levels in the absence of hide residues, the sediments will be dredged to a depth of 16 inches and a permeable cap placed. The permeable cap will consist of a 16 ounce nonwoven geotextile at the bottom of the excavation followed by 8 inches of gravel to discourage animal burrows, and 8 inches of topsoil, meeting the wetlands mitigation requirements presented in Chapter 14. The area to be dredged will be determined by the extent of standing water at the time of dredging plus an additional approximate 10-foot strip around the wetland above the water level. An additional area may need to be dredged for construction practicality and, in some locations, above grade capping around the dredged area may be required as part of the permeable cover. This remedy will be used for part of Wetland 1C.

Second, where Arsenic, Lead and/or Chromium exceed Consent Decree action levels and hide residues were found, a 16 inch thick permeable cap will be placed over the sediments; this remedy will be used for part of Wetland 1C and for Wetland 8. For the part of Wetland 1C, the permeable cap will consist of a 16 ounce nonwoven geotextile placed on the sediments, followed by 8 inches of gravel to discourage animal burrows, and a 8 inch layer of topsoil, meeting the wetlands mitigation requirements of Chapter 14. For Wetland 8 the permeable cap will consist of a 16 ounce nonwoven geotextile placed on the sediments, followed by a 12 inch soil cover with a 4 inch thick topsoil layer. The prevention of animal burrows in Wetland 8 is not а remediation goal, because this shallow wetland will be

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completely eliminated by the covering required by the Consent Decree (see Chapter 14).

In all cases, at specific locations where velocities or wave action may cause erosion, gravel/cobble protection has been included in the design.

The Chromium Lagoons (Wetlands 7A and 7B) will be filled completely due to the high metal concentrations and hide residues present, and their low wetland value. The filled lagoons will then be capped with a permeable cover meeting the requirements of Chapter 11.

Transitions between remediated and nonremediated sections of the wetlands have been designed (see Sheet 13-4). In areas where remediation has caused an elevation difference between areas in the wetlands, a 10 percent slope grade change will be incorporated.

The excavation of animal burrows in the permeable cover within Wetlands 1C will be discouraged by the use of gravel in the cover as follows. An 8 inch layer of gravel will be placed directly on the geotextile and covered with appropriate soil to provide a total cover thickness of 16 inches. This gravel medium will also be placed in a 10 foot wide skirt around the perimeter of the area undergoing remediation. This gravel barrier will inhibit burrowing by the mammals, reptiles, and amphibians expected to inhabit the remediated wetlands.

Table 13-2 summarizes these three remedies as applied to the wetland sediments requiring remediation and details are presented on Sheet 13-4.

## 13.6 RELATED STRUCTURES

In addition to the specific remediation designs, additional structures have been designed to supplement stormwater management. These additional structures are used to regulate and channel stormwater through the Site. The structures are as follows:

- Extension of the Atlantic Avenue Drainway;
- Channel connecting Wetland 1C and the Wetland Creation Area;
- Multi-stage stormwater outflow structure;
- Roadway culverts; and,
- Stormwater holding areas.

The extension of the Atlantic Avenue Drainway has been created in order to maintain a positive outflow from the created wetland area and to assist in the management of storm flows. This extension will connect the created wetland area to the existing Atlantic Avenue Drainway (see Sheet 13-1). The extension will have a 3 foot bottom width and one to one side slopes (see Detail D on Sheet 13-2).

The channel connecting Wetland 1C and the Wetland Creation Area will supply surface water to the created wetland area and provide a corridor for wildlife. The channel will have a 4 foot bottom width with 2H:1V side slopes. Lining the channel will be a 16 inch gravel/cobble layer with a  $d_{50}$  of 3 inches. Underlying the gravel/cobble lining will be 16 ounce non-woven geotextile. Underlying the 16 ounce nonwoven geotextile will be a 6 inch thick layer of silty clay loam to enhance surface water retention in the wetland creation area.

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A multi-stage stormwater outflow structure will control the outflow from the created wetland area (see Detail 1 on The structure will act to detain peak storm Sheet 13-5). flows in the created wetland area, and is designed to allow manipulation of water levels during some initial establishment of the wetland. When a suitable wetland hydrology has been established, the outflow levels will be permanently fixed.

Modifications to the Site grading have made it necessary to design culverts to transfer stormwater at some locations. All culverts have been designed with prefabricated flared end sections (see Detail 2 on Sheet 13-5) to improve their hydraulics at the entrance and exits. Culvert exits have also been designed with rip-rap aprons to protect against erosion.

Three areas will be excavated to hold stormwater (see Sheets 13-1 and 13-6). These areas have been created to help balance the stormwater storage losses resulting from the remediation. The stormwater holding areas will also contain additional storm runoff that will be generated from areas of the Site where soils are being covered with asphalt. These holding areas will be excavated with three to one side slopes and vegetated to prevent erosion. Discharges from the holding areas will be directed to either the New Boston Street Drainway, the storm sewer in New Boston Street, or to the storm sewer leading to the channel adjacent to Wetland 8. The design of these stormwater storage areas is conceptual and will be confirmed upon review of the conditions existing at the time of remediation.

# 13.7 EXCAVATION TECHNIQUES

The excavation techniques for the stream sediments will entail the use of either a backhoe or a dragline. The excavation techniques for the wetland sediments may involve the use of suction dredging, backhoe, or a dragline. The method will depend upon factors such as the standing water area at the time of excavation in relation to the reach of the equipment and contractor's preference.

The excess water in the sediments will be removed prior to placement of the sediments in other areas of the Site that will receive permeable cover. Dewatering of the sediments will be achieved by an approved method so that the compaction performance specification may be attained.

During the excavation of sediments potentially containing hide residues, odor control techniques outlined in Section 01563 of the Specifications will be implemented.

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#### 13.8 CONCLUSION

The Consent Decree, via the RDAP, establishes the requirements for the remedies for the stream and wetland sediments. The results of the application of these criteria are the remedial actions discussed within this chapter.

The main sediments remedy selected for the streams consists of dredging and capping with a gravel/cobble cover. When the main remedy is not applicable because other conditions prevail, the alternative culvertization has been designed. Cleaning of existing culverts adjacent to remediated streams has also been included as part of the remedy.

The remedies selected for the various wetlands are:

- Dredging and capping;
- Capping; and
- Filling and capping.

#### REFERENCES

Golder Associates Inc., 1990. <u>Remedial Design Work Plan</u>, Industri-Plex Site, Woburn, MA, July.

USEPA, see U. S. Environmental Protection Agency.

U. S. Environmental Protection Agency, 1989a. <u>Industri-</u> <u>Plex Site Consent Decree</u>, Civil Action 89-01960MC, April.

Wetlands Management Specialists, 1986. <u>Floodplain and</u> <u>Wetlands Assessment</u>, Woburn Industri-Plex 128, Superfund Site, Woburn, Massachusetts.

# TABLE 13-1 SUMMARY OF STREAM SEDIMENTS REMEDIATION

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NAME OF WATERBODY	CHANNEL TYPE	
Atlantic Avenue Drainway (Wetland 7C)	Man-made	Dredge the upper 16 inches and place a gravel/cobble cover
New Boston Street Drainway	Man-altered	Dredge the upper 16 inches and place a 16 inch gravel/cobble cover in the northern portion of the New Boston Street Drainway, and limited dredging and placement of a 16 inch gravel/cobble cover for the portion adjacent to Wetland 8
Channel draining into New Boston Street Drainway from the west	Man-altered	Dredge the upper 16 inches and place a gravel/cobble cover
Western Branch of Aberjona River (Wetland 2A)	Man-made	Limited dredging and placement of a 16 inch gravel/cobble cover in the western portion; place a hydraulically sized concrete culvert in the eastern portion

	TABLE 13-2 SUN	MARY OF WETLAND SEDIMENTS REMEDIATION
NAME OF WATERBODY	TYPE	PRELIMINARY REMEDIATION
Wetland 8	Natural	Place an above grade permeable cap
Wetland 1C	Man-altered	Dredge a minimum of 16 inches and place an at grade permeable cap in areas with metals at or above Consent Decree action levels. Place an above grade permeable cap in areas with metals at or above Consent Decree action levels and hide residues
Chromium Lagoons (Wetlands 7A & 7B)	Man-made	Filling and capping

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APPENDIX 13-A Supplementary Sediment Sampling

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## LIST OF ATTACHMENTS

Attachment A - Technical Procedures Attachment B - Borehole Logs Attachment C - Chain of Custody Forms Attachment D - Laboratory Report Attachment E - Data Quality Assessment

**GOLDER ASSOCIATES** 

## 1.0 INTRODUCTION

Supplementary sediment sampling was undertaken in order to further refine the extent of arsenic, lead, and chromium above Consent Decree action levels in selected wetlands at the Industri-Plex Site. The samples were also examined for the presence of hide residue. This sampling supplemented previous sampling undertaken as part of Pre-Design Investigation (PDI) Task SW-1 (Golder Associates Inc., 1990).

This report outlines the work which was conducted, presents the results, and documents the data quality assessment. Supporting documents, such as borehole logs, chain of custody forms, and laboratory analyses are included as attachments to this Appendix.

#### August 1991

# 2.0 SUPPLEMENTARY SEDIMENT SAMPLING

All work was conducted in accordance with the Golder Associates Inc. Technical Procedures given in the PDI Field Sampling Plan (Golder Associates Inc., 1989a) included as Attachment A to this Appendix.

Sediment sampling was carried out at five locations in Wetland 3B and two locations in Wetland 8. Sample locations are shown on Sheets 11-2B and 11-2C. Except for location 123, five samples were taken from each borehole in Wetland 3B at the following depths: 0-6 inches, 6-12 inches, 12-18 inches, 18-27 inches, and 27-36 inches. Only the 0-6 inch and 6-12 inch samples were collected at location 123. In Wetland 8, three samples were taken from each borehole at the following depths: 0-6 inches, 6-18 inches and 18-36 inches. The two boreholes in Wetland 8 were used only to assess whether hide residue was present, since extensive metals data was available at this location. Three samples from each borehole were considered sufficient for this purpose. Samples were collected, using a hand auger, by a drilling contractor under the supervision of a Golder Associates field geologist.

Quality Control samples were collected at a rate of one per twenty primary samples, including matrix spikes, matrix spike duplicates, field duplicates and equipment rinsate blanks.

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### 3.0 SAMPLE ANALYSIS AND DATA QUALITY ASSESSMENT

Analyses for arsenic, lead, and chromium were performed by Savannah Laboratories according to SW-846 methods as presented in the PDI Quality Assurance Project Plan (QAPjP, Golder Associates Inc., 1989b). All sediment samples were analyzed microscopically for hide residue in Golder Associates' soils laboratory in Mt. Laurel, New Jersey. The presence or absence of hair fibers in an oven-dried sample was used to determine whether the sample contained hide residue. All instances where hair fibers were detected were confirmed by a second microscopist.

The laboratory results for arsenic, lead, and chromium were assessed in accordance with procedures given in the QAPjP. The results are presented in Table 1. The concentrations of arsenic, lead and chromium were below Consent Decree action levels in all samples collected from Wetland 3B during this task. One sample from borehole 121 contained hide residue in the 0-6 inch depth interval.

Hide residue was also detected in the 6-18 inch depth interval samples from boreholes 135 and 136 in Wetland 8. Analyses for arsenic, lead, and chromium were not performed on these samples because these metals were found above Consent Decree action levels in samples from Wetland 8 collected and analyzed as part of the Remedial Investigation (Stauffer Chemical Co., 1984).

All QC sample results were found to be within control limits specified in the QAPjP.

#### **GOLDER ASSOCIATES**

# 4.0 REFERENCES

Golder Associates Inc., 1989a. <u>Field Sampling Plan</u>, Pre-Design Investigation, Industri-Plex Site, Woburn, MA, December, 1989.

Golder Associates Inc., 1989b. <u>Quality Assurance Project</u> <u>Plan</u>, Pre-Design Investigation, Industri-Plex Site, Woburn, MA, December, 1989.

Golder Associates Inc., 1990. <u>Pre-Design Investigation Task</u> <u>SW-1</u>, <u>Extent of Hazardous Substances in Wetlands and</u> <u>Surface Water Sediments</u>, Interim Final Report, Industri-Plex Site, Woburn, MA, September, 1990.

Stauffer Chemical Company, 1984. <u>Woburn Environmental</u> <u>Studies, Phase II, Volume 1, Remedial Investigation</u>, August, 1984.

C:95%:SEDSAM

#### TABLE 1

# SUMMARY OF ARSENIC, LEAD, CHROMIUM AND HIDE RESIDUE ANALYSES

NOTE: Sample ID is designated as described for the example given below.

IP/SW-1/001/006/1/3/1

The first two characters (IP) stand for the Industri-Plex Site;

The third through fifth characters (SW-1) stand for the Pre-Design task number;

The sixth through eighth characters (001) stand for the sample location number within that task (EBA and EBB=equipment rinsate blanks);

The ninth through eleventh characters (006) stand for the depth of the bottom of the sample interval in inches below ground surface, where applicable;

The twelfth character (1) stands for the matrix type (1=solid, 2=liquid, 3=gas);

The thirteenth character (3) stands for the sampling round number (D=field duplicate sample); and

The fourteenth character (1) stands for the analysis type (1=arsenic, lead and chromium).

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SUMMARY OF ARSEMIC, LEAD, CHROMIUM AND HIDE RESIDUE ANALYSES - TASK SW-1

IABLE 1

Matrix: SOIL **WOBURN, MA** PRE-DESIGN INVESTIGATION INDUSTRI-PLEX SITE

		Date	<u>Arsenic</u>	(mg/kg)	Lead (	<u>mg/kg)</u>	Chromium	(mg/kg)	X Moistur		
ATACAMASE	(in.)	(bymmdd)	Result	AC RL	Result	AC RL	Result AC	RL	Resul t	RL	Residue
1P/SW1/120/006/1/3/1	900	910624	<16 15	16	22	A NR	¥ 2.1	N.	39	۲.	-
1/2/1/21/0/01/1M2/1/2/	210	91024			21		< - · · >	X	72	ž	
10/10/00/10/10/10/10/10/10/10/10/10/10/1	010	1022014			• • •		× ~ ~ ~	K Q	97	ž	
IP/Sul/120/036/1/3/1	38	910624	;÷	12	<b>6.2</b>	0 6.2	5.0 A	Ĩ	15	Ĩ	
1P/SW1/121/006/1/3/1	800	910624	<37	u 37	27	A NR	37 A	¥	5	ž	۲
IP/SW1/121/006/1/0/1+	80	910624	ŝ	u 33_	087	A N	38 A	AN N	02	X	NE
IP/Su1/121/012/1/3/1	012	910624	£.	U 11	<b>\$.</b> \$	U 6.6	5.8 A	M	54	ž	W
IP/SW1/121/018/1/3/1	018	910624	<u>5</u>	۲ ت	<b>6.3</b>	U 6.3	2 <del>7</del> 2	¥	21	ž	z
1/2/1/22/121/1/1/1/1/1/1/1/1/1/1/1/1/1/	027	910624	<u>5</u>	12	6.1 1.9	с • • • •	<	X I	18 18	ž	¥.
1/2/1/030/1/1/1MS/41	030	470016	<15	U 13	<0.7	0.7	4.7 A	N	8	X X	*
1P/SW1/122/006/1/3/1	900	910624	<56	u 56	310	ANN	37 A	X	82	NR	2
IP/SW1/122/012/1/3/1	012	910624	<b>8*</b> >	n 48	38	A M	4 II A	X	٤	ž	NE
IP/SW1/122/018/1/3/1	018	910624	<26 26	U 26	17	A WR	S5 A	A.M.	61	N.	z
IP/SW1/122/027/1/3/1	027	910624	<u></u>	U 16	<8.2 48.2	U 8.2	5.6 A	ÄN	36	Å,	ME
IP/SW1/122/036/1/3/1	036	910624	<16	U 16	<8.1	U 8.1	5.7 A	X	38	AH A	z
IP/SW1/123/006/1/3/1	800	910625	<45	u 45 l	310	NR	27 A	¥	78	a a	3
IP/SU1/123/006/1/0/1*	8	910625	<45 <45	1 1 1 1 1 1	300		22	ž	22	ž	NE
1P/SW1/123/012/1/3/1	012	910625	<24	U 24	23	MR	8.7 A	X	58	N	z
IP/SW1/124/006/1/3/1	900	910624	¢3	U 43	8	A NR	24 A	Ä	11	AN	-
1P/SW1/124/012/1/3/1	012	910624	<19	u 19	12	A	19 A	A.	84	Ä	NE
IP/SW1/124/018/1/3/1	018	910624	<14 <14	1	\$ <b>6.8</b>	0.9 0.9	8.9 ×	ž	<b>2</b>	Ĩ	z
1P/SW1/124/02//1/3/1 1P/SW1/124/034/1/3/1	20	910624	41 71	21	8.9 7 7	0.0 1	V - 9 V - 9	ž 3	27	ž a	N N
	3		;	2				É		-	E
IP/SW1/134/006/1/3/1	800	910625	M	<b>A</b> M	M	<b>N</b> A	<b>N</b> A	<b>W</b>	VN	NA	Z
IP/Su1/134/018/1/3/1	018	910625	¥.	KN .	<b>A</b> M	<b>V</b> N	A N	Y.	A N	A	۲
1/5/1/960/961/1MS/41	030	CZ9016 1	M	NN	N	NN	VN	NN	NA	VN	X
IP/SW1/135/006/1/3/1	906	910625	AN	M	M	VN	YN	M	MA	MA	*
1P/Su1/135/018/1/3/1 10/5u1/135/018/1/3/1	018	910625	A N	A A	¥ 1	Ă	¥:	¥3	¥1	ž	~ 1
i le li loco leci li un l i	3	1 210000	£	£		4	5	ž	~~	~	E

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NOTES: \* - Field Duplicate Sample RL - Reporting Limit NA - Not Applicable NR - Not Reported

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SUMMARY OF ARSENIC, LEAD, CHRONIUM AND HIDE RESIDUE ANALYSES - TASK SU-1

TABLE 1

INDUSTRI-PLEX SITE PRE-DESIGN INVESTIGATION WOBURN, NA MATRIX:AQUEQUS

Sample1D	Depth	Date Sampled	<u>Arsenic (mg</u>	 ภ	Lead (mg/L)		Chromium (	( <del>1/6</del> ш	X Moistur	뙨	
	(in.)	()yymudd)	Result AC	R	Result AC	R	Result AC	R	<b>Resul</b> t	R	Residue
IP/Su1/EBA/000/2/3/1	000	910624	<0.10 U	0.10	<0.050 U	0.050	<0.010 U	0.010	×	ž	VN
IP/SW1/EB8/000/2/3/1	000	910625	<0.10 U	0.10	<0.050 U	0.050	<0.010 U	0.010	M	Ă	<b>V</b> N

Mide Residue Detected...... Y - Detected NA - Not Applicable N - Not Detected BS - Background Sample NS - Not Sampled NE - Not Examined MOTES: \* - Field Duplicate Sample RL - Reporting Limit MA - Not Applicable MR - Not Reported -

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ATTACHMENT A Technical Procedures

#### 1.0 PURPOSE

This Technical Procedure is to be used to establish uniform methods of sampling of surface soils. Provisions are made for analyses and recording of data.

#### 2.0 APPLICABILITY

This Technical Procedure is applicable to personnel sampling surface soils for chemical analyses.

# 3.0 DEFINITIONS

- 3.1 Surface Soil: Any soils that are on the land surface or are exposed by hand digging or boring within five (5) feet of the land surface.
- 3.2 Sampling Interval: The depth interval which the soil sample represents.
- 3.3 In Situ Soils: Soils that are in place within the soil column.

# 4.0 REFERENCES

4.1 U.S. EPA, 1982 (updated 1984). Test Methods for Evaluating Solid Waste: Physical/Chemical Methods: SW-846. Office of Solid Waste and Emergency Response. Washington, D.C.

#### 5.0 DISCUSSION

5.1 None

#### 6.0 RESPONSIBILITY

- 6.1 Sampling Technician: Responsible for completing the assigned sampling in accordance with this Technical Procedure.
- 6.2 Task Leader: Responsible for determining the soils to be sampled and ensuring that sampling procedure and sample documentation are in accordance with this procedure and applicable project plans.

SAMPLING SURFACE SOIL FOR CHEMICAL ANALYSIS December 1989

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6.3 Project Manager: Responsible for determining the type of chemical analyses to be performed on the soil samples.

#### 7.0 EQUIPMENT AND MATERIALS

- 7.1 Site map, map board and/or clipboard.
- 7.2 Field notebook or Field Report forms (Exhibit A).
- 7.3 Assorted standard field equipment (e.g., hammers, posthole digger, shovel, hand auger) for exposing soils to be sampled.
- 7.4 Measuring tape.
- 7.5 Engineers rule (minimum 6 feet long, with 0.10 foot graduations).
- 7.6 Indelible ink pens.
- 7.7 Two inch wood stakes and flagging material.
- 7.8 Sampling equipment appropriate for soils to be analyzed for non-volatile constituents. All such equipment shall be metal (steel, stainless steel or aluminum) and includes split spoon samplers, hand augers, hand scoops, sampling thiefs or sampling tiers (see reference 4.1 for details on sampling equipment).
- 7.9 If volatile constituents are to be analyzed in the soil samples, the sampling equipment shall be designed to minimize exposure to the atmosphere. A metal drive tube appropriate for the size of the soil particles shall be used.
- 7.10 Sample bottles, size commensurate with the desired sample and soil particle size.
- 7.11 Chain-of-Custody Records and seals.
- 7.12 Sample Integrity Data Sheets (Exhibit B).
- 7.13 Carbon paper, if necessary.
- 7.14 Decontamination solutions such as organic free distilled/deionized water, non-phosphate detergent, tap water, methanol (for organic analytes), nitric acid (for metal analytes).
- 7.15 Decontamination equipment such as brushes, sprayers and containers for capturing waste solutions.

7.16 Sample labels.

#### 8.0 PROCEDURE

- 8.1 The sample location will have been surveyed and marked with a wooden stake, labeled with the boring number, prior to sampling.
- 8.2 Relevant sampling events, including on-site personnel and visitors, shall be recorded on the Field Report forms (Exhibit A) in triplicate. Events shall be recorded chronologically with the time of each event noted.
- All sampling equipment (split spoons, hand augers, 8.3 drive tubes, etc.) shall be decontaminated before and after each use. Hollow stem auger flights shall be steam cleaned prior to use at each sample location. The sampling equipment will be washed with nonphosphate detergent solution. Brushes shall be used to aid in removing all visible soil grit. A tap water rinse will be used to thoroughly removal all detergent solution. If trace metals are of interest, rinse three times with distilled water, followed by a rinse with 10 percent trace-metal analysis grade nitric acid, followed by another triple rinse of distilled water. If organics are to be analyzed, a final step is required, consisting of an HPLC-grade methanol rinse followed by a triple rinse with distilled water. The methanol should be allowed to evaporate before a final rinse with distilled water. All rinseate shall be captured and contained for proper disposal. Responsibility for disposal shall be as identified in the project plans.
- 8.4 The soils to be sampled will be exposed prior to sample acquisition. If the upper six inches of soils are to be sampled, then surface vegetation shall be removed. If samples are to represent discrete depth intervals below land surface then overlying soils shall be removed by a shovel, post-hole digger or hand auger to the desired interval.
- 8.5 A soil sample of in-situ materials shall be obtained from the desired sampling interval. If analytes are not volatile, an in-situ soil sample can be obtained from the desired sampling interval using the most convenient equipment such as: a hand scoop, hand auger, sampling (thief) or tier, whichever is most suitable for obtaining in-situ soils. The soils shall be visually inspected and immediately put into the

appropriate sample bottle. No preservatives shall be added to the sample.

- 8.6 If analytes are volatile, the in-situ soil sample shall be obtained from the desired sampling interval using a drive tube sampler. Contact between the atmosphere and the sample must be minimized. The drive tube sampler shall be driven into the materials with a hammer.
- 8.7 Materials shall be transferred from the sampler directly to the sample container using spatulas (plastic for metals analysis, stainless steel or aluminum for organics). Special care should be taken to avoid sample contact with other materials. An airtight cap shall be placed immediately on the sample bottle. No preservatives shall be added to the sample.
- 8.8 If soil sample composites are to be established, equal volumes of individual samples will be added together for the composite sample. The composite sample will be given an individual sample number and the sample number of each added sample (compositing the composite sample) will be recorded on the Sample Integrity Data Sheet (Exhibit B). Locations of the individual samples are recorded on the base map.
- 8.9 Samples are immediately labeled and relevant data recorded on the Sample Integrity Data Sheet for each sample. Site-specific details regarding labeling and recording shall be provided in the project QA plan.
- 8.8 Samples shall be placed in a cold cooler (about 4°C) as soon as possible and the temperature of the cooler shall be recorded on the Sample Integrity Data Sheet. The cooler of samples shall be within view of the Golder Geologist/Hydrogeologist at all times or in locked storage. A Chain-of-Custody Record shall be filled out and maintained as specified in the project QA plan.
- 8.9 Samples sent or delivered to the chemical analytical laboratory shall be transferred in accordance with the project QA plan. The original Chain-of-Custody Record shall accompany the samples to the laboratory.
- 8.10 Any hole made to obtain samples shall be backfilled with soil materials removed from the hole, unless the hole collapses.
- 8.11 Field Report forms (Exhibit A) shall be prepared by the Golder Geologist/Hydrogeologist to record daily sampling activities. The Field Report forms shall follow chronological format and include the time of

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each event documented. The base map shall be used to record each sampling location by the Golder Field Engineer/Geologist. Sample Integrity Data Sheets shall be used to record information regarding soil samples that will be chemically analyzed. Chain-of-Custody Records shall be used to record the custody and transferal of samples.

- 8.11.1 Field records shall be made in triplicate at the work site and the originals (except Chain-of-Custody Records) shall be transmitted to the home office on a daily basis. A copy shall be given to the Task Leader and the Golder Geologist/Hydrogeologist shall retain the other copy for reference.
- 8.11.2 All copies of field records (including original base map and chain-of-custody record) shall be hand delivered to the home office upon completion of the field activity.
Exhibit B

### SAMPLE INTEGRITY DATA SHEET

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Plant/Site	Projec	t No
Site Location	Sample	e ID
Sampling Location	· · · · · · · · · · · · · · · · · · ·	
Technical Procedure Referenc	e(s)	
Type of Sampler		
Date	Time	
Media	Station	
Sample Type: grab	time composite	space composite
Sample Acquisition Measureme	ents (depth, volume of static we	ell water and purged water, etc
Sample Description	<u></u>	
		~~~~~
Field Measurements on Sample	e (pH, conductivity, etc.)	
Aliquot Amount	Container	Preservation/Amount
Sampler (signature)	Date _	
Supervisor (signature)	Date _	
		De Golder Associates Inc.

ATTACHMENT B Borehole Logs

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		BOREHOLE LOG SW-1/120
PROJECT: SURFACE DRILLING	Industri- ELEV: 64.8 METHOD: H	Plex Site Pre-Design Investigation DATE: 06/24/91 DATUM: NGVD (1929) and Auger LOCATION: N:554254.8 E:697853.8
SAMPLE LOCATION	DEPTH INCHES	SOIL DESCRIPTION
1	- 2.0 - 4.0 -	Brown fine SAND and SILT (SM). Large amount of organic material.
2	6.0 8.0 10.0 10.0	Brown coarse to fine SAND with some silt (SM).
3	$\begin{array}{c} 12.0 \\ 14.0 \\ 14.0 \\ 16.0 \\ \end{array}$	Orange-brown coarse to medium SAND, some silt (SM).
4	$\begin{array}{c} & 18.0 \\ & 20.0 \\ & 22.0 \\ & 24.0 \\ & 26.0 \end{array}$	Orange-brown coarse to fine SAND, trace silt (SP).
5	$\begin{array}{c} - & 28.0 \\ - & 30.0 \\ - & 32.0 \\ - & 34.0 \\ - & 36.0 \end{array}$	Brown coarse to fine SAND, trace silt (SP).
Job No.	893-6255	GOLDER ASSOCIATES INC. Logged: D. Ley Checked: B. Glazier

			BOREHOLE LOG SW-1/121
PROJ SURF DRIL	ECT: ACE LING	Industri- ELEV: 63.1 METHOD: H	Plex Site Pre-Design Investigation DATE: 06/24/91 DATUM: NGVD (1929) and Auger LOCATION: N:554267.5 E:697799.0
SAMP LOCA	LE TION	DEPTH INCHES	SOIL DESCRIPTION
1		2.0 4.0 6.0	Medium to dark brown, fine to medium SAND and SILT (SM). Large amount of organic matter.
2		8.0 8.0 10.0	Grey-brown, coarse to fine SAND, trace silt, trace of organic matter (SP).
3		12.0 14.0 14.0 16.0	Grey coarse to fine SAND, trace silt, abundant muscovite flakes (SP).
		18.0  20.0	Grey coarse to fine SAND, trace silt (SP).
4		$\begin{bmatrix} - & 22.0 \\ - & 24.0 \\ - & - \\ - & 24.0 \\ - & - \\ - & 26.0 \end{bmatrix}$	
5			Grey-brown, coarse to fine SAND, trace silt (SP).
J		32.0 - 34.0 - 36.0	
Job	No.	893-6255	GOLDER ASSOCIATES INC. Logged: D. Ley Checked: B. Glazier

		BOREHOLE LOG SW-1/122
PROJECT: SURFACE DRILLING	Industri- ELEV: 63.1 METHOD: H	Plex Site Pre-Design InvestigationDATE: 06/24/91DATUM: NGVD (1929)and AugerLOCATION: N:554321.4E:697794.7
SAMPLE LOCATION	DEPTH INCHES	SOIL DESCRIPTION
1	2.0 4.0 	Brown fine SAND and SILT (SM), large amount of organic matter.
2	8.0 - - - - - - - - - - - - 0.0	Brown, fine SAND and SILT (SM), large amount of organic matter.
3	$\begin{array}{c} & 12.0 \\ - & \\ & 14.0 \\ - & \\ & 16.0 \\ - & \end{array}$	Brown fine to medium SAND and SILT (SM).
	$ \begin{array}{c} - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ - & \\ 2 & \\ - & \\ - & \\ 2 & \\ - & \\ - & \\ 2 & \\ - & $	Grey-brown, coarse to fine SAND, little silt (SP).
4		
5	28.0 - - 30.0 -	Grey-brown, coarse to fine SAND, trace silt (SP).
	32.0 34.0 	
Job No.	893-6255	GOLDER ASSOCIATES INC. Logged: D. Ley Checked: B. Glazier

			BOREHOLE LOG SW-1/123
PROJE SURFA DRILL	CT: CE E ING	Industri- LEV: 64.1 METHOD: H	Plex Site Pre-Design Investigation DATE: 06/25/91 DATUM: NGVD (1929) and Auger LOCATION: N:554291.1 E:697743.9
SAMPL LOCAT	E ION	DEPTH INCHES	SOIL DESCRIPTION
1		- 2.0 - 4.0 -	Brown fine SAND and SILT (SM). Large amount of organic matter.
2		6.0 8.0 8.0 10.0 10.0	Brown fine SAND and SILT (SM). Large amount of organic matter.
3		12.0 	Not sampled.
4		$ \begin{array}{c} & 18.0 \\ & 20.0 \\ & 22.0 \\ & 24.0 \\ & 26.0 \\ \end{array} $	Not sampled.
5		$\begin{array}{c} - & 28.0 \\ - & 30.0 \\ - & 32.0 \\ - & 34.0 \\ - & 34.0 \\ - & 36.0 \end{array}$	Not sampled.
Job N	<b>o.</b> 8	93-6255	GOLDER ASSOCIATES INC. Logged: D. Ley Checked: B. Glazier

		BOREHOLE LOG SW-1/124
PROJECT SURFACE DRILLIN	: Industri- ELEV: 63.6 G METHOD: H	Plex Site Pre-Design Investigation DATE: 06/24/91 DATUM: NGVD (1929) and Auger LOCATION: N:554421.1 E:697819.1
SAMPLE LOCATIO	N DEPTH INCHES	SOIL DESCRIPTION
1	- 2.0 - 4.0 -	Brown fine to medium SAND and SILT (SM). Large amount of organic matter.
2	$ \begin{array}{c} & 6.0 \\ \\ & 8.0 \\ \\ \\ \\ \\ \\ \\ \\ -$	Brown fine to medium SAND and SILT (SM).
3	$ \begin{array}{c} & 12.0 \\ & \\ & 14.0 \\ & \\ & 16.0 \\ & \\$	Grey coarse to fine SAND, trace silt (SP).
4	$ \begin{array}{c} - & 18.0 \\ - & 20.0 \\ - & 22.0 \\ - & 24.0 \\ - & 24.0 \\ - & 26.0 \\ \end{array} $	Grey-brown coarse to fine SAND, trace silt (SP).
5	$ \begin{array}{c} - & 28.0 \\ - & 30.0 \\ - & 32.0 \\ - & 34.0 \\ - & 36.0 \\ \end{array} $	Grey coarse to fine SAND, trace silt (SP).
Job No.	893-6255	GOLDER ASSOCIATES INC. Logged: D. Ley Checked: B. Glazier

Γ

			BOREHOLE LOG SW-1/135
PROJ SURF DRIL	ECT: ACE LIN(	: Industri- ELEV: 59.0 G METHOD: H	Plex Site Pre-Design Investigation DATE: 06/25/91 DATUM: NGVD (1929) and Auger LOCATION: N:552346.1 E:695721.0
SAMPI LOCA	LE FIOI	N DEPTH INCHES	SOIL DESCRIPTION
1		- 2.0 - 4.0	Dark brown fine SAND and SILT (SM) with root mass.
2		$ \begin{array}{c} - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\$	Brown fine SAND and SILT (SM) with root mass.
		12.0 14.0 16.0	
		18.0 18.0 20.0	Grey-brown, coarse to fine SAND, some silt (SP).
3		22.0 24.0 24.0	
		28.0 30.0	
		32.0 34.0 	
Job 1	No.	- 36.0 - 893-6255	GOLDER ASSOCIATES INC. Logged: D. Ley Checked: B. Glazier

BURFACE E	Industri- LEV: 58.9 METHOD: H	Plex Site Pre-Design Investigation DATE: 06/25/91 DATUM: NGVD (1929) and Auger LOCATION: N:552289.9 E:695853.0
SAMPLE LOCATION	DEPTH INCHES	SOIL DESCRIPTION
1	- 2.0 4.0 	Dark brown fine SAND and SILT (SM).
2	8.0 8.0 10.0 12.0	Dark brown fine SAND and SILT (SM). Possibly hide residue present, strong hide odor
	14.0 16.0 18.0	Dark brown fine SAND and SILT (SM).
3	- 20.0 - - 22.0 - - 24.0	Strong hide odor.
	- - 26.0 - - 28.0	
	30.0 32.0 34.0	
	- 36.0 -	

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ATTACHMENT C Chain of Custody Forms

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NAH LABORATORIES AND ENVIRONMENTAL SERVICES, INC. Second Damage Anna Andrea Anna Andrea Anna Andrea Anna Andrea Anna Andrea	Trauchri-Plex Site Required MULTARE MILLING OF	les Inc. 101-273-1110 E	Sto Autowel 11 story 3 3 3 ( 4	16 BE 20 00		110/00e/1/3/1 × ×	1,120/02/1/2/V X X 1/E/1/210/02/	1/120/018/1/3/1 K X	1/s/1/200/mi/	1/20/036/1/3/1 X X	1/11/006/1/3/1 X X	·//1/2/1/2/1 X X // /2/1/2/12/12/12/12/12/12/12/12/12/12/12/	-/u/018/1/3/1 X X	1/10/02//3/1 X X 1/5//20/10/10	DAVE/THE RECOMPOST (SIGNITURE) DATE/THE RELAYOURSED ST: (SIGNITURE) DATE/THE	DATE/NAK RECORD ON: DICANDARD DATE/LAK RELAVOUDED ON: DICANDARD DATE/LAK	LADONLIGHT LE EN AIrbill No. 774886342	TURE) J RANETIME CARTON SEALING SELECTION. INCOMPONY REMANDER CARTON SEALING SELECTION.
BAVANNAH LABORATORIE ANALYSIS REQUEST	Industri-Plax S	sociates Inc. 101-279-1	Why these Mykunel M 05	Glazier	a shurt a	P/24-1-120/006/1/31	1/2/1/210/021/1-198/0	P/SW-120/018/1/3	18/1/200/021/1-18/	P/SW-1/120/036/1/3	2/1/ 200/11/1-MS/009/1/3	P/Sw-1/121/012/1/3/	of sur-1 na 1018/1/3/	15/1/20/121/1-MS/0	DE DAVETINE REC DAVETINE REC	DATE/BLEE REG		AN UN, WILL YN T GANLMOUS :NG
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ATTACHMENT D Laboratory Report

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5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

10G NO: \$1-34317

Received: 26 JUN 91

Ms. Elisabeth Auda Golder Associates, Inc. 20000 Horison Way, Suite 500 Mt. Laurel, RJ 08054

> Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

Page 1

log no	SAMPLE DESCRIPTION ,	SOLID OR S	EMISOLID S	Amples D	ATE SAMPLED	
34317-1	IP/SW-1/121/036/1/3/1	(06.24.9)	1)	C	6-24-91	
34317-2	IP/SW-1/122/006/1/3/1	(06.24.9)	1)	C	6-24-91	
34317-3	IP/SW-1/122/012/1/3/1	(06.24.91	L)	C	6-24-91	
34317-4	IP/SW-1/122/018/1/3/1	(06.24.93	L)	C	6-24-91	
34317-5	IP/SW-1/122/027/1/3/1	(06.24.93	L)	c	6-24-91	
Parameter	*	34317-1	34317-2	34317-3	34317-4	34317-5
Argenic. m	/ka dw	 e13		<48	<26	<16
Lead, mg/kg	dr .	<6.7	310	38	17	<8.2
Chromium, m	g/lg dw	4.7	37	11	55	5.6
Percent Sol	ids, ł	75	18	21	39	61
			•••••			

Laboratory locations in Savannah, GA • Tallahassee, FL • Mobile, AL • Deerfield Beach, FL • Tampa, FL

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### SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

LOG NO: \$1-34317

Received: 26 JUN 91

Ms. Elizabeth Auda Golder Associates, Inc. 20000 Horizon Way, Suite 500 Mt. Laurel, MJ 08054

> Project: Industri-Plex Site Sampled By: Client

### REPORT OF RESULTS

Page 2

TOG NO	SAMPLE DESCRIPTION ,	SOLID OR S	semisolid	BAMPLES	DATE SAMPLE	•
34317-6 34317-7	IP/SW-1/122/036/1/3/2 IP/SW-1/124/006/1/3/2	1 (06.24.9) 1 (06.24.9)	1) 1)		06-24-91 06-34-91	
34317-8	IP/SW-1/124/012/1/3/2	(05.24.9	1)		06-24-91	
34317-9	IP/SW-1/124/018/1/3/:	1 (06.24.9	1)		06-24-91	
34317-10	IP/SW-1/120/006/1/3/	L (05.24.9	1)		06-24-91	
Parameter		34317-6	34317-7	34317-8	34317-9	34317-10
Arsenic, mg	/kg dw	<16	<43	<19	<14	<15
Lead, mg/kg	dw	<8.1	86	12	<6.8	52
Chronium, m	g/kg đw	5.7	24	19	8.9	1.7
Percent Sol	ids, t	62	23	52	74	<b>6</b> 1

Laboratory locations in Savannah, GA • Talishassee, FL • Mobile, AL • Dearlield Beach, FL • Tampa, FL

SAVANNAH LABORATORIES

ENVIRONMENTAL SERVICES, INC.

- - -

5102 LaRoche Avenue · Savannah, GA 31404 · (912) 354-7858 · Fax (912) 352-0165

LOG NO: 81-34317

Received: 26 JUN 91

Ms. Elizabeth Auda Golder Associates, Inc. 20000 Horizon Way, Suite 500 Mt. Laurel, NJ 08054

> Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

Page 3

log no	SAMPLE DE	SCRIPTION , S	OLID OR	SEMISOLID	Samples	DATE SAMPLE	D
34317-11	IP/\$W-1/1	20/012/1/3/1	(06.24.	) )		06-24-91	
34317-12	IP/SW-1/1	20/018/1/3/1	(06.24.9	))		06-24-91	
34317-13	IP/SW-1/1	20/027/1/3/1	(06.24.9	91)		05-24-91	
34317-14	IP/SW-1/1	20/036/1/3/1	(06.24.	)))		06-24-91	
34317-15	IP/SW-1/1	21/005/1/3/1	(06.24.	91)		06-24 <b>-9</b> 1	
PARAMETER		34	317-11	34317-12	34317-13	34317-14	34317-15
Arsenic, m	g/kg dw		<14	<14	<13	<12	<37
Lead, mg/k	a dw		12	<6.9	<6.6	<5.2	470
Chromium, i	ng/kg dw		3.1	6.2	6.2	5.0	37
Percent So	lids. 4		73	72	76	81	27
				• • • • • • • • • • • • • • •			********

Laboratory locations in Savannah, GA + Tallahassee, FL + Mobile, AL + Deerfield Beach, FL + Tampa, FL

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SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

LOG NO: \$1-34317

Page 4

Received: 26 JUN 91

Ms. Elizabeth Auda Golder Associates, Inc. 20000 Horizon Way, Suite 500 Mt. Laurel, MJ 08054

> Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION ,	SOLID OR	SEMISOLID &	Samples	DATE SAMPLE	0
34317-16	IP/5W-1/121/012/1/3/	1 (06.24.9	1)		05-24-91	
34317-17 34317-18	IP/SW-1/121/018/1/3/ IP/SW-1/121/027/1/3/	1 (06.24.9 1 (06.24.9	)) )		05-24-91 05-24-91	
34317-19 34317-20	IP/SW-1/124/027/1/3/ IP/SW-1/124/036/1/3/	1 (06.24.9 1 (06.24.9	)1) )1)		06-24-91 06-24-91	
PARAMETER		34317-16	34317-17	34317-18	34317-19	34317-20
Arsenic, mg.	/kg_dw Ar	<13	<13	<12 <6_1	<14	<13 <6.4
Chromium, m	g/kg dw	5.8	5.4	5.5	6.7	7.3
Percent Sol	1 <b>95, 7</b>	76	79	<b>8</b> 2	73	78

Laboratory locations in Sevenneh, GA • Tellahassee, FL • Mobile, AL • Deertield Beech, FL • Tampe, FL

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### **SAVANNAH LABORATORIES A ENVIRONMENTAL SERVICES, INC.**

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LOG NO: 81-34317

Received: 26 JUN 91

Ms. Elisabeth Auda Golder Associates, Inc. 20000 Horison Way, Suite 500 Mt. Laurel, NJ 08054

> Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

TO

Page 5

log No	SAMPLE DESCRIPTION	, SOLID OR	SEMISOLID	SAMPLES	DATE SAMPLE	D
34317-21	IP/8W-1/121/006/1/D	/1 (06.24.9	91)		06-24-91	
34317-22	IP/8W-1/120/036/1/M	/1 {06.34.9	91)		06-24-91	
34317-23	IP/8W-1/120/036/1/N	/1 {06.24.9	91)		06-24-91	
34317-24	IP/8W-1/123/006/1/3	/1 (06.25.9	91)		06-25-91	
34317-25	IP/SW-1/123/012/1/3	/1 (06.25.	91)		06-25-91	
PARAMETER		34317-21	34317-22	34317-23	34317-24	34317-25
Arsenic, mg.	/kg dw	<33	116	124	<45	<24
Lead, mg/kg	đv	480	128	135	310	23
Chromium, m	g/kg dw	38	128	134	27	8.7
Percent Sol:	ids, t	30	82	80	22	42

Laboratory locations in Savannah, GA • Tallahassee, FL • Mobile, AL • Deerfield Beach, FL • Tampa, FL

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> Project: Industri-Plex Site Sampled By: Client REPORT OF RESULTS Page 6

LOG . HO	SAMPLE DESCRIPTION ,	SOLID O	r semisolid	SAMPLES	DATE SAMPLE	D
34317-26	IP/8W-1/123/006/1/D/	1 {06.25	.91)	• • • • • • • • • • • • •	06-25-91	**
34317-27 34317-28	IP/SW-1/123/012/1/M/ IP/SW-1/123/012/1/N/	1 (06.25 1 (06.25	.91) .91)		06-23-91 06-25-91	
PARAMETER	•••••	•••••		34317-26	34317-27	34317-28
Arsenic, sg/	kg dw			<45	207	192
Chromium, mg	uw /kg dw			25	211	195
Percent Soli	ds, ¥			22	<b>4</b> 7	51 

Leboratory locations in Sevenneh, GA • Tellahessee, FL • Mobile, AL • Deerfield Beech, FL • Tampe, FL

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LOG NO: 81-34317

Received: 26 JUN 91

Ms. Elizabeth Auda Golder Associates, Inc. 20000 Horizon Way, Suite 500 Mt. Laurel, MJ 08054

> Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

Page 7

log no	SAMPLE DESCRIPTION	, QC REPOR	t for solid/	SEMISOLID		
34317-29 34317-30 34317-31 34317-32 34317-33	Method Blank-Soil MS/MSD & Recovery ( & RPD (IP/SW-1/120/ MS/MSD & Recovery ( & RPD (IP/SW-1/123/	IP/8W-1/12 036/1/M-8/ IP/SW-1/12 012/1/M-8/	0/036/1/M-N/ 1) 3/012/1/M-N/ 1)	'1) '1)		
PARAMETER		34317-29	34317-30	34317-31	34317-32	34317-33
Arsenic, mg Lead, mg/kg Chromium, m	/kg dw dw g/kg dw	<10 <5.0 <1.0	95/99 % 105/108 % 100/102 %	4.1 * 2.8 * 2.0 *	97/98 ¥ 103/103 ¥ 94/94 ¥	1.0 % 0 % 0 %
MS Exp Chromi MSD Ex Chromi MS Exp Chromi MSD Ex Chromi	acted Value (S134317 UM = 123 (mg/kg dw). pected Value (S13431 UM = 126 (mg/kg dw). ected Value (S134317 UM = 215 (mg/kg dw). pected Value (S13431 UM = 198 (mg/kg dw).	-22) Arsen 7-23) Arse 2-27) Arsen 7-28) Arse	ic, Lead = 17 nic, Lead = 1 ic, Lead = 21 nic, Lead = 1	22 .25 .3 .96		

Laboratory locations in Savannah, GA + Taliahassoe, FL + Mobile, AL + Deerfield Beach, FL + Tampe, FL

TO

### SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

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LOG NO: \$1-34317

Received: 26 JUN 91

MS. Elizabeth Auda Golder Associates, Inc. 20000 Horizon Way, Suite 500 Mt. Laurel, MJ 08054

> Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

Page 8

log no	SAMPLE DESCRIPTION , QC 1	eport for solid/semisolid	
34317-34	Date Analysed		
PARAMETER		34317-34	
Arsenic, Sg. Lead, mg/kg Chromium, m	/kg dw ˈdw g/kg dw	07.09.91 07.01.91 07.01.91	
MS Exp Chromit MSD Exp Chromit MS Exp Chromit MSD Exp Chromit	ected Value (S134317-22) / um = 123 (mg/kg dw). pected Value (S134317-23) um = 126 (mg/kg dw). ected Value (S134317-27) / um = 215 (mg/kg dw). pected Value (S134317-20) um = 198 (mg/kg dw).	Arsenic, Lead = 122 Arsenic, Lead = 125 Arsenic, Lead = 213 Arsenic, Lead = 196	

Laboratory locations in Savannah, GA + Taliahassee, FL + Mobile, AL + Deerfield Beach, FL + Tempe, FL

SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

e envinumental services, was

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LOG NO: 81-34317

Received: 26 JUN 91

Ms. Elisabeth Auda Golder Associates, Inc. 20000 Horison Way, Suite 500 Mt. Laurel, MJ 08054

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Project: Industri-Plex Site Sampled By: Client

#### REPORT OF RESULTS

Page 9

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LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES		DATE SANPLED
34317-35 34317-36	IP/SW-1/EBA/000/2/3/1 (06.24.91) IP/SW-1/EBB/000/2/3/1 (06.25.91)		06-24-91 06-25-91
PARAMETER		34317-35	24317-36
Arsenic, mg/ Lead, mg/l Chromium, mg	/1 g/1	<0.10 <0.050 <0.010	<0.10 <0.050 <0.010

Laboratory locations in Savannah, GA • Taliahassee, FL • Mobile, AL • Dearfield Beach, FL • Tampe, FL

TD

### SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

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LOG NO: \$1-34317

Received: 26 JUN 91

Ms. Elisabeth Auda Golder Associates, Inc. 20000 Morison Way, Suite S00 Mt. Laurel, NJ 08054

> Project: Industri-Plex Site Sampled By: Client

### REPORT OF RESULTS

Page 10

log no	SAMPLE DESCRIPTION ,	QC REPORT FOR LIQUI	D SAMPLES		
34317-37 34317-38 34317-39 34317-40	Method Blank-Water Lab Spike/Duplicate & & RPD Date Analysed	Recovery			
PARAMETER		34317-37	34317-38	34317-39	34317-40
Arsenic, mg Lead, mg/l Chromium, m	/l mg/l	<0.10 <0.050 <0.010	110/109 ¥ 105/105 ¥ 103/102 ¥	0.91 ¥ 0 ¥ 0.98 ¥	07.02.91 07.02.91 07.02.91
Method	ls: EPA 8W-846.				

D. Shurron Williams

William D. Sherrod

Laboratory locations in Savannah, GA • Tallahessee, FL • Mobile, AL • Deerfield Beach, FL • Tamps, FL

ATTACHMENT E Data Quality Assessment

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Lab Log No. S1-34317

### INDUSTRI-PLEX PRE-DESIGN INVESTIGATION

### ASSESSMENT OF OVERALL DATA QUALITY FOR TASK <u>SW-1/Phase</u> 2

PERFOR	MED BY: Bob Glazier	DATE:	7/15/91	
				YES/NO/NA
1. W d	ere the QAPjP, laboratory reports, and f ocumentation available to support data a	ield ssessme	nt	
P	rocedures?			Yes
2. F	recision:			
	Are DCS RPD within control limits?			Yes
	Are lab duplicate RPD within control li	mits?		Yes
	Are field duplicate RPD within control	limits?		Yes
	Overall assessment of precision The date	a are of	enfficien	<u>Yes</u>
	overall about the of precision <u>the data</u>	a are or	SULLICIC	10
	precision for use in Remedial Design.			
3. Ac	curacy:			
	Is absolute recovery within control lim	its for	DCS?	Yes
`	Is relative recovery within control lim MS/MSD?	its for	•	Yes
	Overall assessment of accuracy The data	are of s	ufficien	<u> </u>
	accuracy for use in Remedial Design.			<del></del>
4. R	epresentativeness:			
	Were procedures in the FSP followed?			Yes
	If not, were procedural variations appr and documented?	roved		N/A
	were sample preservation procedures giv the FSP followed?	en in		Vag
	Were data reported in the proper units?	•		Yes
	Was blank contamination not evident or	well		
	documented at low levels?			Yes
	Were field duplicates within control li	.mits?		Yes
	overall assessment of representativenes	·s		
	The data are representative of site conditions	s.		

### INDUSTRI-PLEX PRE-DESIGN INVESTIGATION

ASSESSMENT OF OVERALL DATA QUALITY FOR TASK <u>SW-1/Phase</u> 2

### (continued)

YES/NO/NA

5. Comparability:

Are data traceable to a standard method?	Yes
Are methods approved/accepted as giving valid	
results?	Yes
Are data reported in proper units?	Yes
Overall assessment of comparability	

The data are comparable to other data collected in the RI/FS and

Pre-Design Investigation.

### 6. Completeness:

Is the fraction of valid data within control limits?	Yes	
If not, are the data sufficient to meet the task objectives?	N/A	<b>مر</b> ،
Are critical (background) samples sufficient and valid?	N/A	
Overall assessment of completeness		

The data set is complete.

7. Are the data useable and consistent with the objectives of the study?

Yes

8. Comments: N/A

C:6255:0DQFORM

Lab Loy No. 51-31317

### INDUSTRI-PLEX PRE-DESIGN INVESTIGATION

ASSESSMENT OF FIELD PERFORMANCE FOR TASK SW-1/Phase 2

SAMPLER/ORGANIZATION: David S. Ley / Golder Associates	<b>REPORT #</b> <u>S1-34317</u>
VALIDATED BY: Bob Glazier	date: <u>7/16/91</u>

YES/NO/NA

ues

1. Does field documentation include:

date/time samples collected? sample location? name of sampler? field measurements? sampling method? instruments/methods for field measurements? calibration/maintenance of field instruments? sampling containers used (COC\*)? sample preservation procedures (see COC\*)? Chain-of-Custody procedures? field quality control procedures?

- 2. Were procedures in the Field Sampling Plan followed? If not, were procedural variances approved and documented?
- 3. Was contamination of field blank samples not evident, or well documented at low levels?
- 4. Are field duplicates within control limits?
- 5. Comments: N/A

\* Chain-of-Custody Form

C:6255:FPFORM

## Lab Log No. 51-34317

### INDUSTRI-PLEX PRE-DESIGN INVESTIGATION

ASSESSMENT OF LABORATORY PERFORMANCE FOR TASK <u>Sw-1/Phase 2</u>

LABORATORY:	Savamah	Labs	
VALIDATED BY:	_ Bob	Clazie	

-34317 REPORT # )/ DATE:

YES/NO/NA

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yes

yes

- 1. Release authorization with signature present?
- 2. Sample identification summary/description present?
- 3. Analytical results present, including:

correct units? detection limits? method used? date sampled? date received? date prepared? date analyzed? dilutions noted?

- 4. Holding times met?
- 5. Lab duplicate RPDs within control limits (35%)? Field duplicate RPDs within control limits (50%)?
- 6. MS/MSD % recoveries within control limits (75-125%)?
- 7. MS/MSD RPDs within control limits (50%)?
- 8. Duplicate control sample (DCS) accuracy within given control limits (80-120%)?
- 9. DCS precision within given control limits (20%)?
- 10. Method blanks "clean"?
- 11. Chain-of-Custody present and complete with signatures and dates?
- 12. Name of analyst/supervisor given?
- 13. Procedural deviations noted?
- 14. QC procedures given?

### INDUSTRI-PLEX PRE-DESIGN INVESTIGATION

ASSESSMENT OF LABORATORY PERFORMANCE FOR TASK <u>Sw-1/ Phase 2</u>

(continued)

Note any violations to the assessment criteria listed above:

C:6255:ALP1FORM

NIR