Golder Associates

PRELIMINARY CLOSURE AND POSTCLOSURE MAINTENANCE PLAN

HAY ROAD LANDFILL, SOLANO COUNTY

Prepared for:

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1.0 INTRODUCTION

1.1 Background and Purpose

The Norcal Waste Systems Hay Road Landfill (NWSHRL) is a disposal and recycling facility owned and operated by Norcal Waste Systems Hay Road Landfill, Inc. (NWSHRLI), a wholly-owned subsidiary of Norcal Waste Systems, Inc. The facility is located at 6246 Hay Road, approximately 12 miles south of Dixon, California in Solano County, California (Figure 1). NWSHRL operates under Solid Waste Facilities Permit 48-AA-0002 and Waste Discharge Requirements (WDRs) Order No. R5-2003-0118.

The primary purpose of this Preliminary Closure and Postclosure Maintenance Plan (PCPMP) is to provide a reasonable estimate of the maximum expected cost that would be incurred at any time during the Unit's projected life for a third party both to close and carry out the first 30-years of postclosure maintenance (Title 27 of the California Code of Regulations (CCR), §21769[b][1]). The PCPMP provides a basis for the operator to establish a preliminary estimate of closure costs certified for accuracy by a registered civil engineer or certified engineering geologist, and enables the California Integrated Waste Management Board (CIWMB) to assess the reasonableness of the cost-estimate for non-water quality aspects of closure (§21790[a]).

This PCPMP updates and supercedes the previous PCPMP dated June 2002 submitted to satisfy Section J, Provision 9 of WDR 5-01-101. In comparison to the 2002 PCPMP, modifications contained in this document include:

- Revised closure cover grading plan;
- Updated closure and postclosure cost estimates and capacity and site life estimates based on the current cover grading plan; and
- Updated slope, stability, surface water drainage plan and postclosure cover settlement calculations.

This PCPMP is included by reference as revised Appendix T of the existing Joint Technical Document (JTD) for the site entitled "Joint Technical Document, Norcal Waste Systems Hay Road Landfill, Solano County, California." This PCPMP is not prepared as a stand-alone document and, therefore, refers to specific sections of the JTD for further detail as necessary.

1.2 Title 27 Cross-Reference

Table 1 provides a cross-reference between specific Title 27 closure/postclosure requirements and the applicable sections of this PCPMP.

TABLE 1
TITLE 27 CROSS-REFERENCE

Title 27 Requirement	PCPMP Reference
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2.0 PRELIMINARY CLOSURE PLAN

2.1 Site Description and Maps

The NWSHRL is located at 6426 Hay Road, Vacaville, California approximately 12 miles south of Dixon (Figure 1). The site is located immediately south of Hay Road and immediately west of Highway 113. The permitted disposal area measures approximately 260 acres in plan area. In compliance with all current permits, NWSHRL currently accepts non-hazardous solid waste and recyclables, high liquid content waste, designated waste, Asbestos Containing Waste and waste requiring special handling. The State Water Resources Control Board defines non-hazardous solid waste, designated waste, and inert waste in 27 CCR sections 20210, 20220, and 20230. Section 4.1.1 of the JTD provides a detailed description of the waste types accepted at the landfill.

Figure 2 shows the facility boundaries, the current limits of wastes that have been disposed of to date, and the permitted 260-acre waste disposal footprint. To date, approximately 125 acres has been built-out with waste disposal units.

Figure 3 shows the parcel boundaries and the surrounding land use and topography. Excluding the temporary on-site support facilities (administration trailer, equipment maintenance building, and scalehouse) there are no buildings or structures within 1,000 feet of the landfill.

The final closure contours are shown in Figure 4 and Drawing 1 (Appendix A). The final cover design and supporting engineering analyses are presented in Section 2.2. The maximum slope inclination is 4H:1V (horizontal to vertical); the maximum elevation is 215 feet mean sea level (msl).

Figure 5 shows the pre-existing topographic contours and impacts on surrounding drainage patterns. The pre-existing drainage was directed to the A-1 Channel, which flowed in a southeasterly direction through the eastern portion of the site. In 1994, the A-1 channel was relocated along the northern and eastern boundary of the site as indicated in Figure 5.

All existing landfill modules, excluding DM-1, and all future modules are or will be composite-lined. Section 5.2 of the JTD describes the containment systems. Section 5.3 of the JTD describes the DM-1 groundwater extraction system and the leachate collection and removal system for the other landfill modules.

2.2 Final Cover Design

A final cover system will be constructed over the waste at NWSHRL as part of the closure activities. The landfill will employ a Class II landfill cover system as most of the landfill area to be capped will be Class II. The primary functions of the final cover system are to:

- Isolate the waste from the environment;
- Control odors, vectors and litter;
- Control surface water infiltration into the landfill;
- Control erosion and run-on (if any), and convey run-off to the surface water management system; and
- Control landfill gas.

NWSHRL is designed and permitted with an Engineered Alternative Design (EAD) cover system, which is reflected in the WDR Order No. R5-2003-0118. The EAD cover system for the top deck and side-slopes is illustrated in Figure 6 and consists of the following components from top to bottom:

Top-Deck:

- A one-foot thick vegetative soil layer;
- A protective 10-oz/yd geotextile cushion layer;
- A 60-mil HDPE geomembrane layer (textured on both sides);
- A low-permeability geosynthetic clay liner (GCL); and
- A one-foot thick foundation layer

Side-Slopes:

- A one-foot thick vegetative soil layer;
- A geocomposite drainage layer;
- A 60-mil HDPE geomembrane layer (textured on both sides); and
- A one-foot thick foundation layer.

The permitted EAD components for NWSHRL substitute geosynthetic materials in place of soil components, thereby reducing final cover soil construction needs to just that needed for the foundation and vegetative layer construction, which are available on-site. Section 2.2.1 presents the equivalency evaluation for the EAD.

2.2.1 Equivalency Evaluation

In terms of water quality protection, the EAD cover system provides equal or better performance than the prescriptive standard. Key technical issues regarding water quality protection and performance are presented below.

Foundation Layer

Title 27 CCR §21090 stipulates that not less than two feet of a soil foundation layer shall be constructed for the final cover, unless it is shown that differential settlement and ultimate land use do not adversely affect the integrity of the final cover. Postclosure use for the site will remain as non-irrigated open-space. Therefore, the ultimate land use is not an issue regarding differential settlement.

For a prescriptive cover design that utilizes a compacted clay layer for a low-permeability hydraulic barrier layer, differential settlement is an issue of concern. Because clayey soils cannot support any significant tensile stresses, clay soils tend to crack under tensile strains of 1 to 2 percent or less, which can create relatively high permeability pathways to the underlying refuse. This concern is often partially mitigated by providing a minimum two-foot thick foundation layer beneath the clay layer. A two-foot thick foundation layer also improves the foundation support necessary to achieve adequate compaction of a low-permeability clay layer.

For this project, the low-permeability hydraulic barrier layer is provided by geosynthetic materials (GCL and/or HDPE geomembrane) and drainage is provided by a geocomposite drainage layer. These geosynthetic materials can tolerate substantially higher strains up to 10 to 20 percent or greater before yielding. Because these materials can tolerate strains 10 times larger than soil components without adverse impacts, a two-foot foundation layer thickness required for a clay layer is not required for geosynthetic materials. Furthermore, modern landfilling techniques focus on achieving a high degree of compaction to optimize airspace, and large containers are typically diverted from the landfill that could otherwise collapse and cause large differential settlements. As a result, differential settlements at the top of the refuse are expected to be relatively small and considerably less than 3 to 4 percent (Appendix D). Therefore, the foundation layer for the proposed EAD cover design only needs to be thick enough to provide a clean, firm surface for the geosynthetic materials. For NWSHRL, a foundation layer of one foot is more than sufficient to achieve this objective.

Due to NWSHRL's efforts and practices to divert large appliances/containers from the landfill, the development of large differential settlements resulting from large voids is considered unlikely. However, a very conservative analysis was completed that considered the potential development of a void in the underlying wastes (Appendix D). This analysis indicates that the resulting strains (3 to 5%) are well within the limits that can be tolerated by the proposed cover materials in the unlikely event that a void develops beneath the cover system.

Hydraulic Performance

Title 27 requires an EAD to be consistent with the protection goal of the prescriptive standard and to provide equivalent protection against water quality impairment. For a cover system, equivalent protection between systems can be evaluated based on the ability of each system to minimize infiltration of water into the underlying waste.

A hydraulic equivalency evaluation was performed for the prescriptive standard cover, the 1993 PCPMP EAD cover, and the current EAD cover systems using the USEPA's Hydrologic Evaluation of Landfill Performance (HELP) model (v. 3.07). The HELP model is a water balance analysis for the landfill containment/barrier system that uses site specific climatological data.

Key assumptions and input parameters for the HELP model are summarized below:

- The final cover will be vegetated with erosion resistant and drought resistant grasses that can thrive under natural precipitation conditions. The cover will not be irrigated.
- Rainfall data for Sacramento, California spanning 5 years, from 1992 to 1996, was used;
- Contact between the HDPE geomembrane liner and the underlying foundation soil was classified as "Good";
- A geomembrane installation defect frequency of 2 holes per acre was assumed (within the range for "good installation quality");
- A manufacturing defect (pinhole) frequency of 0 holes per acre was assumed;
- The vegetative or erosion resistant layer was modeled as low plasticity, clayey silt (ML) with a permeability of 1.9×10^{-4} cm/sec;

- The low-permeability soil layer (for the prescriptive standard) was modeled as low plasticity clay (CL) with a permeability of $1x10^{-7}$ cm/sec; and
- The foundation layer was modeled as low plasticity clayey silt (ML – same material for vegetative layer) with a permeability of $1.9x10^{-4}$ cm/sec.

The flux through the barrier layer was used as the measure for comparison of hydraulic equivalency between the two systems. The results of the HELP analyses are included in Appendix B and summarized below in Table 2.

TABLE 2
HYDRAULIC FLUX COMPARISON

COVER SYSTEM	TOP DECK	SIDE-SLOPE
Prescriptive Standard	0.35 gpad	0.01 gpad
1993 PCPMP EAD	0.35 gpad	138 gpad
Current PCPMP EAD	0.14 gpad	0.01 gpad

Note: Flux values represent peak daily leakage through the cover.

As indicated in the above table, the current EAD provides significantly improved infiltration performance over the previous 1993 EAD cover system, and provides equal or improved performance to the prescriptive standard cover system. Therefore, on the basis of infiltration performance, the EAD cover system performance exceeds that provided by the prescriptive standard requirements of Title 27.

2.2.2 Final Cover Grading

False

Figure 4 and Drawing 1 (Appendix A) show the final cover grades for NWSHRL. Consistent with the previous PCPMP, the final cover grades reach a maximum elevation of 215 feet above mean sea level (msl) and maintain a maximum side-slope inclination of 4H:1V (horizontal to vertical). To facilitate drainage and minimize erosion, 25-foot wide benches are incorporated into the side-slopes a maximum of every 50 feet vertically. The top surface will be graded at 5 percent to accommodate postclosure settlements and maintain positive drainage.

The previously approved PCPMP max elev is 165'

2.2.3 Erosion

Final landfill slopes will be inclined no steeper than 4H:1V. Minimum final surface slopes will be 5 percent. As part of the closure activities, the integrity of the final site face will be maintained by the placement of a vegetative layer to provide erosion control. The slopes will be revegetated with an application of seed mixes and fertilizers after the final grading is complete. The cover will be vegetated with erosion and drought resistant grasses that can thrive under normal precipitation conditions without irrigation. Table 3 provides a revegetation seed mix that will be incorporated in the Final Closure Plan. When vegetated, these surfaces are not expected to be significantly eroded by rainfall run off.

TABLE 3
PROPOSED FINAL COVER VEGETATION MIX

Botanical/Common Name	Annual/ Perennial	Specific Characteristics
Grasses		
Vulpia myuros *Zorro Fescue*	Annual	fast growing, excellent drought tolerance, adapted to all regions, excellent erosion protection
Bromus mollis *Blando Brome*	Annual	fast growing, good drought tolerance, adapted to all regions, moderate erosion protection
Dactylis glomerata *Orchardgrass*	Perennial	moderate growing, good drought tolerance, adapted to many regions, moderate erosion protection
Legumes		
Trifolium species *Woogenellup Subclover*	Perennial	fast growing, good drought tolerance, adapted to some regions, good erosion protection
Trifolium species *Kondinin Rose Clover*	Annual	fast growing, good drought tolerance, adapted to some regions, good erosion protection

An erosion analysis was completed for the slopes using the Revised Universal Soil Loss Equation program, RUSLE Version 1.06 (United States Office of Surface Mining and Reclamation, 1998). The analysis results indicate an estimated maximum soil loss for the proposed final grades of 1.3 tons per acre per year. This value is less than the USEPA's maximum allowable soil loss of 2 tons per acre per year. The erosion loss analysis is presented in Appendix C.

Revegetation will be completed using hydroseed methods. As is consistent with local construction practices in Northern California, hydroseed and mulch will be applied in the fall (approximately September 15th through November 15th) prior to the rainy season. The seeds will germinate naturally during the rainy season, and therefore, an irrigation system is not warranted.

2.2.4 <u>Settlement</u>

The settlement analyses include the base settlement, the impacts on the LCRS due to base settlement and the postclosure cover settlement. The calculations are shown in Appendix D.

2.2.4.1 Base Settlement

The placement of additional refuse changes the stresses acting on the foundation soils, which will result in additional settlement of the soils supporting the liner system. This settlement will tend to result in flatter drainage grades along the liner system in the future. The analyses presented in this section evaluate the magnitude of the calculated settlements and the resulting impact on the future drainage capacity of the LCRS. The results of our calculations show a minimum post-settlement grade of 0.25 percent, which maintains positive drainage to the existing and proposed perimeter collection sumps.

2.2.4.1.1 Settlement Calculations

Geosyntec (1995) developed a representative subsurface profile for calculating settlement of the soils underlying the NWSHRL. The profile consisted of the following:

- Depth of 0 to 16 feet: Clayey deposit
- Depth of 16 to 24 feet: Sandy deposit
- Depth of 24 to 85 feet: Clayey deposit
- Depth of 85 to 95 feet: Sandy deposit
- Depth of 95 to 100 feet: Clayey deposit

For the evaluation of the base settlement, we generally adopted the Geosyntec (1995) subsurface profile, but considered an additional 50 feet of subsurface soils as follows:

- Depth of 100 to 115 feet: Clayey deposit
- Depth of 115 to 120 feet Sandy deposit
- Depth of 120 to 135 feet Clayey deposit
- Depth of 135 to 140 feet Sandy deposit
- Depth of 140 to 150 feet: Clayey deposit

As indicated above, the lower 50 feet of materials contain 20 percent sand.

Based on our review of the consolidation testing by Emcon (1993) and more recent tests completed by Golder, we used consolidation parameters similar to those selected by Geosyntec.

Settlement calculations included in Appendix D indicate a differential settlement of 5.6 feet between the sump and the maximum differential stress at a distance of 800 feet from the sump. This results in a minimum post-settlement grade of 0.25 percent, which maintains positive drainage to the perimeter collection sumps. Additional information on the geology and hydrogeology of the landfill site is provided in Appendix C of the JTD.

2.2.4.1.2 Settlement Impacts on the LCRS

The design of the LCRS consists of high permeability gravel blanket draining a 2 percent grades toward perforated HDPE collection pipes. The HDPE pipes drain at a one percent grade toward the perimeter of the landfill.

The impact of base settlement is most severe in a direction perpendicular to the refuse slopes, which is in a direction parallel to the LCRS collection pipes. The settlement calculations indicate a post-settlement grade of approximately 0.25 percent along these pipes in existing and proposed constructed systems. Settlement along the floor grades toward the LCRS pipes will be considerably less since the differential stresses and resulting differential settlements are much less in the flow direction along the floor toward the pipes.

The historical leachate generation rate for the site indicates that operational leachate generation rates average 29 gallons per acre per day (Golder 2003a). This leachate rate is largely controlled by the operating practices of the site (i.e. diverting stormwater, type of daily cover etc.) and is not significantly impacted by the depth of refuse. Therefore, this rate is representative of anticipated future leachate generation rates. Following closure, the leachate generation rates are expected to steadily decline to approximately zero within 10 years (EPA, 2002).

At final build out, the maximum area draining to a single sump will be approximately 15 acres. Using the operational average peak monthly leachate generation rates measured for the site, maximum leachate generation that is drained by a single collection line is approximately 435 gallons per day or 0.3 gpm.

The capacity of a 4-inch diameter HDPE pipe at a 0.25 percent grade servicing that flow is 54 gpm (Golder 2003d). Given potential base settlement and the maximum leachate generation rates, the resulting factor of safety is 180, which far exceeds minimum regulatory requirements. CCR Title 27 requires a minimum factor of safety of 2.0 for flow capacity of the LCRS.

2.2.4.1.3 LCRS Pipe Structural Capacity

The impact of increased stress on the LCRS collection pipe system resulting from modifications to the final grading plan was addressed in the Optimization of the Final Cover Grading Plan, (Golder 2003d). The total vertical loading resulting from the modified final cover grades was still well below the structural design capacity of the LCRS collection pipe system. Calculated factors of safety for pipe breakage (wall crushing) and pipe collapse (wall buckling) were greater than 3 exceeding the minimum factors of safety for those physical properties. In addition, calculated distortion (ring deflection) for the LCRS collection pipe was considerably less than allowable levels. The results of these revised capacity calculations are given in the Draft EIR for the site. These summary calculations are also included in Appendix D.

2.2.4.2 Postclosure Cover Settlement

Settlement analyses were performed to evaluate the impact of postclosure settlement on the final cover grades. Refuse settlement typically exhibits a large, rapid, initial settlement rate referred to as primary settlement, which is followed by a long-term, progressively decreasing, settlement rate that is referred to as secondary settlement. Primary settlement generally occurs within weeks to months of the initial refuse placement. However, secondary settlement occurs for many years as waste materials decompose and compress.

The calculated postclosure settlements assume that primary settlements are complete prior to closure, but secondary settlements will continue throughout the entire 30-year postclosure monitoring period. As indicated in Appendix D, the postclosure grades following settlement will be approximately three percent, which is sufficient to promote positive drainage from the cover.

Appendix D also presents calculations of estimated differential settlement based on heterogeneous waste settlement properties. Reported values of the refuse modified secondary compression index for landfills most representative of modern landfill practices typically range from about 0.01 to 0.07 (Fasset et.al, 1994). Assuming that a four-fold variation in the modified secondary compression index occurs over a horizontal distance of 50 feet along the top deck, the maximum increase in the tensile strain is estimated to be less than 3 to 4 percent, which is well within the allowable range for the geosynthetic materials (geomembrane, geocomposite drainage net, and GCL).

2.2.5 Slope Stability

2.2.5.1 General

Slope stability evaluations for landfills generally consider the following potential failure modes, which are illustrated in Figure 7:

- **Foundation stability.** This potential failure mode considers a failure surface developing beneath and through the liner system. This failure mode is generally a concern to landfills sited over relatively weak soils and/or bedrock with adversely orientated discontinuities. Although the soils at the NWSHRL are not considered "weak," the foundation stability was evaluated to confirm adequate strength of the subsurface soils under the proposed stresses. The factor of safety for this failure mode is affected by the overall height of the refuse, and therefore, this failure mode is addressed in this report.

- **Refuse Slope Stability.** Refuse slope stability considers a potential failure surface developing within or above the liner system. Since the liner system interface shear strengths are generally lower than the shear strength of refuse, this failure mode involves the potential movement of refuse along the liner system. The factor of safety for this failure mode is affected by the overall height of the refuse, and therefore, this failure mode is addressed in this report.

- **Cover Veneer Stability.** The stability of the cover system considers the potential occurrence of a failure within the final cover components. This failure mode is primarily a function of the interface strengths of the cover materials and the maximum final slope inclinations. Since the proposed optimized final cover grading plan is not modifying the cover components and maximum slope inclination, the stability of the cover system is not impacted. Therefore, this analysis is not addressed in this report. The cover veneer stability analyses presented in the June 2002 PCPMP addresses this failure mode for both the current cover system and the proposed optimized cover grading plans and finds the performance of the cover system to exceed stability requirements.

Stability analyses were performed using the computer program SLIDE (v. 3.047). SLIDE uses two-dimensional, limit-equilibrium methods to evaluate stability. The static stability of the refuse mass was evaluated using Spencer's or Bishop's method of slices.

Key assumptions common to the foundation and refuse slope stability analyses are summarized below.

- The shear strength of the refuse was modeled by a linear failure envelope represented by an internal angle of friction of 30 degrees and a cohesion of 200 pounds per square foot (psf), which is within the range of refuse strength parameters reported by Singh and Murphy (1990). These parameters are close to the values recommended by Kavazanjian (1995), which presents a refuse shear strength model with an internal friction angle of 33 degrees with a minimum shear strength of 500 psf.

- The unit weight of the total waste fill mass was assumed to be 70 pcf. Golder has completed annual capacity and waste density calculations for the NWSHRL between 1997 and 2003. Historically, the NWSHRL consistently achieves relatively low in-place, compacted refuse densities of around 50 pcf. Allowing for waste settlement and daily cover materials, we estimate the final total waste mass density will be around 60 pcf. Assuming a higher total waste fill density of 70 pcf is conservative and generally results in lower computed factors of safety.

- Seismic stability was evaluated using the simplified seismic design procedure developed by Bray et. al. (1998). The design earthquake event for the site, the maximum credible earthquake (MCE), results from a blind thrust along the Central Valley Coast Range (Geosyntec, 1995) at an epicentral distance of 13 km. The MCE has a moment magnitude (Mw) of 7.0 resulting in a peak bedrock acceleration of 0.35g. Based on the computed yield accelerations, permanent displacements were estimated for the design seismic event.

2.2.5.2 Foundation Slope Stability

Previous stability analyses by Emcon (1993), Geosyntec (1995), and Golder (2002) have evaluated the stability of the landfill foundation assuming undrained conditions based on an undrained shear-strength subsurface profile developed by Emcon (see Appendix E). Computed factors of safety for the 1993 RDSI and June 2002 final cover grading plans generally exceed 1.8 for static conditions.

In our opinion, an undrained analysis is overly conservative because it assumes instantaneous loading of the entire refuse mass without dissipation of pore pressures. The filling of the site over many years in conjunction of the occurrence of sand lenses throughout the subsurface soils will preclude the development of significant excess pore pressures.

Based on an average coefficient of consolidation value (Cv) of 11 m2/year, and an assumed maximum 40-foot thick layer of silty clay bounded by sand lenses, we calculate that 80 percent of the excess pore pressures will dissipate in less than two years and 95 percent of the excess pore pressures dissipated in less than 4 years under an applied load. Our analyses indicate, based on currently permitted waste acceptance limits, the loading rate will not result in significant pore pressure development beneath the landfill, and therefore, the appropriate foundation slope stability analysis is based on drained conditions.

For this study, we completed stability analyses assuming drained conditions. Drained shear strengths were based on tests completed by Emcon (1993). These tests indicated that drained shear strengths were represented by an internal friction angle of 34 degrees and a cohesion of 0 to 1,000 psf. For this study we conservatively assumed drained shear strengths represented by an internal friction angle of 32 degrees with no cohesion.

The results of our calculations indicate a factor of safety of 2.1 under static conditions. For the design seismic event, the computed permanent displacements are estimated to be approximately 0.1 inch. A minimum static factor of safety of 1.5 satisfies the static stability criteria specified in CCR Title 27 for Class II landfills. The computed permanent displacement of less than 0.1 inch is very small and will not result in damage to the liner system. This satisfies the CCR Title 27 requirement that Class II landfills withstand the MCE without damage to the foundation or structures that control leachate, surface drainage, erosion, or gas.

2.2.5.3 Refuse Slope Stability

Refuse slope stability considers movement along a failure plane that extends through the refuse and along the liner system. DM-2.2, 9.1, 11.1, 11.2 and 5.1 were constructed with a composite liner system containing a geosynthetic clay liner as described by Geosyntec (1995). Interface shear strength testing performed by Geosyntec resulted in a critical design GCL/textured geomembrane interface with a minimum design shear strength defined by internal friction angle of 9 degrees with no cohesion (Golder, 2000). Conformance testing by Golder has confirmed that these constructed liner systems met or exceeded this minimum shear strength (Golder, 1999 and 2001).

DM 2.1 was constructed with composite liner consisting of a compacted clay liner (CCL) overlain by a textured HDPE geomembrane. This interface is expected to have higher shear strengths similar to those measured for DM-4.1. Emcon estimated a minimum design shear strength of 10.5 degrees (Emcon, 1993).

DM 4.1 and future cells will be constructed with a double liner system with leak detection layer. This liner system includes a geosynthetic clay liner on the perimeter slopes. The landfill base composite liner consists of compacted clay and textured geomembrane. Accordingly, the design shear strength for the base liner system is represented by an internal friction angle of 12 degrees with no cohesion (Golder, 2003b). This design interface was confirmed by interface direct shear testing completed by Golder (2003c).

For the purpose of this evaluation, the refuse mass stability was analyzed using the lower critical design friction angle of 9 degrees with no cohesion representing the liner systems constructed for DM-2.2, 9.1, 11.1, 11.2 and 5.1.

Two sections were analyzed for refuse slope stability, Sections A-A' and B-B' (see Figure 4). Section A-A' was taken through DM 4.1 and Section B-B' runs through the existing DM 11.2 Section A-A' was found to be the critical section and is illustrated in Figure 7.

The yield acceleration was also calculated for each section. The yield acceleration is the horizontal acceleration required to result in a factor of safety of 1.0. The yield acceleration in conjunction with the characteristics of the design seismic event and seismic source were used to estimate permanent displacements using the simplified Bray Method. Appendix E includes these calculations.

Table 4 summarizes the static and seismic results for refuse slope stability.

TABLE 4
SUMMARY OF REFUSE SLOPE STABILITY ANALYSES

Section	Static Factor of Safety	Seismically Induced Permanent Displacements (inches)
A-A'	1.5	2.6
B-B'	1.7	1.1

The results of the stability analyses indicate that the waste mass has a minimum factor of safety of 1.5 under static conditions. A minimum static factor of safety of 1.5 satisfies the static stability criteria specified in CCR Title 27 for Class II landfills. Permanent displacements calculated for the sections are less than 3-inches. Displacements of up to 12-inches along the liner system are generally accepted as being within the tolerance limits of liner systems without resulting in adverse damage.

Therefore, these small displacements satisfy the CCR Title 27 requirement that Class II landfills withstand the MCE without damage to the foundation or structures that control leachate, surface drainage, erosion, or gas. In particular, movements of less than three inches will not adversely impact the LCRS HDPE pipes, which are very flexible and able to tolerate relatively large movements. Furthermore, these pipes are oriented perpendicular to the sides of the landfill, and any seismically-induced movements would therefore subject the LCRS pipes to tension/compression loading instead of shear loading. Tension and compression loading are more favorable than shear loading in HDPE pipes.

2.2.6 Landfill Gas

The site will have a complete landfill gas collection system prior to closure. Accordingly, closure construction requirements for the landfill gas collection system are limited to activities integrating the landfill gas extraction wells and piping into the closure cover design. Integration of gas controls with a closure cover system is routinely completed and standard conceptual design details for either horizontal or vertical extraction wells are available. Cover construction costs account for the integration of the wells and header systems.

The first phase of the gas control system is currently being designed and is scheduled to be installed and operational by December 1, 2007. Although the remainder of the gas system has not been designed, it is currently anticipated that the Hay Road Landfill will utilize conventional vertical extraction wells. For Class II MSW landfills, such as Hay Road, it is common to install the wells on an average spacing of about 400 feet. Therefore, approximately 70 to 75 vertical gas wells are expected be installed during the operational life of the landfill These wells will be connected by gas collection header pipes and conveyed to a disposal system that will be also installed prior to closure (e.g. gas flare or landfill gas-to-energy system).

2.2.7 Surface Water Drainage

Figure 8 shows a conceptual drainage plan for the NWSHRL. Drainage will be conveyed along the top deck and intermediate slope benches to down-drains located along the sides of the landfill. The down drain pipes will be fitted with diffuser tees at the discharge ends to dissipate high velocity hydraulic energy before discharging to the perimeter channels. Run-off will be conveyed to a perimeter channel that will discharge off site.

Appendix F presents conceptual drainage calculations to verify that the above conceptual drainage facilities can be designed to accommodate a 1,000-year, 24-hour precipitation event as required by Title 27 for Class II Landfills. As part of the Final Closure Plan, a detailed drainage and erosion control plan and final design details will be developed for the final cover.

The NWSHRL has constructed perimeter drainage channels and berms to prevent run-on from off-site drainage. These features will continue to be used at landfill closure.

2.3 Postclosure Land Use

The postclosure end use of the site will be consistent with surrounding terrain, land uses, and the current agricultural use zoning. The site is planned to be maintained as secured non-irrigated open space and the closed landfill will be designed to reduce health and safety impacts with proper site security fencing and access control. No liquids will be discharged to the cover system.

2.4 Environmental Monitoring and Controls

2.4.1 Existing Monitoring and Control Systems

Existing environmental controls include liner systems and leachate collection and removal system, which are described in Sections 5.2 and 5.3 of the JTD. A landfill gas control system is not currently in place, but will be installed during the operational life of the facility. This system will be integrated into the closed site as discussed in Section 2.2.6.

The liner and leachate collection and removal systems (LCRS) for all future modules at the NWSHRL are described in Section 5.2.2 of the JTD. Double composite base liners (60-mil HDPE) will be employed for these future modules. Leak detection geocomposites will be used in the secondary component to monitor for releases from the primary liner component. The LCRS is designed to provide efficient collection and removal of leachate and meet the requirements of CCR Title 27 and Subtitle D. Subtitle D requires the depth of leachate over the liner to be 1 foot or less. Title 27 CCR §20340 requires the LCRS to be designed to collect and remove twice the anticipated daily volume of leachate.

Environmental monitoring consist of groundwater monitoring, vadose monitoring, landfill gas monitoring, and surface water monitoring as described in the following sections. Within each disposal module, there are one or more leachate collection sumps at the perimeter of the landfill where leachate is extracted and pumped to a temporary storage tank. Leachate is then hauled off-site for disposal at a waste water treatment plant. Figure 9 shows the existing monitoring system. Figure 10 shows the existing leachate collection system and surface water controls.

The groundwater-monitoring network currently consists of twenty five (25) monitoring wells, sampled semi-annually. Each detection and background well is designated to monitor one or more disposal modules. There are a total of twelve (12) leachate sump monitoring points, three (3) leachate wells, two (2) leak detection sumps, eleven (11) lysimeters to monitor the unsaturated zone (exclusive of sludge drying area south of DM 9.1), and five (5) surface water sampling points. WDR Order No. R5-2003-0118 (Appendix A of the JTD) includes groundwater monitoring parameters for the landfill.

Explosive gas (5% methane content or greater) monitoring is currently performed at the site perimeter with eleven (11) LFG monitoring probes to maintain compliance with Title 27 CCR Sections 20919.5 and 20925. Additionally, these probes, pan lysimeters, and leak detection sumps are monitored for the parameters required in WDR Order No. R5-2003-0118 (Appendix A of the JTD); methane, carbon dioxide, oxygen, and organic vapors using field instruments. During closure, the monitored gas parameters will comply with the WDR's and any additional relevant requirements by the CIWMB.

The LFG monitoring at the site, including a typical probe detail, monitoring methods and frequencies, are described in Appendix N of the JTD and referenced in WDRs Order No. R5-2003-0118. During these monitoring events, onsite structures will also be monitored for methane levels greater then 1.25% in accordance with Title 27 CCR Section 20920 et seq. There are no offsite inhabitable structures within 1,000 feet of the permitted landfill footprint.

2.4.2 Modifications Required During Closure

As the landfill is developed, leachate storage tanks will be located outside of the landfill footprint. Leachate conveyance lines will also be located outside of the landfill footprint. Therefore, no modifications to the leachate collection system are required during closure.

Final groundwater and lysimeter monitoring systems will be in place prior to closure. Therefore, no modifications are required to these monitoring systems during closure.

At closure, a total of 17 gas probes will be installed around the perimeter at a spacing of approximately 1,000 feet or less. GP-1 through GP-11 are currently in place. GP-7 and GP-8 are within and/or near the landfill footprint and will be located to the perimeter and renamed as GP-7R and GP-8R as shown in Figure 9. Additional gas probes GP-12 through GP-17 will be installed prior to or at closure.

At closure, the landfill gas collection lines and condensate sumps will be disconnected, temporarily relocated as required, and then reconnected after the closure cover system is constructed. Since the collection lines and control valves are typically joined with periodic bolted, flanged connections, the relocation of the lines is a relatively simple process. The cover system will be constructed around the wells using standard design and construction practices. For example, the geomembrane will be sealed to the extraction wells using a booted sleeve placed around the pipe.

2.5 Closure Activities

2.5.1 Maximum Extent of Landfill Requiring Closure

Closure activities will commence following the completion of the landfill development. Therefore, the maximum extent of the landfill requiring closure at any point in time corresponds to the total maximum waste disposal footprint of 260 acres. The maximum closure footprint is reflected in the closure cost estimate (Section 2.7).

2.5.2 Site Security, Dismantling and Structure Removal

Site security upon closure will be provided by NWSHRLI. Site security will include:

- Proper signs posted at all points of access consistent with regulatory requirements at the time of closure. These signs will be placed at least 60 days prior to closure, state the date of closure, identify the alternative waste disposal location, and will remain at least 180 days after receipt of the last load of waste.
- A public notice will be advertised in a local newspaper(s) with general circulation at least 60 days prior to closure.
- Access will be controlled by locked gates at all access points around the perimeter.
- Fencing will be maintained around the entire site.

The existing temporary facility structures are shown on Figure 2 (scale facilities, administration trailer and maintenance shop). These structures are within the future waste disposal footprint and will be removed and relocated as the landfill is developed. Any future permanent structures will be deactivated and dismantled accordingly following closure. The buildings and maintenance and storage facilities will be dismantled and made available for reuse or resale. Material not considered reusable will be appropriately disposed of consistent with applicable state regulations.

It is anticipated that all environmental control systems will remain in place upon closure and during the postclosure maintenance period until it is demonstrated that landfill by-products such as leachate and landfill gas pose no threat. This demonstration will be to the satisfaction of the LEA, the RWQCB, and the CIWMB and will be presented in the form of a written report. Upon closure, unused controls that have come into contact with landfill leachate or gas will be appropriately cleaned and/or disposed of in accordance with federal, state, and local laws.

Environmental control systems removed during or following postclosure will be dismantled and appropriately disposed of consistent with federal, state, and local laws. Gas and groundwater monitoring wells will be abandoned according to the then current federal, state and local laws. Materials intended for reuse will be cleaned. The methods of cleaning that may be used include:

- Washing with water, detergent, or chemical solvents;
- Steam cleaning;
- Scrubbing with abrasives; and
- Sand blasting.

The residues produced as a result of cleaning reusable components will be disposed of consistent with applicable federal, state, and local laws. A more specific plan for decommissioning environmental control systems will be prepared for the final closure plan.

2.5.3 Final Cover Construction

Final Cover

A final cover will be constructed as part of the closure activities. The final cover as described in Section 2.2 is an engineered alternative design that provides equal or improved water quality protection than the prescriptive standard requirements of Title 27 CCR.

Closure activities will commence within 30 days of the receipt of the last load of refuse. A detailed schedule showing the sequencing of construction activities and duration of the activities will be submitted as part of the final closure plan. A minimum of two surface monuments will be located on the top deck of the cover to facilitate periodic topographic surveys and subsequent settlement evaluations. The exact location and number of survey monuments will be determined as part of the final closure design.

Construction Quality Assurance

Construction Quality Assurance (CQA) will be completed during the closure activities to ensure that the construction complies with the closure design plans and specifications. Prior to starting the closure activities, a construction quality assurance plan will be prepared by a Registered Civil Engineer or Certified Engineering Geologist in accordance with Sections 20323 and 20324 of Title 27 CCR, and submitted as part of the final closure plan. Following closure construction, a closure certification report will be prepared and submitted to provide documentation that the closure activities were completed in accordance with the design plans and applicable federal and state regulations. A registered civil engineer or certified engineering geologist will supervise CQA activities and certify the closure report.

Typical CQA activities will include, but are not limited to the following:

- Verifying the materials, thickness and compaction of the foundation layer;
- Observation and inspection of the geosynthetic materials for conformance with the engineering plans and specifications;

- Conformance testing of soil and geosynthetic materials;
- Documentation of construction procedures, and identification and resolution of construction problems; and
- Preparation of a CQA report providing documentation that the closure activities and construction complied with the project plans and specifications.

CQA Plan requirements to be included in the Final Closure Plan are outlined in Table 5.

TABLE 5
CQA PLAN REQUIREMENTS

1. A delineation of the CQA management organization, including a chain of command
2. A detailed description of the level of experience and training of the contractor, work crew, and CQA inspectors.
3. Description of the CQA testing protocols
4. CQA manufacturer or third party data on all geosynthetics utilized
5. CQA documentation
6. Types and frequencies of tests to be performed
   - For consistency, at least two placement tests should be performed on the barrier layer
   - Frequency range:
     - Subgrade: 1 test per acre – 1 test per 5 acres
7. For all cover material the following tests should be performed:
   - Particle size analysis (ASTM D 422-93)
   - Compaction characterization (ASTM D 1557-91)
   - Classification of Soils (ASTM D 2487-93)
8. For low-hydraulic-conductivity layer the following tests should be performed:
9. Review required earth material/geosynthetic placement tests for adequacy and completeness
   - All earth materials:
   - Laboratory soil characterization tests as above (particle size analysis, compaction characterization, classification of soils, liquid limit, plastic limit, plasticity index, triaxial-cell method with back pressure)
   - Description and Identification of Soils (ASTM 2488-93)
   - Four field density tests performed for each 1,000 cubic yards of material placed or a minimum of 4 tests per day.
     - Nuclear density gauge
     - Sand Cone test
   - Compaction curve data (ASTM D 1557-91) represented graphically once a week or every 5000 cubic yards of material placed
   - Atterburg limits (ASTM D 4318-93) represented graphically once a week or every 5000 cubic yards of material placed
10. Flexible Membrane Liner (FML):
    - Preconstruction quality control program
    - Tensile strength
    - Layer thickness strength
    - Peel test for the seaming of the material
    - Inspection of placement
    - Inspections of installation of anchors and seals
11. Geosynthetic Clay Liner

- Preconstruction Quality Control Program
- Bentonite Unit Weight
- Permeability (ASTM D 5084)

2.5.4 Recording

Upon closure of the site, NWSHRLI will file a detailed description of the closed site to the local enforcement agency and County Recorder. The site description shall include:

- A map and description of the closed site;
- The date closure was completed;
- Locations where the Final Closure and Postclosure Maintenance Plan can be obtained;
- The boundaries of each waste management unit and the height and depths of filled refuse; and
- A statement that the site use is restricted in accordance with the postclosure maintenance plan.

2.5.5 Preliminary Closure Schedule

A detailed closure schedule will be prepared as part of the Final Closure and Postclosure Maintenance Plan. The following provides a summary of the currently anticipated closure schedule.

- Proper signs posted at all points of access consistent with regulatory requirements at the time of closure. These signs will be placed at least 60 days prior to closure, state the date of closure, identify the alternative waste disposal location, and will remain at least 180 days after receipt of the last load of waste.
- A public notice will be advertised in a local newspaper(s) with general circulation at least 60 days prior to closure.
- Closure activities will begin within 180 days of closure.
- Completion of closure construction and construction quality assurance (CQA) will likely need to be phased to allow construction to be limited to the dry season. Assuming individual closure construction phases will involve between 50 to 90 acres of cover area, it is anticipated that closure construction and CQA of the entire landfill may require 3 to 5 construction seasons to complete.
- A CQA Report for each phase of closure construction will be submitted within 30 days of the completion of each closure phase.

2.5.6 Health and Safety

The construction contractors completing the closure activities will be required to prepare a Health and Safety Plan that identifies and addresses the anticipated construction hazards. There are no hazardous wastes at the Hay Road Landfill and disposed wastes will not be exposed during closure construction. Therefore, construction activities are expected to be completed using Level D Personal Protective Equipment (PPE), which is common to all standard construction projects.

2.6 Landfill Capacity and Life

Golder Associates has completed landfill capacity and life estimates on an annual basis for NWSHRL since 1998. These evaluations have been based on aerial topographic surveys and gate receipts of refuse tonnage. As of April 1, 2007, the remaining net landfill airspace was estimated to be 30.9 million cubic yards. Table 6 summarizes the landfill capacity calculations.

Based on a projected effective density of 1,035 pcy and an annual one percent waste stream growth rate, the remaining life of the facility is estimated to be approximately 70 years, which corresponds to a closure date in 2077 (Table 7). NWSHRL accepted 156,700 tons of refuse from June 30, 2004 to June 30, 2005. The projected effective density of 1,035 pcy and one percent growth rate are consistent with the projections completed for the past two years. These projections are reviewed on an annual basis. The projected effective density of 1,035 pcy takes into account anticipated waste settlement. Settlement of the foundation soils is not expected to significantly increase disposal capacity from that summarized in Table 6.

DM-4.2 was the most recent cell that was constructed. Currently, NWSHRLI anticipates that the remaining portion of landfill will be developed and filled in the following sequence:

- DM-4 (remaining portion)
- DM-3
- DM-7
- DM-8
- DM-6
- DM-9 (remaining portion)
- DM-2 (remaining portion)
- DM-11 (remaining portion)
- DM-10

The locations of the planned disposal modules are shown on Figure 2. This sequence is only for planning purposes and may be changed as needed to respond to external influences.

TABLE 6
LANDFILL CAPACITY

Item Description	Quantity	
1. Gross Total Refuse Airspace[1]	36,626,000	cy
2. Cover Volume Requirements		
2a. 1 ft Vegetative Soil Layer	433,000	cy
2b. 1 ft Foundation Layer (will be in place at the time of closure)	0	cy
Total	433,000	cy
4. Liner Volume	1,382,000	cy
5. Net Refuse Airspace (1-2-3)	34,811,000	cy
6. Estimated Airspace Consumed As of April 1, 2007	3,910,000	cy
7. Remaining Refuse Airspace (5-6)	30,901,000	cy
8. Remaining Refuse Capacity[2]	15,991,000	tons

1. Gross airspace does not include refuse or inert fill within DM-1 prior to 1996.

2. Based upon a predicted overall effective density of 1,035 pcy for the life of the landfill, which accounts for waste settlement

TABLE 7
LANDFILL LIFE ESTIMATE

Year	Remaining Airspace (cy)	Tons	Year	Remaining Airspace (cy)	Tons
2007	30,815,934	157,684	2043	17,558,988	225,610
2008	30,508,183	159,261	2044	17,118,667	227,866
2009	30,197,355	160,854	2045	16,673,944	230,144
2010	29,883,418	162,462	2046	16,224,773	232,446
2011	29,566,342	164,087	2047	15,771,111	234,770
2012	29,246,096	165,728	2048	15,312,912	237,118
2013	28,922,646	167,385	2049	14,850,130	239,489
2014	28,595,963	169,059	2050	14,382,722	241,884
2015	28,266,012	170,749	2051	13,910,639	244,303
2016	27,932,762	172,457	2052	13,433,835	246,746
2017	27,596,179	174,181	2053	12,952,263	249,213
2018	27,256,231	175,923	2054	12,465,875	251,706
2019	26,912,883	177,683	2055	11,974,624	254,223
2020	26,566,102	179,459	2056	11,478,460	256,765
2021	26,215,852	181,254	2057	10,977,334	259,333
2022	25,862,101	183,066	2058	10,471,197	261,926
2023	25,504,812	184,897	2059	9,959,999	264,545
2024	25,143,949	186,746	2060	9,443,689	267,191
2025	24,779,479	188,614	2061	8,922,216	269,862
2026	24,411,363	190,500	2062	8,395,528	272,561
2027	24,039,567	192,405	2063	7,863,573	275,287
2028	23,664,052	194,329	2064	7,326,298	278,040
2029	23,284,783	196,272	2065	6,783,651	280,820
2030	22,901,720	198,235	2066	6,235,577	283,628
2031	22,514,827	200,217	2067	5,682,023	286,464
2032	22,124,065	202,219	2068	5,122,933	289,329
2033	21,729,396	204,241	2069	4,558,252	292,222
2034	21,330,779	206,284	2070	3,987,924	295,145
2035	20,928,177	208,347	2071	3,411,893	298,096
2036	20,521,549	210,430	2072	2,830,102	301,077
2037	20,110,854	212,535	2073	2,242,493	304,088
2038	19,696,052	214,660	2074	1,649,008	307,129
2039	19,277,102	216,806	2075	1,049,587	310,200
2040	18,853,963	218,975	2076	444,173	313,302
2041	18,426,593	221,164	2077	0	229,860
2042	17,994,948	223,376			

Notes:
1. Effective density of 1,035 pcy
2. Annual growth rate = 1.0%

2.7 Closure Cost Estimate

Closure and postclosure maintenance funding for NWSHRL complies with current state regulations. Title 27 of the California Code of Regulations states that an irrevocable fund be established, or provide other means to ensure closure for the site. NWSHRL has a closure fund established with the current amount of the closure fund based on the total closure costs prorated to reflect the proportion of the permitted airspace that has been consumed. The closure costs and closure fund are reviewed and updated annually.

The current cost estimate for closure of NWSHRL is based upon information presented in this report. The following key assumptions were made in compiling these estimates:

- The source of the vegetative soil cover will be on-site.
- The foundation layer will be obtained from on-site soils or consist of suitable alternative cover and will be placed and compacted as part of the interim cover layer.
- Two survey monuments will be installed on the top deck.
- 8 Additional perimeter gas probes will be installed during closure.
- All closure activities will be observed and documented by a registered civil engineer or a certified engineering geologist as required by CCR, Title 27.
- The maximum area expected to be closed at any one time is 260 acres.
- The landfill gas system collection lines will be disconnected, temporarily removed and then reconnected after the cover is constructed. Allowing this work to be completed in ten working days by five laborers (unit rate of $60/hr), and one backhoe (unit rate of $150/hr including operator) results in a cost of $36,000, or about 0.1% of the estimated closure cost.
- Unit costs presented include all mobilization, equipment, materials, labor, and contract administration to complete the work

Table 8 provides the updated closure costs reflecting the revised closure cover system components. The closure costs for the site of $21,716,321 are funded and incurred incrementally during the operational life of the landfill as areas are developed and filled to the final grades.

TABLE 8
2007 CLOSURE COST SUMMARY

Item	Unit	Unit Cost	Quantity	Total
1. Final Soil Cover[1]				
a. Foundation Layer	cy	$ 4.00	-	$ -
b. Vegetative Layer	cy	$ 5.00	432,743	$ 2,163,715
2. Geosynthetic Layers				
a. Geomembrane (60 mil HDPE)[2]	sf	$ 0.57	11,684,063	$ 6,659,916
b. Geocomposite drainage layer[2]	sf	$ 0.58	10,105,109	$ 5,860,963
c. GCL[2]	sf	$ 0.65	1,578,954	$ 1,026,320
d. 10-oz/yd Geotextile	sf	$ 0.25	1,578,954	$ 394,739
e. Geosynthetic testing	%	2.0%		$ 278,839
3. Design/CQA				
a. Design, plans, specifications	ls	$ 95,000	1	$ 95,000
b. Post-closure maintenance plan	ls	$ 30,000	1	$ 30,000
c. CQA	acre	$ 2,308	260	$ 600,000
4. Revegetation	acre	$ 1,000	260	$ 260,000
5. Landfill Gas Monitoring Network	ls	$ 16,042	1	$ 16,042
6. Gas Control				
Install gas control system[3]		$ -	-	$ -
Relocate collection lines[6]	ls	$ 30,000	1	$ 36,000
7. Groundwater Monitoring System[4]	ls	$ -	1	$ -
8. Drainage Structures				
a. CMP and drop inlets	lf	$ 50	10,700	$ 535,000
b. V-ditches	lf	$ 8	16,300	$ 130,400
9. Security Measures[5]	ls	$ -	1	$ -
10. Closure Survey, Settlement Monuments	ls	$ 10,000	1	$ 10,000
			Subtotal	$ 18,096,934
			20% Contingency	$ 3,619,387
			Total	$ 21,716,321

Notes
1. Cover Profile - foundation layer (1 ft already in place), geosynthetic layers and vegetative layer (1 ft).
2. Geomembrane, GCL and geotextile on top deck. Geomembrane and geocomposite on side-slopes.
3. Gas control system will be installed prior to closure. 8 additional gas probes installed at closure.
4. Groundwater monitoring system will be installed prior to closure. The existing network is sufficient to monitor current operations.
5. Security measures will be installed prior to closure.
6. Assumes 10 days for backhoe and operator and 5 laborers at a cost of $3,600/day.

3.0 PRELIMINARY POSTCLOSURE MAINTENANCE PLAN

Postclosure maintenance of NWSHRL will be performed in accordance with Title 27 CCR, Section 21180. Postclosure activities will consist of groundwater and surface water monitoring, landfill gas monitoring, and the inspection of the final cover system, leachate collection and disposal controls, and environmental monitoring systems (groundwater, vadose zone, surface water, and landfill gas), and inspection of the site security system. Postclosure monitoring and maintenance will occur an on an annual or semi-annual basis for a period of at least 30 years.

NWSHRLI will be responsible for implementing postclosure inspection and maintenance activities. A Final Postclosure Maintenance Plan will be submitted to the regulatory agencies at least two years prior to closure for review and approval.

3.1 Monitoring and Sampling Activities

Monitoring and sampling activities include leachate, groundwater, vadose zone, surface water, and landfill gas. The frequency of monitoring and analyses performed are shown in Table 6.1 of the JTD and comply with WDR R5-2003-0118 and the current Landfill Gas Monitoring Plan (Appendix H). The total number of leachate and vadose zone monitoring points will depend in part on the number of sumps and design of landfill cells. Based on current conceptual base development plans, the final landfill development is expected to result in 22 leachate sumps and 22 vadose lysimeters.

LFG monitoring during the postclosure period will confirm explosive gas content is less than 5% methane at the perimeter boundary and less than 1.25% (25% of methane LEL) in any remaining onsite structures. The gas monitoring parameter list will consist of the list currently in the WDR's. Reports from LFG monitoring will be made available to the LEA within 90 days of monitoring events.

The leachate collection and gas collection systems will be operated throughout the postclosure period until leachate and gas are no longer produced. Leachate and landfill gas will be handled to ensure that it is controlled and contained to prevent contact with the public.

3.2 Postclosure Inspection and Maintenance Activities

Postclosure inspection and maintenance activities will include the final cover, the site drainage system, environmental controls, and security system as described in the following sections. Written notification of unusual incidents or occurrences observed during inspections will be provided to the LEA, or other appropriate agency in 2077 and beyond, regarding such events as; vandalism, fires, explosions, earthquakes, floods, the collapse or failure of artificial or natural dikes, levees or dams; surface drainage problems; and other incidents involving or threatening waste releases.

3.2.1 Final Cover

The final cover will be inspected semi-annually to confirm that the final cover continues to function as an infiltration barrier. Visual inspections will be performed for the following:

Final Cover Integrity

Qualified personnel will inspect the final cover for signs of settlement and subsidence, erosion, cracking or other items that could adversely affect the integrity and effectiveness of the final cover. Items requiring corrective action will be repaired as soon as feasible. Monitoring of the cover integrity will be completed periodically by temporarily shutting down the gas collection system and then monitoring for possible leaks in the cover system. Evaluation of potential leaks will be completed using surface monitoring equipment and/or soil gas probes.

Some minor differential settlement is expected at every landfill. Minor settlement can create relatively small depressions on a landfill surface where water will pond. At NWSHRL, repair of such ponds will be completed in one of the following ways:

- Small depressions will be filled with soil to promote positive surface drainage.
- Larger depressions in which the underlying geocomposite drainage layer is not positively drained will be excavated to remove the cover system components above the foundation layer. Additional foundation soils will be added as necessary to establish suitable drainage grades. The overlying cover components will be replaced using the existing cover materials or new materials as may be necessary. The replaced materials will be constructed in compliance with the original closure engineering plans, specifications, and CQA plan.

Appendix D presents the results of settlement analyses that were completed to evaluate the effects of post-closure settlement on the final cover grades. The results of these analyses indicated that the proposed grades are sufficient to accommodate the anticipated post-closure settlement and still provide adequate drainage.

The final landfill contours are designed to accommodate storm water drainage from the completed landfill after settlement and to minimize erosion of the final soil cover. To verify the integrity of the final cover, a program of periodic observation and maintenance will be instituted. At least two permanent survey control monuments to provide reference points for landfill settlement measurements will be installed and maintained throughout the postclosure as required by Title 27 CCR Section 20950(d). There are currently 16 survey benchmarks or aerial photogrammetry benchmarks located along the northern (Hay Road) and southern perimeters of the facility, including one at the intersection of Hay Road and Highway 113. At least one pair of these survey monuments currently used for aerial surveying will be converted into permanent benchmarks for the site's closure.

Aerial photographic surveys of the entire permitted site will be conducted following closure and then every five years throughout the postclosure maintenance period or until settlement is no longer occurring. The aerial photographs used to evaluate landfill settlement will be prepared consistent with Title 27 CCR§21090(e). Iso-settlement maps will be produced showing the change in elevation from the map produced upon closure and the most recent topographic map. The maximum contour interval will be 2 feet.

Differential settlement observed visually on the cover surface will be tracked by mapping the location and extent of the settlement [27 CCR§21090(e)(4)]. The location of these differential settlement areas will monitored each year for drainage problems and final cover integrity and highlighted on the 5-year iso-settlement maps.

Vegetative Cover

Qualified personnel will inspect the vegetative cover for signs of erosion, degradation, and areas that lack vegetative growth. Items requiring corrective action will be repaired as soon as feasible. The postclosure maintenance costs provided in Section 3.3 assume that reseeding will be completed for an average of 13 acres per year prior to the first winter rains to allow for natural seed germination.

3.2.2 Drainage System

The surface drainage controls will be inspected annually for evidence of damage, excessive erosion, settlement, and obstruction by debris. The effectiveness of the surface water drainage ditches will be maintained by keeping the ditches, down-drains, and culverts clear of debris, excess soils and excess vegetation. Repairs to the structures will be made if the inspections reveal excessive damage to the ditches, down-drains and culverts. In addition, regrading will be performed as necessary to maintain positive drainage.

3.2.3 Environmental Controls

As part of the periodic sampling program, the groundwater wells, vadose zone probes and riser pipes, and landfill gas probes will be inspected for damage. Well heads, locks, caps, sampling ports, and/or tubes that appear damaged or excessively worn will be identified and replaced.

SCS has estimated that the landfill gas control system will be operated for the 30 year post-closure period (Appendix H).

The groundwater extraction system for DM-1 will continue to be operated throughout the post-closure period.

3.2.4 Security

All locks, gates, signs, and fences will be inspected on an annual basis. Any damage to the security system due to vandalism, trespassing, or natural wear and tear will be immediately repaired and/or replaced. Signs will be repainted or replaced on an as-needed basis to maintain their visibility.

3.2.5 Notification Procedures

An emergency response plan will be prepared as part of the Final Closure and Postclosure Maintenance Plan per the requirements of Title 27 CCR§21130. This plan will include requirements to notify the LEA or any other appropriate agency of any occurrences of spills, fires, and other incidents involving or threatening waste releases.

3.3 Cost Estimate

Table 9 presents a 30-year postclosure maintenance cost estimate for the NWSHRL. Funding of the postclosure maintenance for the NWSHRL complies with current state regulations. Title 27 of the California Code of Regulations states that an irrevocable fund be established, or provide other means to ensure postclosure maintenance of the site for 30 years. The NWSHRL has a postclosure maintenance fund established and the current amount of the postclosure fund is based on the total postclosure maintenance costs prorated to reflect the proportion of the permitted airspace that has been consumed. The postclosure maintenance costs and fund are reviewed and updated annually.

The current cost estimate for postclosure maintenance of the NWSHRL is based upon information presented in this report. The following key assumptions were made in compiling these estimates:

- Environmental monitoring costs are based on the projected number of sampling points (Section 3.1), WDR R5-2003-0118 testing frequencies and constituents, and current third party testing costs for the site;
- Gas monitoring is conducted quarterly;

- Leachate is conservatively assumed to be collected throughout the postclosure period;
- On average, about 13-acres of the cover (5% of total area) will require maintenance, repair, and reseeding each year;
- Inspections are completed annually and settlement surveys completed every 10 years;
- Groundwater wells are replaced every ten years at a cost of $5,000 well (average).
- SCS estimates the landfill gas system will create revenue from energy generation to Norcal in excess of the operation and maintenance costs by approximately $3.1 million over the 30 year operating period. These estimates are presented in Appendix H (SCS Landfill Gas System O&M Cost Estimate). We have conservatively assumed for the purposes of estimating postclosure maintenance costs that the annual revenue from energy generation will only offset the landfill gas system operations and maintenance costs.

As indicated in Table 9, the projected annual postclosure maintenance cost is $237,091/year.

TABLE 9
2007 POST-CLOSURE MAINTENANCE COST SUMMARY

Item	Unit	Unit Cost	Annual Quantity	Total
1. Vegetation Maintenance	acre	$ 250	13.0	$ 3,250
2. Leachate				
a. Sampling and Inspection[1]	annually	$ 53,070	1	$ 53,070
b. O&M, Off-site disposal	annually	$ 15,700	1	$ 15,700
3. Landfill Gas Monitoring/Maintenance	annually	$ 6,861	1	$ 6,861
4. Vadose Zone Monitoring/Maintenance[1]	annually	$ 26,966	1	$ 26,966
5. Groundwater Monitoring/Maintenance[1]	annually	$ 50,260	1	$ 50,260
6. Surface Water Monitoring/Maintenance[1]	annually	$ 27,246	1	$ 27,246
7. Drainage/Cover Maintenance	annually	$ 18,000	1	$ 18,000
8. Security Maintenance	annually	$ 1,000	1	$ 1,000
9. Inspections	semi-annually	$ 1,000	2	$ 2,000
10. Miscellaneous				
a. Aerial Survey, Settlement Report	every five yrs	$ 10,000	0.2	$ 2,000
b. DM-1 Groundwater Maintenance	annually	$ 11,000	1	$ 11,000
11. Permitting Fees	annually	$ 11,000	1	$ 11,000
			Total Annual Cost	$ 237,091
			Cost x 30 yrs	$ 7,112,715

Notes

1. Sampling and testing costs based on revised number of sumps/vadose pan lysimeters and testing protocol outlined in the WDR's.

4.0 CLOSURE OF WASTE PILE 9.1 AND LAND TREATMENT UNIT

NWSHRLI currently operates two temporary waste management units within the Class II permitted disposal footprint. Waste Pile 9.1 measures approximately 6.5 acres in area and is located within Disposal Module 9.1. The Land Treatment Unit (LTU) is located adjacent to DM-9.1 and measures approximately 22.5 acres in area. The following sections describe the closure of these facilities.

4.1 Waste Pile 9.1

Waste Pile (WP) 9.1 occupies a portion of the footprint of Disposal Module 9.1 and is used to store biosolid sludges during the wet season. During the dry season, the biosolid sludge is removed and hauled to the LTU, where it is spread and dried, and then used for daily cover of refuse, or admixed with soil for use as an operations layer within the construction of different modules.

Prior to operation as a waste pile, DM-9.1 was designed and constructed as a Class II Waste Management Unit. The facility has a composite liner and leachate collection system with a pan lysimeter that complies with current federal and state regulations for a Class II Landfill.

At the completion of the WP-9.1's operation as a waste pile, all remaining sludges, excess soil (e.g. operations pad) and perimeter berms will be removed and disposed of properly or used as daily cover. The monitoring records for environmental controls (groundwater, leachate, and pan lysimeter) and the remaining surface of the waste management unit will be inspected by a registered civil engineer or certified engineering geologist to evaluate suitability to begin operations as a Class II Landfill and determine if any rehabilitation measures are required. Recommendations for rehabilitation measures will be completed and documented.

The above actions to terminate the waste pile operations and return the unit to use as a Class II landfill module will effectively close the waste pile. No postclosure monitoring and maintenance associated with the waste pile will be necessary, because these activities will be completed for the Class II Landfill (DM-9.1).

4.2 Land Treatment Unit

The Land Treatment Unit (LTU) is contained within the permitted footprint of the Class II Landfill. The LTU measures approximately 22.5 acres and occupies portions of future DM's 4, 5, and 6. The LTU is operated only during the dry season. At the conclusion of each season of operation, the soils beneath the LTU are sampled to verify the depth of the treatment zone. To comply with Title 27 requirements for groundwater separation, one to three feet of soil is first placed over the existing ground surface prior to biosolids treatment operations.

Upon closure, the remaining biosolids will be removed and properly disposed of, admixed with soil for use as an operations layer within the construction of different modules or used as ADC. After determining the depth of the treatment zone, the treatment zone soils will be excavated and properly disposed of, admixed with soil for use as an operations layer within the construction of different modules or used as ADC. Construction activities will then commence in the former LTU area to construct Class II landfill disposal modules.

The above actions to terminate the LTU operations and convert the facility to a landfill will effectively close the LTU. No postclosure monitoring and maintenance associated with the LTU will, therefore, be necessary.

4.3 Closure and Postclosure Costs

WP-9.1 and the LTU will be closed as part of the ongoing development of the Class II Landfill. The NWSHRL has already established irrevocable funds for Closure and Postclosure Monitoring and Maintenance of the Class II Landfill. Title 27 requires the operator to establish a fund based on the maximum cost of closure at any point in time.

Currently, NWSHRLI has established a fund based on closing the entire 260-acre landfill, which currently contains both WP-9.1 and the LTU. The closure costs presented in Table 8 correspond to an average unit cost of $83,000/acre.

In the event site operations are terminated prior to developing WP-9.1 and the LTU area into a Class II landfill, these facilities will be decommissioned. From a cost perspective, the worse case scenario is when WP-9.1 is at capacity in the spring. In 2001, NWSHRLI contracted with a third party to haul, spread and dry all of the sludges in WP-9.1, which was near capacity, for a total cost of $225,000.

For early termination of site operations scenario, the worse case total decommissioning/closure costs for WP-9.1 and the LTU are estimated be to $274,000 as follows:

- Sludge removal and drying costs are approximately $250,000 based on 2001 third party costs to perform this work.
- The sludges will be used as an economical daily and intermediate cover for the most recently active waste disposal areas. Therefore, there is not a net cost associating with the disposal of the sludges.
- The LTU soils, and soil components of the WP-9.1 liner system will be used as an economical source of daily or intermediate cover of refuse or as a economical source of cover foundation soils. Therefore, there is not a net cost associating with the disposal of the soil materials.
- The geosynthetic materials will be removed and hauled to one of the landfill units for proper disposal. Allowing this work to be completed in one week by five laborers (unit rate of $60/hr), one excavator (unit rate of $200/hr including operator), and one dump truck (unit rate of $100/hr including driver) results in a removal and disposal cost of $24,000.

The above total decommissioning/closure costs correspond to a unit rate of $42,000/acre for WP-9.1. This projected cost ($42,000/acre) is less than the current closure funding that is in place ($83,000/acre). Therefore, adequate funding of closure activities is in place and a separate closure fund is not required for WP-9.1 and the LTU.

5.0 REFERENCES

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Figures

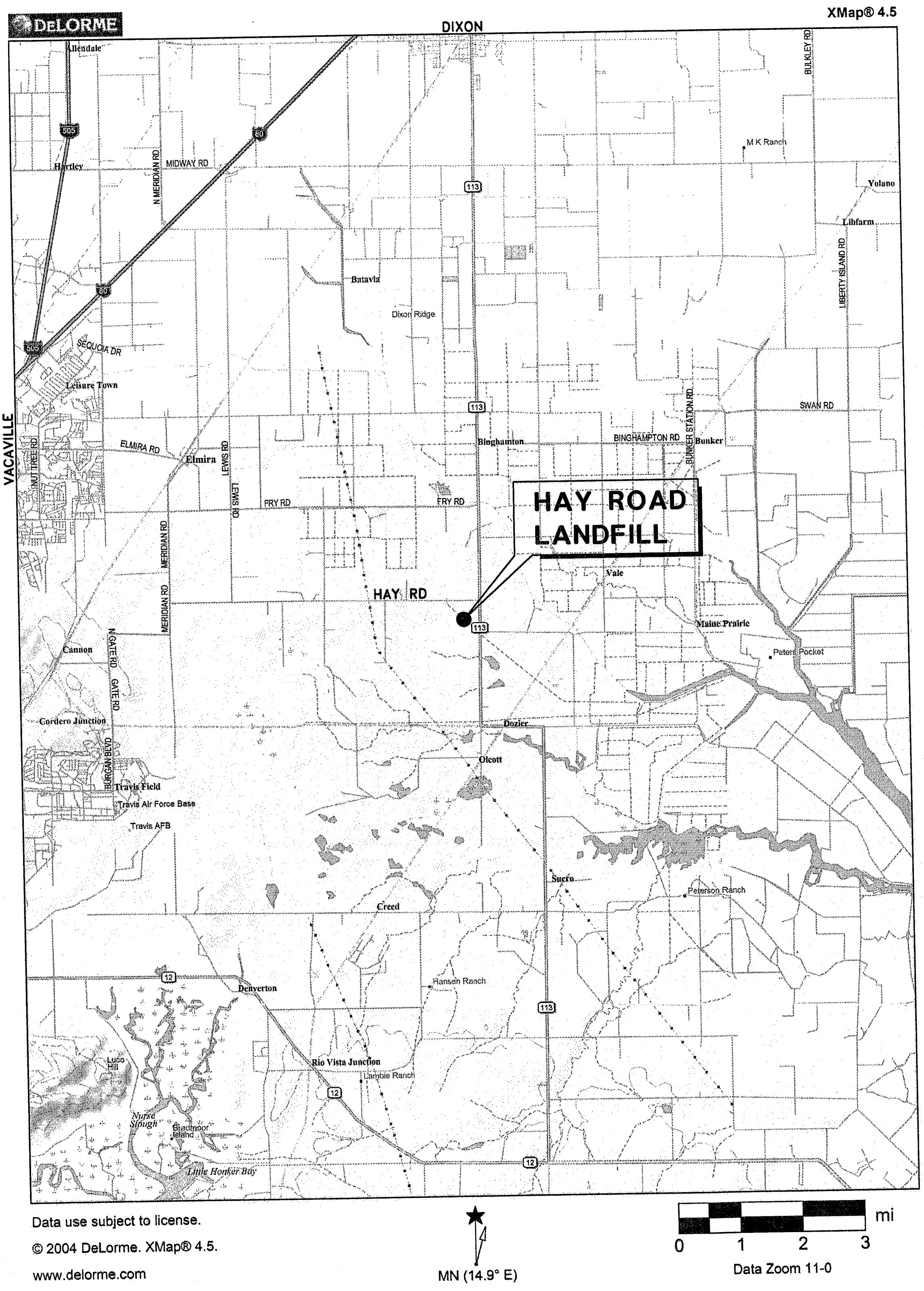

FIGURE 1

SITE LOCATION MAP

NORCAL/HAY ROAD PCPCMP/CA

NOTES:
1) BASE MAP OBTAINED FROM DELOME SOFTWARE TITLED XMAP, VERSION 4.5. DATE OF MAP: 2004.

Golder Associates

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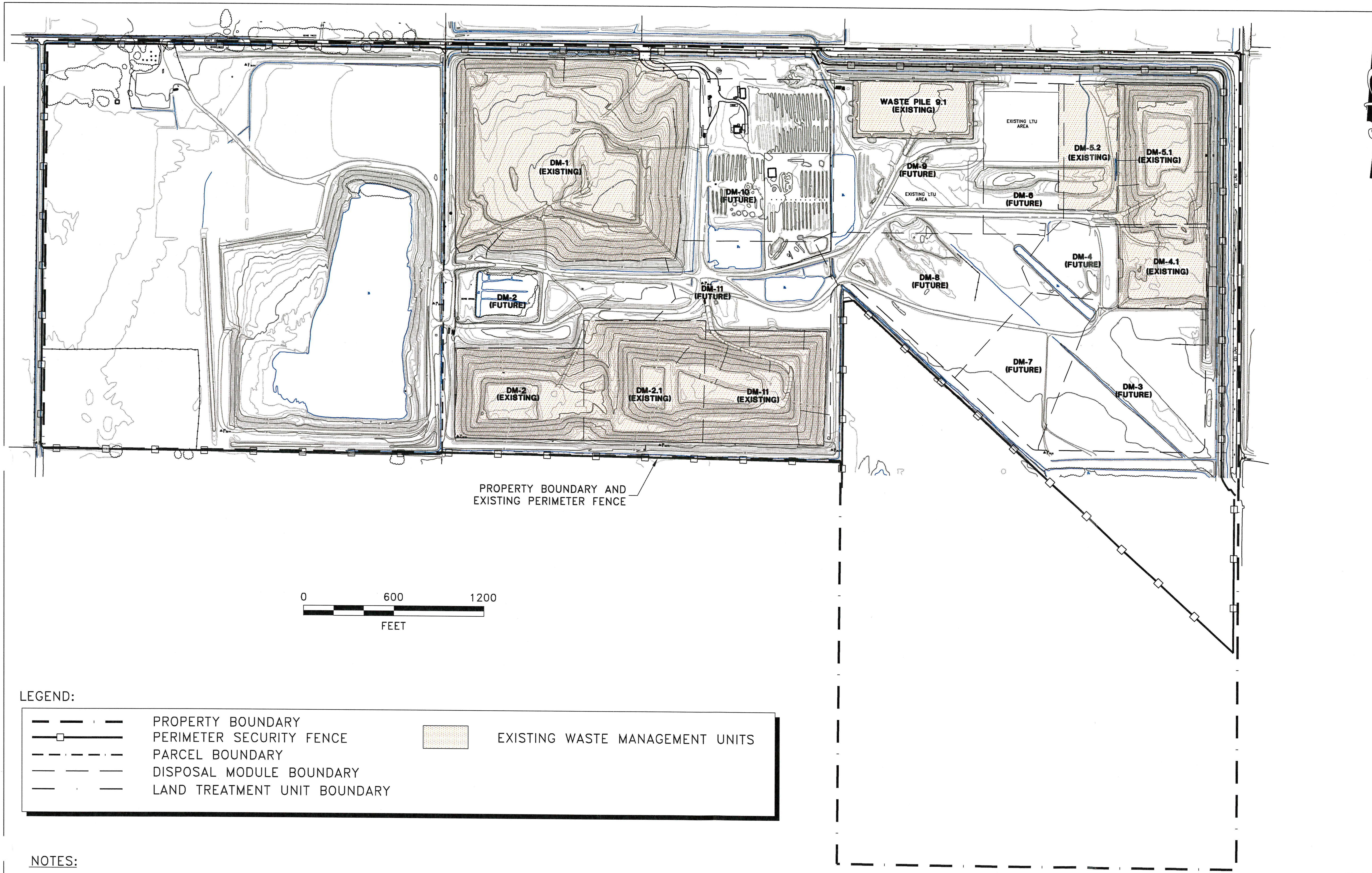

LEGEND:

— — -	PROPERTY BOUNDARY
—□—	PERIMETER SECURITY FENCE
- - - · -	PARCEL BOUNDARY
— — —	DISPOSAL MODULE BOUNDARY
— · —	LAND TREATMENT UNIT BOUNDARY
(shaded)	EXISTING WASTE MANAGEMENT UNITS

NOTES:

1) TOPOGRAPHIC CONTOURS PREPARED USING PHOTOGRAMMETRIC METHODS BY AERO GEODETIC CORP. DATES OF PHOTOGRAPHY: MAY, 2004.

FIGURE **2**

LANDFILL FACILITY PLAN

NORCAL/HAY ROAD PCPCMP/CA

Golder Associates

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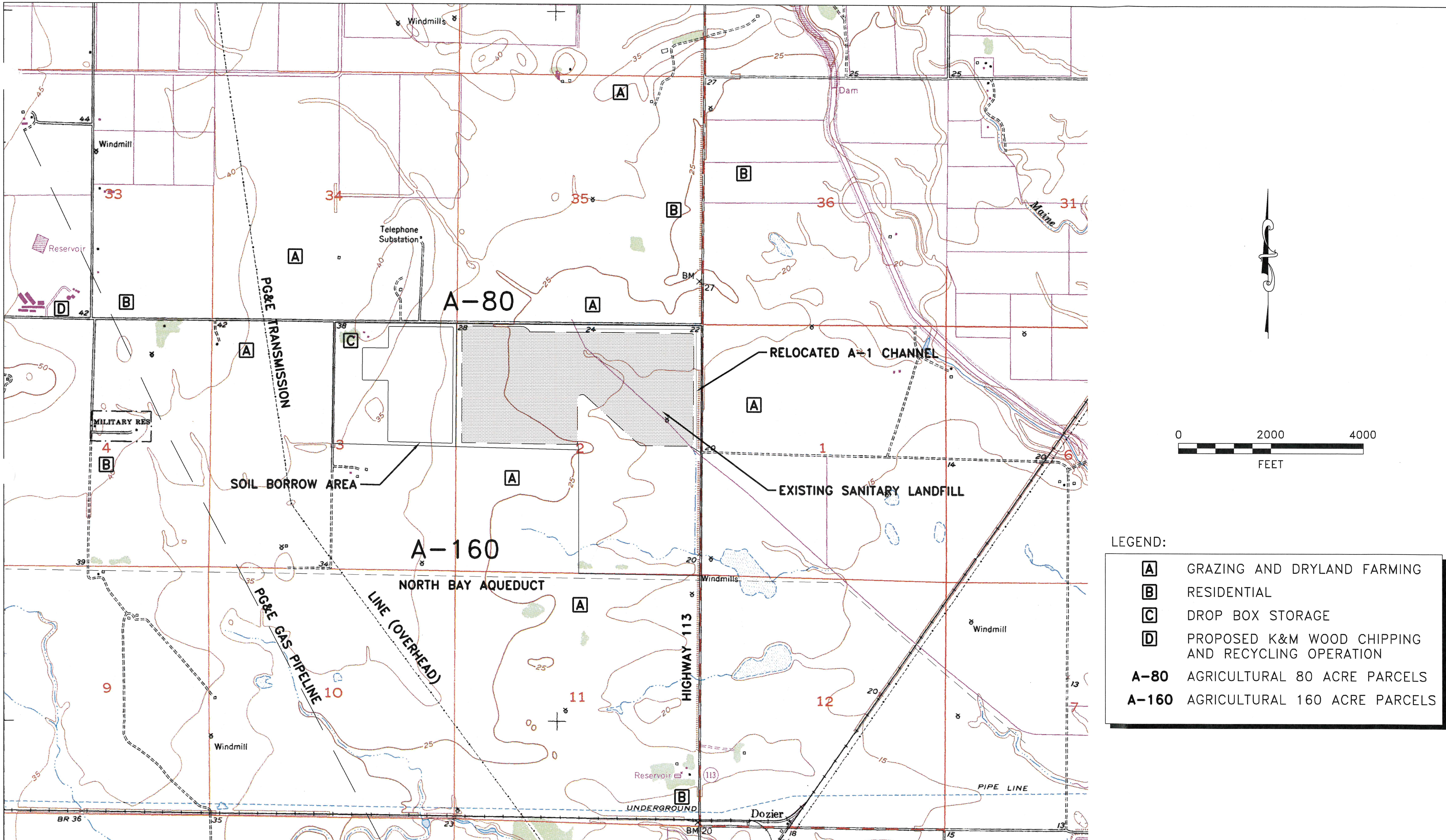


BASE MAP: USGS 7.5 MIN. QUADRANGLE DOZIER, CALIFORNIA
REFERENCE: EMCON ASSOCIATES, TITLED: REPORT OF WASTE DISCHARGE, JANUARY 1993

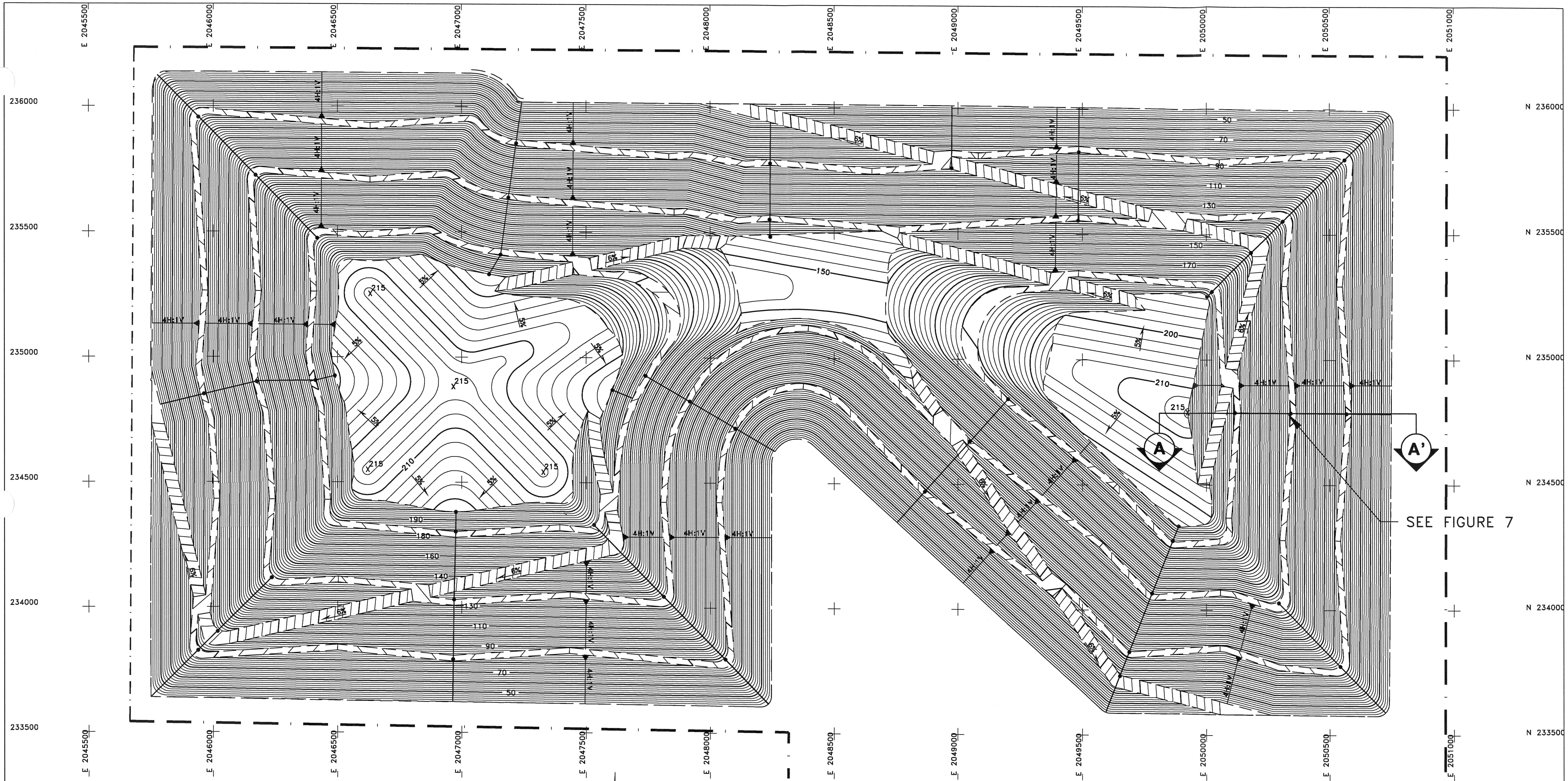
FIGURE 3

LAND USE AND PARCEL MAP

NORCAL/HAY ROAD PCPCMP/CA

DWG ID: JRaub | N:\Projects\053-7433 (Norcal-NWSHRL JTD Update)\2005 PCPMP Update\Figures\Figure 3 Rev1.dwg | 4-24-7 10:34 | xrf: NONE

Golder Associates



LEGEND:

(dash-dot line)	PROPERTY LINE
(dashed line)	PARCEL LINE
(line with dots)	DOWNRAIN WITH INLET-LOCATIONS
2H:1V	SLOPE INDICATOR
2%	GRADE INDICATOR

0 400 800

FEET

FIGURE **4**

FINAL GRADING PLAN

NORCAL/HAY ROAD PCPCMP/CA

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Golder Associates

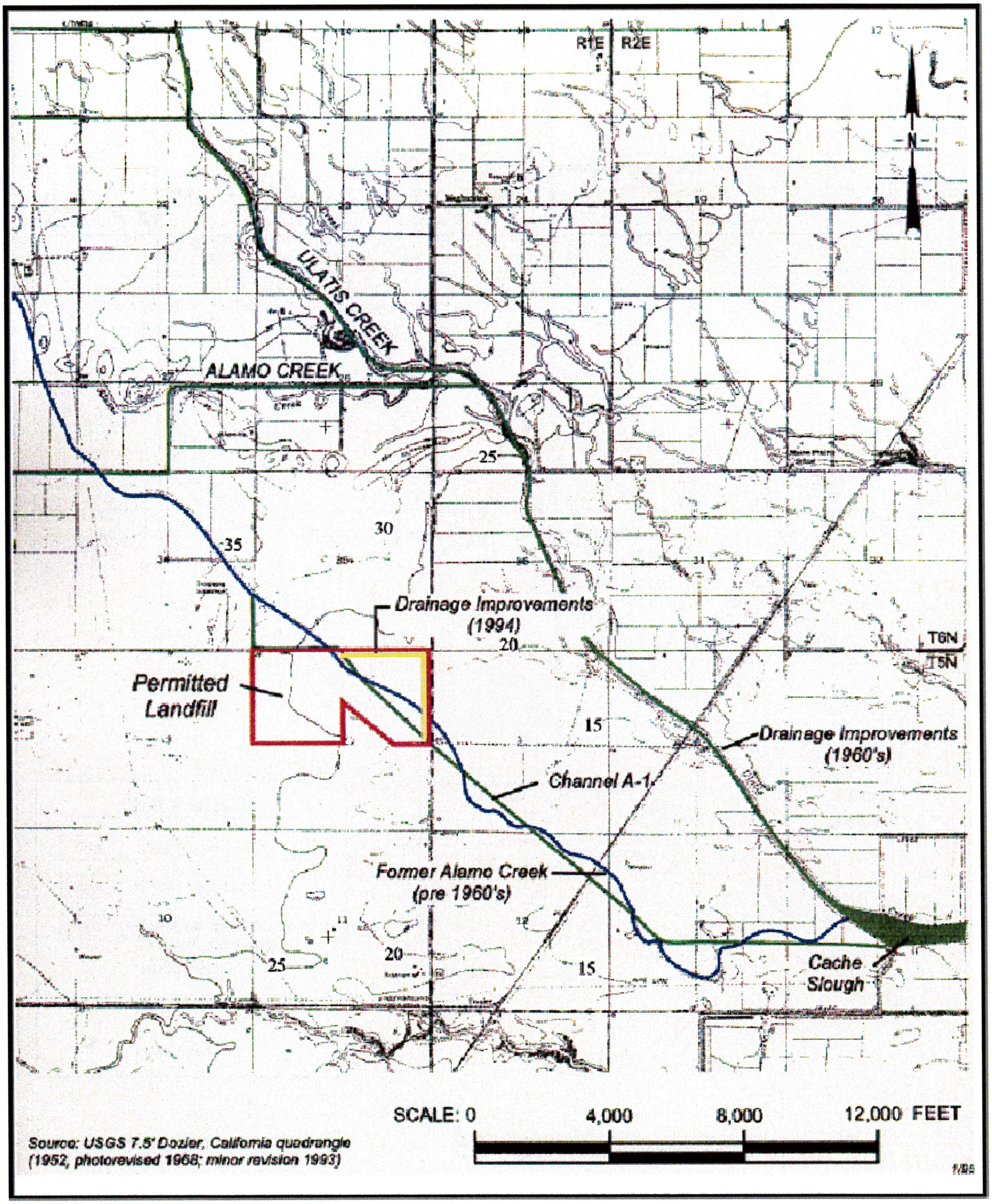

FIGURE **5**

REGIONAL TOPOGRAPHY AND SURFACE DRAINAGE MAP

NORCAL/HAY ROAD PCPCMP/CA

NOTES:
1) BASE MAP OBTAINED FROM CONOR PACIFIC/EFW, MAY 2000. ELEVATIONS ARE FEET MSL.

DWG ID: jraub | N:\Projects\053-7433\2005...Update\Figures\Figure 5.dwg | 3-1-5 12:60 | xrf: NONE

Golder Associates

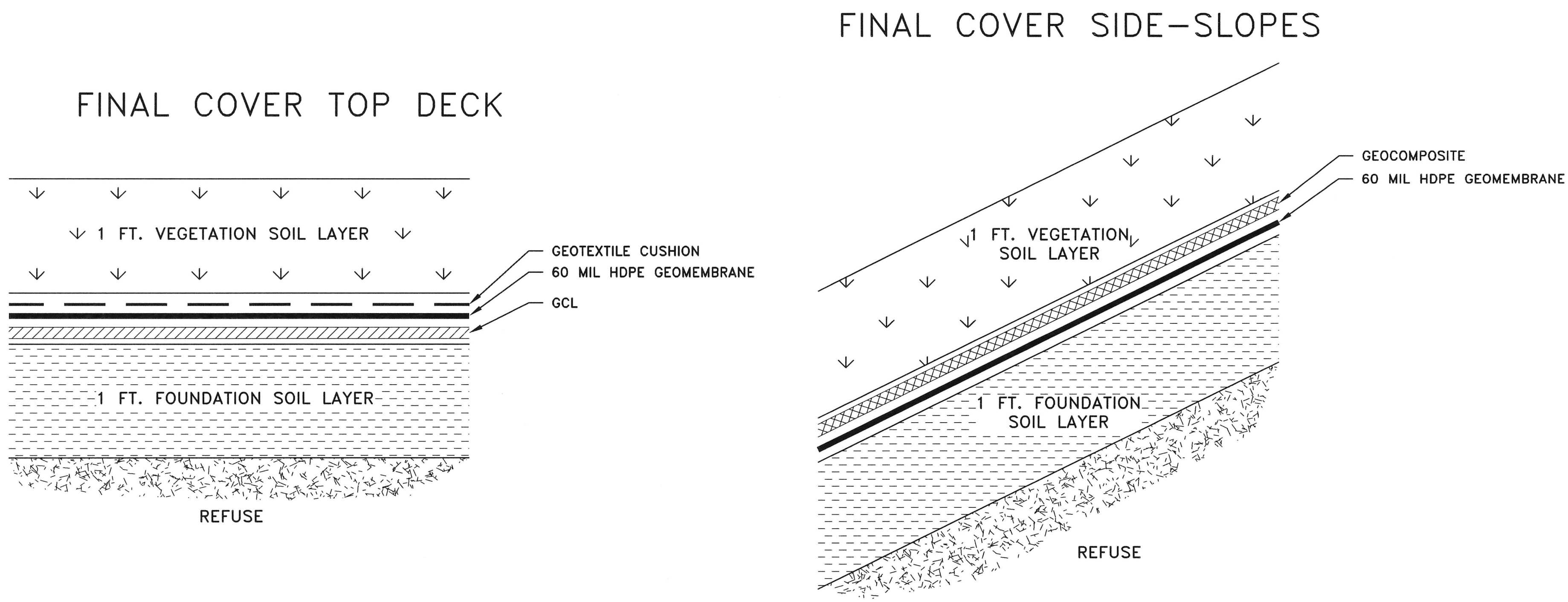

FIGURE **6**

COVER SYSTEM COMPONENTS

NORCAL/HAY ROAD PCPCMP/CA

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Golder Associates

TYPICAL CRITICAL SLOPE SECTION

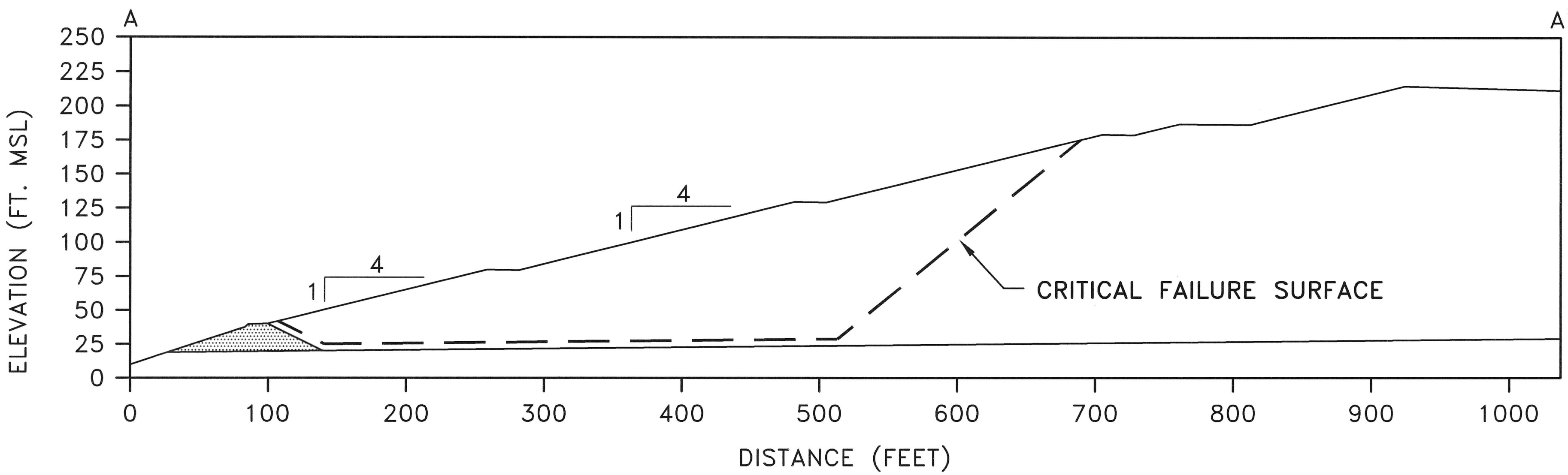

FIGURE 7
TYPICAL CRITICAL SLOPE GEOMETRY
NORCAL/HAY ROAD PCPCMP/CA

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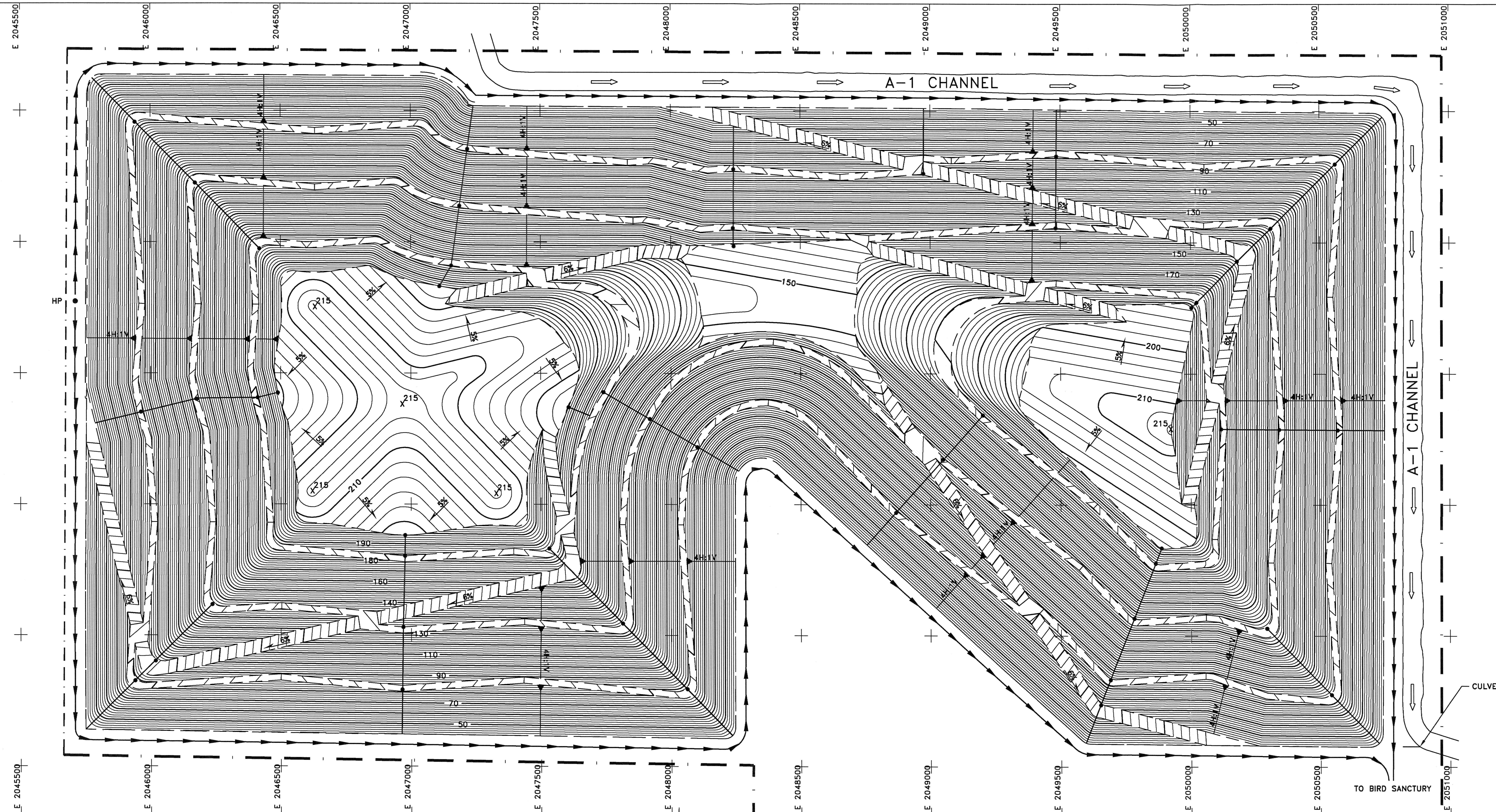
Golder Associates



LEGEND:

→→→→	PERIMETER DRAINAGE CHANNEL
— · —	PROPERTY LINE
- - - -	PARCEL LINE
—•—•—	DOWNDRAIN WITH INLET-LOCATIONS
2H:1V	SLOPE INDICATOR
2%	GRADE INDICATOR

0 400 800
FEET

FIGURE 8
CONCEPTUAL DRAINAGE PLAN
NORCAL/HAY ROAD PCPCMP/CA

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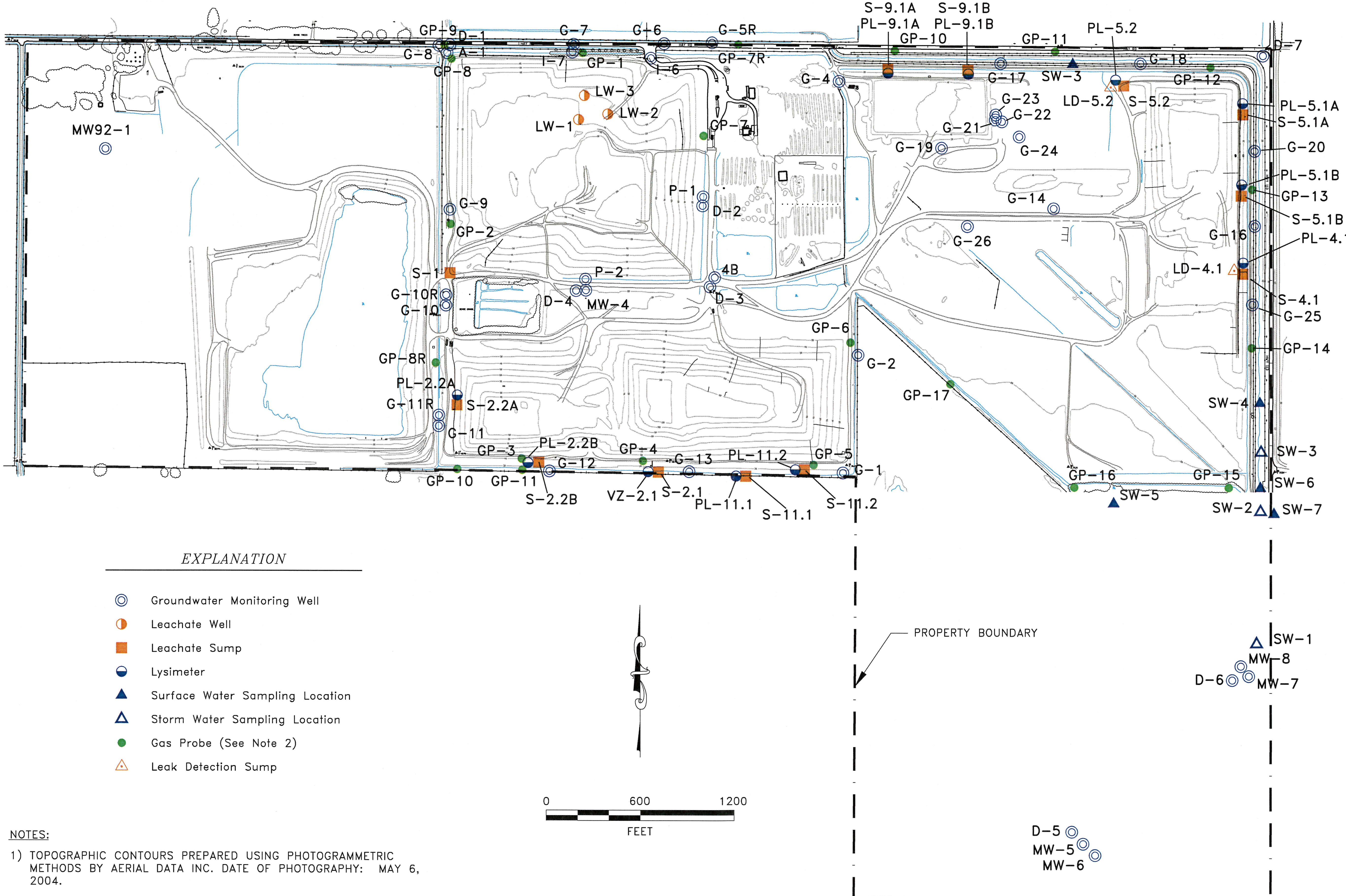
Golder Associates



EXPLANATION

- Groundwater Monitoring Well
- Leachate Well
- Leachate Sump
- Lysimeter
- Surface Water Sampling Location
- Storm Water Sampling Location
- Gas Probe (See Note 2)
- Leak Detection Sump

NOTES:

1) TOPOGRAPHIC CONTOURS PREPARED USING PHOTOGRAMMETRIC METHODS BY AERIAL DATA INC. DATE OF PHOTOGRAPHY: MAY 6, 2004.

2) GP-1 THROUGH GP-11 ALREADY IN PLACE. GP-7R, GP-8R, GP-9 THROUGH GP-17 TO BE INSTALLED AT OR PRIOR TO CLOSURE.

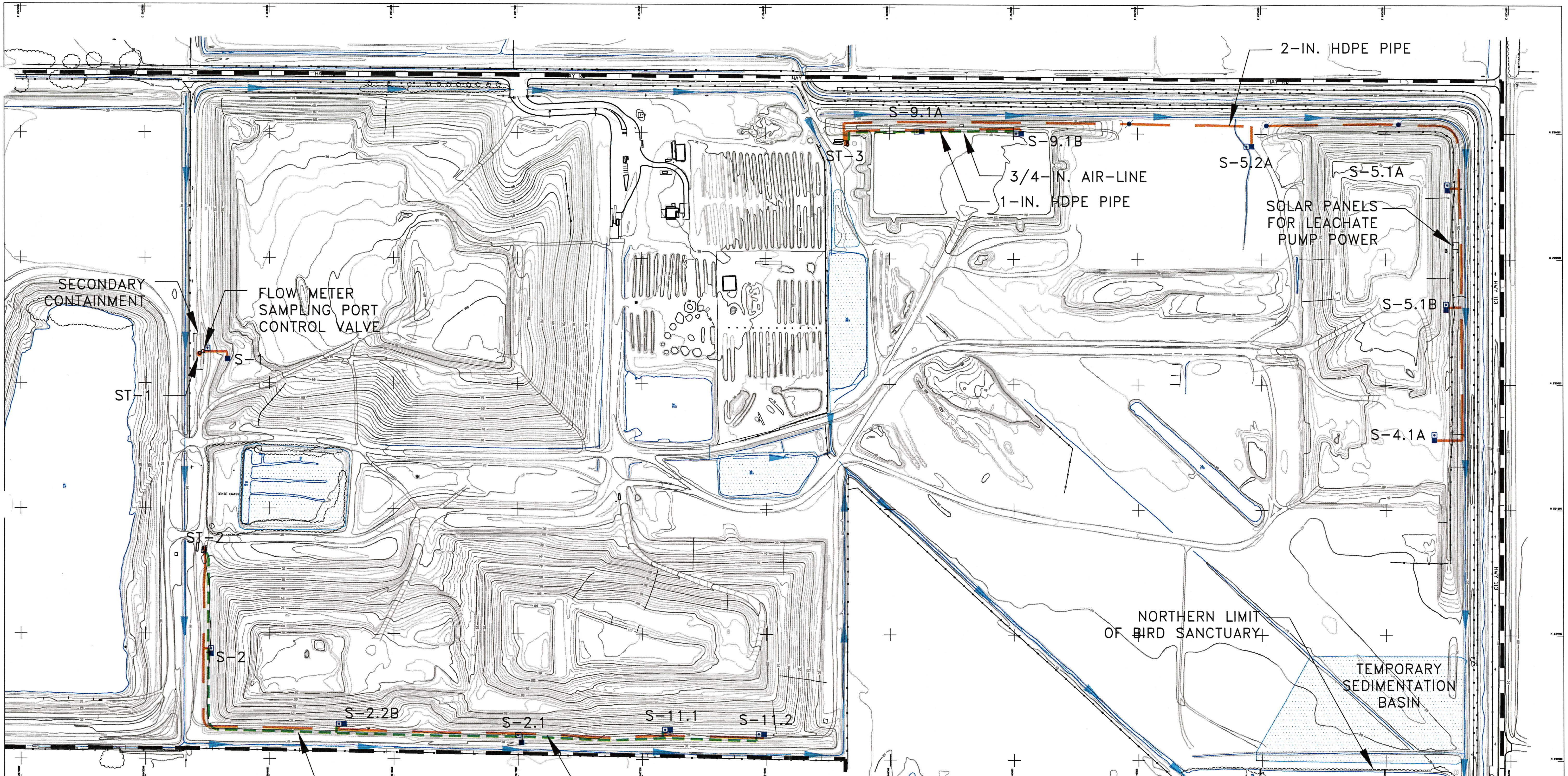
FIGURE 9

ENVIRONMENTAL MONITORING PLAN

NORCAL/HAY ROAD PCPCMP/CA

DWG ID: JRaub | N:\Projects\053-7433 (Norcal-NWSHRL JTD Update)\2005 PCPMP Update\Figures\Figure 9.dwg | 4-24-7 11:00 | xrf: BLK-HRL-504

Golder Associates



NOTES

ST-1 ●	LEACHATE TANK AND I.D. NO.
■	LEACHATE EXTRACTION POINT
▣	PUMP CONTROL PANEL
———	LEACHATE CONVEYANCE
– – –	AIR CONVEGANCE LINE
●	CLEAN-OUT STUB
— ► —	SURFACE WATER DITCH
(stippled)	STORMWATER BASIN

REFERENCE: CONCOR PACIFIC/EFW, 1999 4TH QUARTER AND ANNUAL MONITORING REPORT, B&J DROP BOX SANITARY LANDFILL, SOLANO COUNTY, JANUARY 2000.

FIGURE **10**

CURRENT LEACHATE AND STORMWATER CONTROLS

NORCAL/HAY ROAD PCPCMP/CA

DWG ID: jraub | N:\Projects\053-7433 (Norcal-NWSHRL JTD Update)\2005 PCPMP Update\Figures\Figure 10.dwg | 3-25-5 16:25 | xrf: BLK-HRL-504

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Appendix A

Conceptual Closure Plan and Details

Large 24x36" drawings Sheets 1 and 2

Appendix B

Infiltration Analyses

Prepared by A.K.
Revised NGA 11/01

APPENDIX B

HELP MODEL SIMULATIONS HAY ROAD SANITARY LANDFILL SOLANO COUNTY, CALIFORNIA

B.1 Introduction

This appendix provides a summary of evaluations of the performance of a prescriptive final cover and engineered alternative final cover systems for the Hay Road Sanitary Landfill. A HELP (Hydrologic Evaluation of Landfill Performance) Model Version 3.07 simulation of the cover systems was conducted to demonstrate the acceptable performance of Golder's engineered alternative design (EAD) final cover, by having an average percolation through the system equivalent to or lower than that of the prescriptive final cover system described in California Code of Regulations (CCR) Title 27. HELP simulations for six scenarios were conducted.

1. Prescriptive Final Cover: Top Deck
2. Prescriptive Final Cover: Side slope
3. Golder's Design Alternative Final Cover: Top Deck
4. Golder's Engineered Alternative Design Final Cover: Side slope
5. 1993 RDSI Engineered Alternative Design Final Cover: Top Deck
6. 1993 RDSI Engineered Alternative Design Final Cover: Side slope

The top deck and side slopes were used in the evaluation and comparison of the final cover systems for the landfill. The top deck was evaluated based on a 5 percent slope which yields a greater amount of percolation than the much steeper side slopes (4H:1V) and an average drainage length of 250-ft was used. A drainage length of 250-ft was used for the side slopes as well to compare the performance of the final cover systems. 100 percent of the surface was allowed for runoff. The infiltration results are based on an area of 1 acre and are presented as attachment A for the prescriptive cover, attachment B for Golder's design alternative cover, and attachment C for the RDSI design alternative cover.

B.2 Description of Cover Systems Evaluated

a) Prescriptive Cover System

The surficial 1-ft. final cover is assumed to consist of a vegetative clayey silty (ML) soil layer. The HELP program contains a list of soil types and soil parameters for default

Under the foundation layer is a 150-ft. thick layer of refuse, modeled using the same parameters as described in the scenario above. (See illustration in Figure B-1)

The layer configuration for Golder's engineered Alternative design is similar to the top deck but includes a tri-planar geocomposite for the side slopes and omits the GCL layer. (See Figure B-2)

c) 1993 RDSI Design Alternative

The surficial 1-ft. vegetative layer is the same as the previous two cases.

Below the vegetative layer is a 0.06-in. HDPE geomembrane with parameters described previously.

The HDPE geomembrane overlies a 2-ft thick layer of low permeability soil barrier layer with the same engineering parameters as in the first scenario.

The soil barrier layer overlies a 1-ft thick foundation layer. It was modeled with parameter described above.

Below the foundation layer is a 150-ft thick layer of refuse modeled as previously described. (See Figure B-1)

The RDSI alternative design excludes the HDPE geomembrane on the side slopes. (See Figure B-2).

The HELP program selected the initial volumetric water content of each layer by estimating values near steady-state and then running one year of initialization to refine the estimates before starting the simulations.

B.3 HELP Model Climatological Parameters

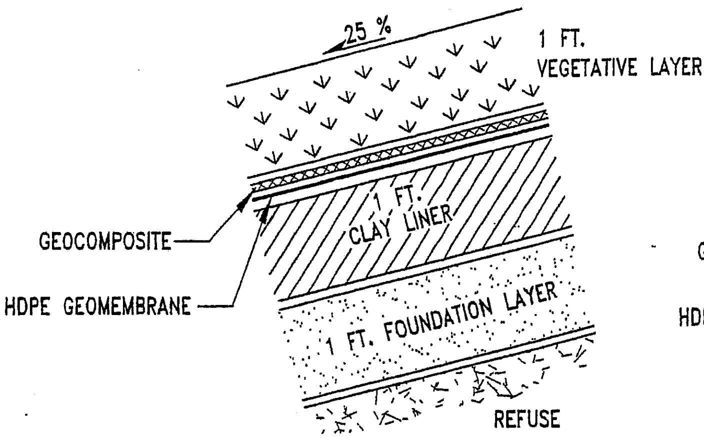
The precipitation data was entered from HELP's default data file for the city of Sacramento. Temperature and solar radiation data used in the analysis were synthetically generated using coefficients for Sacramento by the HELP program. The weather data obtained for Sacramento ranged from 1974 to 1978.

Evaporation data used in the analysis consisted of a value of evaporative depth and additional site weather entered by the user. In this analysis the evaporative zone depth was specified as 12 inches. The soil cover quality for the final cover was specified by the user as a fair soil.

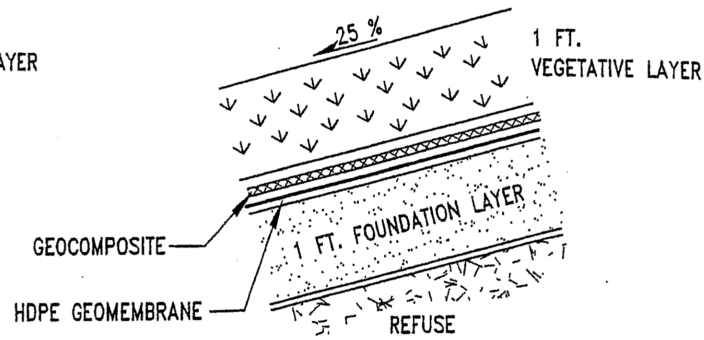
TABLE B–1
SUMMARY OF HELP ANALYSIS FOR HAY ROAD SANITARY LANDFILL –PCPMP

	Condition	Units	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Selected model input	Cover	Vary	Prescriptive Top Deck	Golder EAD Top Deck	1993 RDSI Top Deck	Prescriptive Side Slope	Golder EAD Side slope	1993 RDSI Side slope
	Refuse thickness	feet	150	150	150	150 as max. used	150 as max. used	150 as max. used
	Exposure Period	years	30	30	30	30	30	30
Selected Model output	Synthetically-generated Average Annual Rainfall	inches	14.01	14.01	14.01	14.01	14.01	14.01
	Percolation Through Final Cover Liner	Peak Daily value (inches) (gpad)	0.000013 0.35	0.000005 0.15	0.000013 0.35	0.00000 0.01	0.00000 0.01	0.005102 138.56
		Average Annual Total (inches) (gpad)	0.00106 0.08	0.00034 0.03	0.00106 0.08	0.00000 0.00	0.00000 0.00	0.72269 53.77
	Percolation through Base liner	Peak Daily Value (inches) (gpad)	0.00000 0.00	0.00000 0.00	0.00000 0.00	0.00000 0.00	0.00000 0.00	0.00000 0.01175
		Average Annual Total (inches) (gpad)	0.00000 0.00	0.00000 0.00	0.00000 0.00	0.00000 0.00	0.00000 0.00	0.00004 0.00334
	Lateral Drainage collected through Base Liner	Peak Daily Value (inches) (gpad)	0.00001 0.35	0.00001 0.15	0.00001 0.35	0.00000 0.00	0.00000 0.00	0.00760 206.42
		Average Annual Total (inches) (gpad)	0.00106 0.08	0.00034 0.03	0.00106 0.08	0.0000 0.00	0.00000 0.00	0.71717 53.36

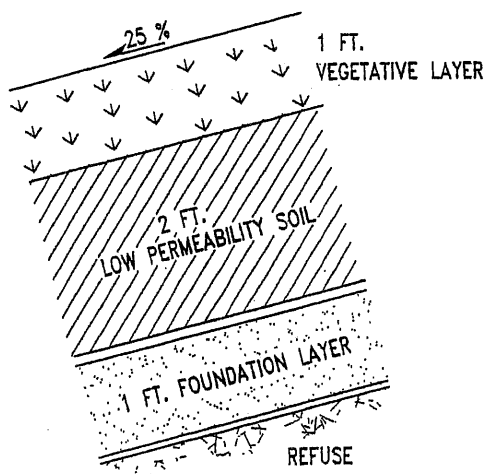
PRESCRIPTIVE FINAL COVER SIDE-SLOPE



GOLDER'S EAD FINAL COVER SIDE-SLOPE



1993 RDSI FINAL COVER SIDE-SLOPE



NOT TO SCALE

FIGURE **B-2**

HELP Analysis Models

Hay Road Sanitary Landfill

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Golder Associates Inc.

Attachment A

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******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:      P:\HELPMO~1\HELP3\PRSS.D4
TEMPERATURE DATA FILE:        P:\HELPMO~1\HELP3\PRSS.D7
SOLAR RADIATION DATA FILE:    P:\HELPMO~1\HELP3\PRSS.D13
EVAPOTRANSPIRATION DATA:      P:\HELPMO~1\HELP3\PRSS.D11
SOIL AND DESIGN DATA FILE:    P:\HELPMO~1\HELP3\PRSS.D10
OUTPUT DATA FILE:             P:\HELPMO~1\HELP3\PRSS.OUT


TIME:   9:25      DATE:  11/ 7/2001


******************************************************************************

     TITLE:  B&J Sanitary Landfill-Prescriptive Final Cover for sideslope

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                    LAYER  1
                                    --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                            MATERIAL TEXTURE NUMBER   9
         THICKNESS                      =      12.00    INCHES
         POROSITY                       =       0.5010 VOL/VOL
         FIELD CAPACITY                 =       0.2840 VOL/VOL
         WILTING POINT                  =       0.1350 VOL/VOL
         INITIAL SOIL WATER CONTENT     =       0.3077 VOL/VOL
         EFFECTIVE SAT. HYD. COND.      =   0.190000006000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
              FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0400	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 14

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4790 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3710 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.249999994000E-04 CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1800.00 INCHES
POROSITY	=	0.6710 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 11

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4640 VOL/VOL
FIELD CAPACITY	=	0.3100 VOL/VOL
WILTING POINT	=	0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.639999998000E-04 CM/SEC

LAYER 8

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3970 VOL/VOL
FIELD CAPACITY	=	0.0320 VOL/VOL
WILTING POINT	=	0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000 CM/SEC
SLOPE	=	2.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 9

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 10

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	83.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.692	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	552.556	INCHES
TOTAL INITIAL WATER	=	552.556	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM SACRAMENTO CALIFORNIA

STATION LATITUDE	=	38.40 DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	73
END OF GROWING SEASON (JULIAN DATE)	=	319
EVAPORATIVE ZONE DEPTH	=	12.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	60.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA FOR SACRAMENTO CALIFORNIA WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SACRAMENTO CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
45.30	50.30	53.20	58.20	64.90	71.20
75.60	74.70	71.70	63.90	53.00	45.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SACRAMENTO CALIFORNIA AND STATION LATITUDE = 38.40 DEGREES

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ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.16	55030.812	100.00
RUNOFF	0.007	24.046	0.04
EVAPOTRANSPIRATION	11.880	43124.156	78.36

DRAINAGE COLLECTED FROM LAYER 2	3.2723	11878.482	21.59
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.001	4.210	0.01
SOIL WATER AT START OF YEAR	552.556	2005778.000	
SOIL WATER AT END OF YEAR	552.557	2005782.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.083	0.00

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	47843.406	100.00
RUNOFF	0.061	220.422	0.46
EVAPOTRANSPIRATION	8.510	30892.170	64.57
DRAINAGE COLLECTED FROM LAYER 2	5.2015	18881.283	39.46
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0013		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.003	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.592	-2150.438	-4.49
SOIL WATER AT START OF YEAR	552.557	2005782.120	

SOIL WATER AT END OF YEAR	551.965	2003631.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.034	0.00

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.25	22687.500	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.446	23398.268	103.13
DRAINAGE COLLECTED FROM LAYER 2	0.3928	1425.724	6.28
PERC./LEAKAGE THROUGH LAYER 4	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0001		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.000	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.589	-2136.480	-9.42
SOIL WATER AT START OF YEAR	551.965	2003631.750	
SOIL WATER AT END OF YEAR	551.376	2001495.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.71	42507.312	100.00
RUNOFF	0.206	748.664	1.76
EVAPOTRANSPIRATION	7.381	26793.941	63.03
DRAINAGE COLLECTED FROM LAYER 2	3.1335	11374.532	26.76
PERC./LEAKAGE THROUGH LAYER 4	0.000001	0.003	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0008		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.002	0.00
PERC./LEAKAGE THROUGH LAYER 10	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	0.989	3590.120	8.45
SOIL WATER AT START OF YEAR	551.376	2001495.250	
SOIL WATER AT END OF YEAR	552.365	2005085.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.053	0.00

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.74	86176.219	100.00
RUNOFF	1.222	4434.834	5.15
EVAPOTRANSPIRATION	10.802	39209.527	45.50
DRAINAGE COLLECTED FROM LAYER 2	12.6143	45789.785	53.14
PERC./LEAKAGE THROUGH LAYER 4	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0036		
DRAINAGE COLLECTED FROM LAYER 8	0.0000	0.007	0.00

PERC./LEAKAGE THROUGH LAYER 10	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 9	0.0000		
CHANGE IN WATER STORAGE	-0.898	-3258.005	-3.78
SOIL WATER AT START OF YEAR	552.365	2005085.370	
SOIL WATER AT END OF YEAR	551.468	2001827.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.072	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	2.62	2.47	1.16	0.23	0.11
	0.17	0.18	0.32	0.67	1.32	1.79
STD. DEVIATIONS	3.66	1.75	1.57	0.89	0.42	0.22
	0.35	0.28	0.33	0.90	1.21	1.72
RUNOFF						
TOTALS	0.183	0.056	0.010	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.020	0.030
STD. DEVIATIONS	0.405	0.103	0.014	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.028	0.064
EVAPOTRANSPIRATION						
TOTALS	0.828	1.348	2.321	1.785	0.494	0.088
	0.224	0.135	0.240	0.138	0.500	0.903
STD. DEVIATIONS	0.555	0.470	0.546	0.679	0.365	0.104
	0.479	0.223	0.219	0.113	0.344	0.639

LATERAL DRAINAGE COLLECTED FROM LAYER 2

TOTALS	2.1913	1.2974	0.5965	0.0079	0.0006	0.0000
	0.0000	0.0000	0.0000	0.0000	0.2422	0.5870
STD. DEVIATIONS	3.1983	1.5316	0.6328	0.0095	0.0011	0.0000
	0.0000	0.0000	0.0000	0.0000	0.4170	1.0588

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 10

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0076	0.0041	0.0017	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0007	0.0017
STD. DEVIATIONS	0.0119	0.0048	0.0018	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0012	0.0030

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	14.01	(6.368)	50849.0	100.00
RUNOFF	0.299	(0.5224)	1085.59	2.135
EVAPOTRANSPIRATION	9.004	(2.2871)	32683.61	64.276
LATERAL DRAINAGE COLLECTED FROM LAYER 2	4.92285	(4.62826)	17869.961	35.14316
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000	(0.00000)	0.004	0.00001
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.00000	(0.00000)	0.003	0.00001
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.00000	(0.00000)	0.002	0.00000
AVERAGE HEAD ON TOP OF LAYER 9	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.218	(0.7490)	-790.12	-1.554

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	5662.800
RUNOFF	0.320	1161.3956
DRAINAGE COLLECTED FROM LAYER 2	0.95569	3469.15894
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00127
AVERAGE HEAD ON TOP OF LAYER 3	0.272	
MAXIMUM HEAD ON TOP OF LAYER 3	0.228	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	1.3 FEET	
DRAINAGE COLLECTED FROM LAYER 8	0.00000	0.00055
PERCOLATION/LEAKAGE THROUGH LAYER 10	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 9	0.000	
MAXIMUM HEAD ON TOP OF LAYER 9	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.79	2855.3328

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4028
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	2.6096	0.2175
2	0.0020	0.0100
3	0.0000	0.0000
4	5.1240	0.4270
5	8.9040	0.3710
6	525.6000	0.2920
7	3.7200	0.3100
8	0.3840	0.0320
9	0.0000	0.0000
10	5.1240	0.4270
SNOW WATER	0.000	

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**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                 DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                   USAE WATERWAYS EXPERIMENT STATION                      **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      P:\HELPMO~1\HELP3\BJPRE.D4
TEMPERATURE DATA FILE:        P:\HELPMO~1\HELP3\BJPRE.D7
SOLAR RADIATION DATA FILE:    P:\HELPMO~1\HELP3\BJPRE.D13
EVAPOTRANSPIRATION DATA:      P:\HELPMO~1\HELP3\BJPRE.D11
SOIL AND DESIGN DATA FILE:    P:\HELPMO~1\HELP3\BJPRE.D10
OUTPUT DATA FILE:             P:\HELPMO~1\HELP3\BJPRE.OUT


TIME:   9:18      DATE:  11/ 7/2001


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    TITLE:  B&J Sanitary Landfill-Prescriptive Final Cover, Top Deck
                                  AND EMCON EAD TOP DECK
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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
        THICKNESS                  =     12.00    INCHES
        POROSITY                   =      0.5010 VOL/VOL
        FIELD CAPACITY             =      0.2840 VOL/VOL
        WILTING POINT              =      0.1350 VOL/VOL
        INITIAL SOIL WATER CONTENT =      0.3622 VOL/VOL
        EFFECTIVE SAT. HYD. COND.  =  0.190000006000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4094	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 14

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4790	VOL/VOL
FIELD CAPACITY	=	0.3710	VOL/VOL
WILTING POINT	=	0.2510	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3710	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.249999994000E-04	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1800.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 11

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.639999998000E-04	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 9

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	82.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.346	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	552.990	INCHES
TOTAL INITIAL WATER	=	552.990	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM SACRAMENTO CALIFORNIA

STATION LATITUDE	=	38.40	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	73	
END OF GROWING SEASON (JULIAN DATE)	=	319	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 73.00 %

NOTE: PRECIPITATION DATA FOR SACRAMENTO CALIFORNIA
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SACRAMENTO CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
45.30	50.30	53.20	58.20	64.90	71.20
75.60	74.70	71.70	63.90	53.00	45.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SACRAMENTO CALIFORNIA
AND STATION LATITUDE = 38.40 DEGREES

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ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.16	55030.812	100.00
RUNOFF	1.196	4342.410	7.89
EVAPOTRANSPIRATION	13.893	50430.422	91.64
PERC./LEAKAGE THROUGH LAYER 2	0.001460	5.301	0.01
AVG. HEAD ON TOP OF LAYER 2	3.6407		
DRAINAGE COLLECTED FROM LAYER 7	0.0015	5.291	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	0.070	252.576	0.46
SOIL WATER AT START OF YEAR	558.006	2025563.250	
SOIL WATER AT END OF YEAR	558.076	2025815.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.110	0.00

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	47843.406	100.00
RUNOFF	3.452	12532.419	26.19
EVAPOTRANSPIRATION	10.830	39313.949	82.17
PERC./LEAKAGE THROUGH LAYER 2	0.001256	4.559	0.01
AVG. HEAD ON TOP OF LAYER 2	3.1396		
DRAINAGE COLLECTED FROM LAYER 7	0.0013	4.583	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	-1.104	-4007.534	-8.38
SOIL WATER AT START OF YEAR	558.076	2025815.870	
SOIL WATER AT END OF YEAR	556.972	2021808.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.014	0.00

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.25	22687.500	100.00

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.060	25626.166	112.95
PERC./LEAKAGE THROUGH LAYER 2	0.000411	1.493	0.01
AVG. HEAD ON TOP OF LAYER 2	0.9580		
DRAINAGE COLLECTED FROM LAYER 7	0.0004	1.503	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	-0.810	-2940.291	-12.96
SOIL WATER AT START OF YEAR	556.972	2021808.250	
SOIL WATER AT END OF YEAR	556.162	2018868.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.118	0.00

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.71	42507.312	100.00
RUNOFF	0.236	855.637	2.01
EVAPOTRANSPIRATION	8.061	29262.873	68.84
PERC./LEAKAGE THROUGH LAYER 2	0.000466	1.692	0.00
AVG. HEAD ON TOP OF LAYER 2	1.0931		
DRAINAGE COLLECTED FROM LAYER 7	0.0004	1.566	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	3.412	12387.286	29.14
SOIL WATER AT START OF YEAR	556.162	2018868.000	

SOIL WATER AT END OF YEAR	559.574	2031255.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.053	0.00

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.74	86176.219	100.00
RUNOFF	12.874	46733.805	54.23
EVAPOTRANSPIRATION	12.898	46819.562	54.33
PERC./LEAKAGE THROUGH LAYER 2	0.001703	6.181	0.01
AVG. HEAD ON TOP OF LAYER 2	4.2644		
DRAINAGE COLLECTED FROM LAYER 7	0.0017	6.252	0.01
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	-2.034	-7383.408	-8.57
SOIL WATER AT START OF YEAR	559.574	2031255.250	
SOIL WATER AT END OF YEAR	557.540	2023871.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.001	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	2.62	2.47	1.16	0.23	0.11
	0.17	0.18	0.32	0.67	1.32	1.79
STD. DEVIATIONS	3.66	1.75	1.57	0.89	0.42	0.22
	0.35	0.28	0.33	0.90	1.21	1.72
RUNOFF						
TOTALS	1.900	1.008	0.593	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.010	0.040
STD. DEVIATIONS	3.657	1.483	0.798	0.001	0.000	0.000
	0.000	0.000	0.000	0.000	0.016	0.088
EVAPOTRANSPIRATION						
TOTALS	0.787	1.321	2.299	1.837	1.081	1.228
	0.166	0.176	0.224	0.166	0.413	0.850
STD. DEVIATIONS	0.533	0.542	0.495	0.706	0.113	0.800
	0.349	0.283	0.210	0.148	0.201	0.577
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0002	0.0002	0.0002	0.0002	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0002	0.0002	0.0002	0.0002	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	5.5626	6.2337	7.1645	5.1892	3.6908	0.9983
	0.0000	0.0000	0.0000	0.0000	0.2441	2.3466
STD. DEVIATIONS	4.9905	4.4260	3.6620	2.3437	1.7634	0.9563
	0.0000	0.0000	0.0000	0.0000	0.5039	1.9061

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	14.01	(6.368)	50849.0	100.00
RUNOFF	3.552	(5.3870)	12892.85	25.355
EVAPOTRANSPIRATION	10.548	(2.9640)	38290.59	75.302
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.00106	(0.00059)	3.845	0.00756
AVERAGE HEAD ON TOP OF LAYER 2	2.619	(1.509)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00106	(0.00060)	3.839	0.00755
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.005	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.093	(2.0987)	-338.27	-0.665

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	5662.800
RUNOFF	1.444	5240.9170
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.000013	0.04722
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 7	0.00001	0.04719
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.003	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.79	2855.3328

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5010
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	3.8799	0.3233
2	0.0000	0.0000
3	4.9125	0.4094
4	8.9040	0.3710
5	525.6000	0.2920
6	3.7200	0.3100
7	0.3840	0.0320
8	0.0000	0.0000
9	5.1240	0.4270
SNOW WATER	0.000	

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Attachment B

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      P:\HELPMO~1\HELP3\B&J.D4
TEMPERATURE DATA FILE:        P:\HELPMO~1\HELP3\B&J.D7
SOLAR RADIATION DATA FILE:    P:\HELPMO~1\HELP3\B&J.D13
EVAPOTRANSPIRATION DATA:      P:\HELPMO~1\HELP3\B&J.D11
SOIL AND DESIGN DATA FILE:    P:\HELPMO~1\HELP3\B&J.D10
OUTPUT DATA FILE:             P:\HELPMO~1\HELP3\B&J.OUT
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TIME:   9:16     DATE:  11/ 7/2001
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    TITLE:  B&J Sanitary Landfill - Golder EAD Final Cover,Top Deck

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.
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                                  LAYER  1
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                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
          THICKNESS                   =      12.00   INCHES
          POROSITY                    =       0.5010 VOL/VOL
          FIELD CAPACITY              =       0.2840 VOL/VOL
          WILTING POINT               =       0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT  =       0.3622 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.190000006000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06 INCHES
POROSITY	=	0.0000 VOL/VOL
FIELD CAPACITY	=	0.0000 VOL/VOL
WILTING POINT	=	0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12 CM/SEC
FML PINHOLE DENSITY	=	0.00 HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00 HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25 INCHES
POROSITY	=	0.7500 VOL/VOL
FIELD CAPACITY	=	0.7470 VOL/VOL
WILTING POINT	=	0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 14

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4790 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3710 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.249999994000E-04 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1800.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER

MATERIAL TEXTURE NUMBER 11

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3100	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.639999998000E-04	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER

MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER

MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 9

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	82.30	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.346	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	543.813	INCHES
TOTAL INITIAL WATER	=	543.813	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM SACRAMENTO CALIFORNIA

STATION LATITUDE	=	38.40	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	73	
END OF GROWING SEASON (JULIAN DATE)	=	319	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 73.00 %

NOTE: PRECIPITATION DATA FOR SACRAMENTO CALIFORNIA
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SACRAMENTO CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
45.30	50.30	53.20	58.20	64.90	71.20
75.60	74.70	71.70	63.90	53.00	45.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SACRAMENTO CALIFORNIA
AND STATION LATITUDE = 38.40 DEGREES

****

ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.16	55030.812	100.00
RUNOFF	1.197	4344.367	7.89
EVAPOTRANSPIRATION	13.894	50434.762	91.65
PERC./LEAKAGE THROUGH LAYER 3	0.000495	1.796	0.00
AVG. HEAD ON TOP OF LAYER 2	3.6351		
DRAINAGE COLLECTED FROM LAYER 7	0.0005	1.789	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	0.069	250.139	0.45
SOIL WATER AT START OF YEAR	543.813	1974042.750	
SOIL WATER AT END OF YEAR	543.882	1974292.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.247	0.00

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	47843.406	100.00
RUNOFF	3.452	12529.057	26.19
EVAPOTRANSPIRATION	10.831	39317.676	82.18
PERC./LEAKAGE THROUGH LAYER 3	0.000419	1.522	0.00
AVG. HEAD ON TOP OF LAYER 2	3.1393		
DRAINAGE COLLECTED FROM LAYER 7	0.0004	1.525	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	-1.103	-4005.097	-8.37
SOIL WATER AT START OF YEAR	543.882	1974292.870	
SOIL WATER AT END OF YEAR	542.779	1970287.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.241	0.00

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.25	22687.500	100.00

RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	7.060	25627.449	112.96
PERC./LEAKAGE THROUGH LAYER 3	0.000094	0.340	0.00
AVG. HEAD ON TOP OF LAYER 2	0.9566		
DRAINAGE COLLECTED FROM LAYER 7	0.0001	0.339	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.004	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	-0.810	-2940.291	-12.96
SOIL WATER AT START OF YEAR	542.779	1970287.750	
SOIL WATER AT END OF YEAR	541.969	1967347.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.000	0.00

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.71	42507.312	100.00
RUNOFF	0.237	859.509	2.02
EVAPOTRANSPIRATION	8.061	29260.311	68.84
PERC./LEAKAGE THROUGH LAYER 3	0.000124	0.451	0.00
AVG. HEAD ON TOP OF LAYER 2	1.0932		
DRAINAGE COLLECTED FROM LAYER 7	0.0001	0.397	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000001	0.005	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	3.412	12387.286	29.14
SOIL WATER AT START OF YEAR	541.969	1967347.500	

SOIL WATER AT END OF YEAR	545.381	1979734.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	-0.0001	-0.195	0.00

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.74	86176.219	100.00
RUNOFF	12.875	46734.957	54.23
EVAPOTRANSPIRATION	12.899	46822.004	54.33
PERC./LEAKAGE THROUGH LAYER 3	0.000591	2.146	0.00
AVG. HEAD ON TOP OF LAYER 2	4.2644		
DRAINAGE COLLECTED FROM LAYER 7	0.0006	2.178	0.00
PERC./LEAKAGE THROUGH LAYER 9	0.000002	0.006	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
CHANGE IN WATER STORAGE	-2.034	-7382.964	-8.57
SOIL WATER AT START OF YEAR	545.381	1979734.750	
SOIL WATER AT END OF YEAR	543.348	1972351.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.043	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	2.62	2.47	1.16	0.23	0.11
	0.17	0.18	0.32	0.67	1.32	1.79
STD. DEVIATIONS	3.66	1.75	1.57	0.89	0.42	0.22
	0.35	0.28	0.33	0.90	1.21	1.72
RUNOFF						
TOTALS	1.900	1.008	0.593	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.010	0.041
STD. DEVIATIONS	3.657	1.483	0.798	0.001	0.000	0.000
	0.000	0.000	0.000	0.000	0.016	0.088
EVAPOTRANSPIRATION						
TOTALS	0.788	1.321	2.299	1.840	1.081	1.225
	0.166	0.176	0.224	0.166	0.413	0.850
STD. DEVIATIONS	0.533	0.542	0.494	0.709	0.113	0.799
	0.349	0.283	0.210	0.147	0.201	0.578
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LATERAL DRAINAGE COLLECTED FROM LAYER 7						
TOTALS	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 9						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	5.5622	6.2336	7.1647	5.1816	3.6851	0.9938
	0.0000	0.0000	0.0000	0.0000	0.2442	2.3472
STD. DEVIATIONS	4.9906	4.4260	3.6620	2.3397	1.7610	0.9546
	0.0000	0.0000	0.0000	0.0000	0.5039	1.9068

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	14.01	(6.368)	50849.0	100.00
RUNOFF	3.552	(5.3869)	12893.58	25.357
EVAPOTRANSPIRATION	10.549	(2.9645)	38292.44	75.306
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00034	(0.00022)	1.251	0.00246
AVERAGE HEAD ON TOP OF LAYER 2	2.618	(1.508)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00034	(0.00023)	1.246	0.00245
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.00000	(0.00000)	0.005	0.00001
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
CHANGE IN WATER STORAGE	-0.093	(2.0986)	-338.19	-0.665

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	5662.800
RUNOFF	1.444	5240.9497
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000005	0.01944
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 7	0.00001	0.01941
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000000	0.00003
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.002	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.79	2855.3328

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5010
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	3.8801	0.3233
2	0.0000	0.0000
3	0.1875	0.7500
4	4.4520	0.3710
5	525.6000	0.2920
6	3.7200	0.3100
7	0.3840	0.0320
8	0.0000	0.0000
9	5.1240	0.4270
SNOW WATER	0.000	

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**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      P:\HELPMO~1\HELP3\GSS.D4
TEMPERATURE DATA FILE:        P:\HELPMO~1\HELP3\GSS.D7
SOLAR RADIATION DATA FILE:    P:\HELPMO~1\HELP3\GSS.D13
EVAPOTRANSPIRATION DATA:      P:\HELPMO~1\HELP3\GSS.D11
SOIL AND DESIGN DATA FILE:    P:\HELPMO~1\HELP3\GSS.D10
OUTPUT DATA FILE:             P:\HELPMO~1\HELP3\GSS.OUT


TIME:   9:23     DATE:  11/ 7/2001


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     TITLE:  B&J Sanitary Landfill - Golder EAD Final Cover-Sideslopes

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
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                       TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   9
          THICKNESS                    =     12.00    INCHES
          POROSITY                     =      0.5010 VOL/VOL
          FIELD CAPACITY               =      0.2840 VOL/VOL
          WILTING POINT                =      0.1350 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.3096 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.190000006000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.28	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0121	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	40.0000000000	CM/SEC
SLOPE	=	25.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 14

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4790	VOL/VOL
FIELD CAPACITY	=	0.3710	VOL/VOL
WILTING POINT	=	0.2510	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3710	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.249999994000E-04	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1800.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	122.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

LAYER 7

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 8

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE

FML PLACEMENT QUALITY = 3 - GOOD

LAYER 9

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4108	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	83.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.715	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	568.852	INCHES
TOTAL INITIAL WATER	=	568.852	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM SACRAMENTO CALIFORNIA

STATION LATITUDE	=	38.40	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	73	
END OF GROWING SEASON (JULIAN DATE)	=	319	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00	%

AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 60.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 55.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 73.00 %

NOTE: PRECIPITATION DATA FOR SACRAMENTO CALIFORNIA
WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SACRAMENTO CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
45.30	50.30	53.20	58.20	64.90	71.20
75.60	74.70	71.70	63.90	53.00	45.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SACRAMENTO CALIFORNIA
AND STATION LATITUDE = 38.40 DEGREES

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ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.16	55030.812	100.00
RUNOFF	0.009	33.579	0.06
EVAPOTRANSPIRATION	11.922	43277.445	78.64
DRAINAGE COLLECTED FROM LAYER 2	3.2269	11713.797	21.29
PERC./LEAKAGE THROUGH LAYER 3	0.000002	0.008	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.007	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
PERC./LEAKAGE THROUGH LAYER 9	0.037542	136.276	0.25
CHANGE IN WATER STORAGE	-0.036	-130.276	-0.24

SOIL WATER AT START OF YEAR	578.320	2099302.000	
SOIL WATER AT END OF YEAR	578.284	2099171.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	47843.406	100.00
RUNOFF	0.075	272.352	0.57
EVAPOTRANSPIRATION	8.512	30897.805	64.58
DRAINAGE COLLECTED FROM LAYER 2	5.1853	18822.469	39.34
PERC./LEAKAGE THROUGH LAYER 3	0.000004	0.013	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0001		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.010	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
PERC./LEAKAGE THROUGH LAYER 9	0.038658	140.330	0.29
CHANGE IN WATER STORAGE	-0.631	-2289.798	-4.79
SOIL WATER AT START OF YEAR	578.284	2099171.750	
SOIL WATER AT END OF YEAR	577.653	2096882.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0001	0.239	0.00

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.25	22687.500	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.460	23449.209	103.36
DRAINAGE COLLECTED FROM LAYER 2	0.3976	1443.460	6.36
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.001	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
PERC./LEAKAGE THROUGH LAYER 9	0.016070	58.334	0.26
CHANGE IN WATER STORAGE	-0.624	-2263.433	-9.98
SOIL WATER AT START OF YEAR	577.653	2096882.000	
SOIL WATER AT END OF YEAR	577.030	2094618.620	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.072	0.00

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.71	42507.312	100.00
RUNOFF	0.219	796.434	1.87
EVAPOTRANSPIRATION	7.386	26811.742	63.08

DRAINAGE COLLECTED FROM LAYER 2	3.1057	11273.576	26.52
PERC./LEAKAGE THROUGH LAYER 3	0.000002	0.007	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0000		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.006	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000000	0.001	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
PERC./LEAKAGE THROUGH LAYER 9	0.012816	46.521	0.11
CHANGE IN WATER STORAGE	0.986	3579.042	8.42
SOIL WATER AT START OF YEAR	577.030	2094618.620	
SOIL WATER AT END OF YEAR	578.016	2098197.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.74	86176.219	100.00
RUNOFF	1.449	5261.665	6.11
EVAPOTRANSPIRATION	10.808	39232.793	45.53
DRAINAGE COLLECTED FROM LAYER 2	12.3827	44949.031	52.16
PERC./LEAKAGE THROUGH LAYER 3	0.000007	0.027	0.00
AVG. HEAD ON TOP OF LAYER 3	0.0002		
DRAINAGE COLLECTED FROM LAYER 7	0.0000	0.025	0.00
PERC./LEAKAGE THROUGH LAYER 8	0.000001	0.002	0.00
AVG. HEAD ON TOP OF LAYER 8	0.0000		
PERC./LEAKAGE THROUGH LAYER 9	0.016103	58.454	0.07

CHANGE IN WATER STORAGE	-0.916	-3325.801	-3.86
SOIL WATER AT START OF YEAR	578.016	2098197.500	
SOIL WATER AT END OF YEAR	577.100	2094871.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.054	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	2.62	2.47	1.16	0.23	0.11
	0.17	0.18	0.32	0.67	1.32	1.79
STD. DEVIATIONS	3.66	1.75	1.57	0.89	0.42	0.22
	0.35	0.28	0.33	0.90	1.21	1.72
RUNOFF						
TOTALS	0.213	0.070	0.010	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.024	0.033
STD. DEVIATIONS	0.473	0.127	0.014	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.033	0.070
EVAPOTRANSPIRATION						
TOTALS	0.827	1.356	2.319	1.788	0.501	0.090
	0.224	0.134	0.240	0.138	0.499	0.902
STD. DEVIATIONS	0.554	0.474	0.545	0.681	0.368	0.106
	0.479	0.224	0.218	0.114	0.343	0.638
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	2.1632	1.2852	0.5892	0.0075	0.0003	0.0000
	0.0000	0.0000	0.0000	0.0000	0.2337	0.5805
STD. DEVIATIONS	3.1379	1.5132	0.6381	0.0114	0.0004	0.0000
	0.0000	0.0000	0.0000	0.0000	0.4048	1.0575

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

LATERAL DRAINAGE COLLECTED FROM LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 9

TOTALS	0.0071	0.0044	0.0043	0.0015	0.0004	0.0002
	0.0006	0.0002	0.0000	0.0004	0.0018	0.0032
STD. DEVIATIONS	0.0063	0.0026	0.0021	0.0016	0.0004	0.0002
	0.0009	0.0005	0.0000	0.0005	0.0024	0.0022

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0005	0.0003	0.0001	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	14.01	(6.368)	50849.0	100.00
RUNOFF	0.351	(0.6205)	1272.81	2.503
EVAPOTRANSPIRATION	9.018	(2.2968)	32733.80	64.374
LATERAL DRAINAGE COLLECTED FROM LAYER 2	4.85963	(4.53743)	17640.467	34.69184
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.00000	(0.00000)	0.011	0.00002
AVERAGE HEAD ON TOP OF LAYER 3	0.000	(0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	0.00000	(0.00000)	0.010	0.00002
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000	(0.00000)	0.002	0.00000
AVERAGE HEAD ON TOP OF LAYER 8	0.000	(0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.02424	(0.01273)	87.983	0.17303
CHANGE IN WATER STORAGE	-0.244	(0.7586)	-886.05	-1.743

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	5662.800
RUNOFF	0.367	1332.0586
DRAINAGE COLLECTED FROM LAYER 2	0.96496	3502.80786
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.000000	0.00177
AVERAGE HEAD ON TOP OF LAYER 3	0.005	
MAXIMUM HEAD ON TOP OF LAYER 3	0.086	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	0.0 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.00000	0.00106
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00002
AVERAGE HEAD ON TOP OF LAYER 8	0.000	
MAXIMUM HEAD ON TOP OF LAYER 8	0.000	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000637	2.31097
SNOW WATER	0.79	2855.3328

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4225
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	2.6168	0.2181
2	0.0027	0.0100
3	0.0000	0.0000
4	4.4520	0.3710
5	525.6000	0.2920
6	29.7680	0.2440
7	0.3840	0.0320
8	0.0000	0.0000
9	4.8083	0.4007
SNOW WATER	0.000	

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Attachment C

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:       P:\HELPMO~1\HELP3\EMSS.D4
TEMPERATURE DATA FILE:         P:\HELPMO~1\HELP3\EMSS.D7
SOLAR RADIATION DATA FILE:     P:\HELPMO~1\HELP3\EMSS.D13
EVAPOTRANSPIRATION DATA:       P:\HELPMO~1\HELP3\EMSS.D11
SOIL AND DESIGN DATA FILE:     P:\HELPMO~1\HELP3\EMSS.D10
OUTPUT DATA FILE:              P:\HELPMO~1\HELP3\EMSS.OUT


TIME:   9:21     DATE:  11/ 7/2001


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    TITLE:  B&J Sanitary Landfill - 1993 RDSI-Final Cover,Side-slopes

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    NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
             COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                 LAYER  1
                                 --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   9
        THICKNESS                      =     12.00    INCHES
        POROSITY                       =      0.5010 VOL/VOL
        FIELD CAPACITY                 =      0.2840 VOL/VOL
        WILTING POINT                  =      0.1350 VOL/VOL
        INITIAL SOIL WATER CONTENT     =      0.3509 VOL/VOL
        EFFECTIVE SAT. HYD. COND.      =  0.190000006000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
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TOP DECK SEE 1993 RDSI

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4270 VOL/VOL
FIELD CAPACITY	=	0.4180 VOL/VOL
WILTING POINT	=	0.3670 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 14

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4790 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3714 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.249999994000E-04 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	1800.00 INCHES
POROSITY	=	0.6710 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 11

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4640 VOL/VOL
FIELD CAPACITY	=	0.3100 VOL/VOL

WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3138	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.639999998000E-04	CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 21

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0325	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	2.00	PERCENT
DRAINAGE LENGTH	=	250.0	FEET

LAYER 7

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	2.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 25.% AND A SLOPE LENGTH OF 250. FEET.

SCS RUNOFF CURVE NUMBER	=	83.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.210	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.012	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.620	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	553.795	INCHES
TOTAL INITIAL WATER	=	553.795	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM SACRAMENTO CALIFORNIA

STATION LATITUDE	=	38.40	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	73	
END OF GROWING SEASON (JULIAN DATE)	=	319	
EVAPORATIVE ZONE DEPTH	=	12.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA FOR SACRAMENTO CALIFORNIA WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SACRAMENTO CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
45.30	50.30	53.20	58.20	64.90	71.20
75.60	74.70	71.70	63.90	53.00	45.60

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SACRAMENTO CALIFORNIA AND STATION LATITUDE = 38.40 DEGREES

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ANNUAL TOTALS FOR YEAR 1974

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.16	55030.812	100.00
RUNOFF	0.912	3311.028	6.02
EVAPOTRANSPIRATION	13.361	48499.840	88.13
PERC./LEAKAGE THROUGH LAYER 2	0.819973	2976.503	5.41
AVG. HEAD ON TOP OF LAYER 2	3.2932		
DRAINAGE COLLECTED FROM LAYER 6	0.8180	2969.197	5.40
PERC./LEAKAGE THROUGH LAYER 8	0.000011	0.042	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0165		
CHANGE IN WATER STORAGE	0.069	250.803	0.46
SOIL WATER AT START OF YEAR	553.795	2010275.750	
SOIL WATER AT END OF YEAR	553.864	2010526.620	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.095	0.00

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ANNUAL TOTALS FOR YEAR 1975

	INCHES	CU. FEET	PERCENT
PRECIPITATION	13.18	47843.406	100.00

RUNOFF	2.910	10561.622	22.08
EVAPOTRANSPIRATION	10.527	38212.371	79.87
PERC./LEAKAGE THROUGH LAYER 2	0.829769	3012.060	6.30
AVG. HEAD ON TOP OF LAYER 2	2.8790		
DRAINAGE COLLECTED FROM LAYER 6	0.8250	2994.613	6.26
PERC./LEAKAGE THROUGH LAYER 8	0.000012	0.042	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0167		
CHANGE IN WATER STORAGE	-1.081	-3925.336	-8.20
SOIL WATER AT START OF YEAR	553.864	2010526.620	
SOIL WATER AT END OF YEAR	552.783	2006601.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.096	0.00

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ANNUAL TOTALS FOR YEAR 1976

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.25	22687.500	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	6.454	23429.256	103.27
PERC./LEAKAGE THROUGH LAYER 2	0.476291	1728.937	7.62
AVG. HEAD ON TOP OF LAYER 2	0.3136		
DRAINAGE COLLECTED FROM LAYER 6	0.5397	1959.084	8.64
PERC./LEAKAGE THROUGH LAYER 8	0.000008	0.028	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0109		
CHANGE IN WATER STORAGE	-0.744	-2701.009	-11.91
SOIL WATER AT START OF YEAR	552.783	2006601.250	

SOIL WATER AT END OF YEAR	552.039	2003900.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.140	0.00

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ANNUAL TOTALS FOR YEAR 1977

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.71	42507.312	100.00
RUNOFF	0.222	806.156	1.90
EVAPOTRANSPIRATION	7.594	27566.523	64.85
PERC./LEAKAGE THROUGH LAYER 2	0.562865	2043.199	4.81
AVG. HEAD ON TOP OF LAYER 2	0.6526		
DRAINAGE COLLECTED FROM LAYER 6	0.4948	1796.148	4.23
PERC./LEAKAGE THROUGH LAYER 8	0.000008	0.028	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0100		
CHANGE IN WATER STORAGE	3.399	12338.544	29.03
SOIL WATER AT START OF YEAR	552.039	2003900.250	
SOIL WATER AT END OF YEAR	555.438	2016238.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.086	0.00

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ANNUAL TOTALS FOR YEAR 1978

	INCHES	CU. FEET	PERCENT

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PRECIPITATION	23.74	86176.219	100.00
RUNOFF	12.436	45144.367	52.39
EVAPOTRANSPIRATION	12.529	45480.129	52.78
PERC./LEAKAGE THROUGH LAYER 2	0.924529	3356.041	3.89
AVG. HEAD ON TOP OF LAYER 2	4.0138		
DRAINAGE COLLECTED FROM LAYER 6	0.9086	3298.219	3.83
PERC./LEAKAGE THROUGH LAYER 8	0.000013	0.046	0.00
AVG. HEAD ON TOP OF LAYER 7	0.0183		
CHANGE IN WATER STORAGE	-2.134	-7746.541	-8.99
SOIL WATER AT START OF YEAR	555.438	2016238.750	
SOIL WATER AT END OF YEAR	553.304	2008492.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.00	2.62	2.47	1.16	0.23	0.11
	0.17	0.18	0.32	0.67	1.32	1.79
STD. DEVIATIONS	3.66	1.75	1.57	0.89	0.42	0.22
	0.35	0.28	0.33	0.90	1.21	1.72
RUNOFF						
TOTALS	1.819	0.917	0.512	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.015	0.034
STD. DEVIATIONS	3.587	1.398	0.711	0.000	0.000	0.000

	0.000	0.000	0.000	0.000	0.023	0.073

EVAPOTRANSPIRATION

TOTALS	0.805	1.327	2.286	1.812	0.973	0.898
	0.166	0.167	0.219	0.157	0.416	0.866
STD. DEVIATIONS	0.529	0.500	0.529	0.685	0.118	0.705
	0.349	0.265	0.211	0.135	0.208	0.595

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.1219	0.1091	0.1334	0.1200	0.0995	0.0315
	0.0000	0.0000	0.0000	0.0000	0.0155	0.0918
STD. DEVIATIONS	0.0318	0.0349	0.0191	0.0124	0.0342	0.0339
	0.0000	0.0000	0.0000	0.0000	0.0163	0.0520

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.0723	0.0852	0.1030	0.1167	0.1402	0.1068
	0.0404	0.0000	0.0000	0.0000	0.0049	0.0476
STD. DEVIATIONS	0.0223	0.0073	0.0261	0.0225	0.0106	0.0767
	0.0470	0.0000	0.0000	0.0000	0.0055	0.0279

PERCOLATION/LEAKAGE THROUGH LAYER 8

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	5.0886	5.5537	6.3722	4.2193	2.5552	0.5707
	0.0000	0.0000	0.0000	0.0000	0.2480	2.1575
STD. DEVIATIONS	5.1557	4.8247	4.3378	2.9257	2.1074	0.7488
	0.0000	0.0000	0.0000	0.0000	0.4984	1.8887

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0172	0.0222	0.0244	0.0286	0.0332	0.0262
	0.0096	0.0000	0.0000	0.0000	0.0012	0.0113
STD. DEVIATIONS	0.0053	0.0017	0.0062	0.0055	0.0025	0.0188
	0.0111	0.0000	0.0000	0.0000	0.0013	0.0066

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	14.01	(6.368)	50849.0	100.00
RUNOFF	3.296	(5.2367)	11964.63	23.530
EVAPOTRANSPIRATION	10.093	(3.0119)	36637.62	72.052
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.72269	(0.19231)	2623.348	5.15909
AVERAGE HEAD ON TOP OF LAYER 2	2.230	(1.650)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.71720	(0.18666)	2603.452	5.11996
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00001	(0.00000)	0.037	0.00007
AVERAGE HEAD ON TOP OF LAYER 7	0.014	(0.004)		
CHANGE IN WATER STORAGE	-0.098	(2.1087)	-356.71	-0.702

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	1.56	5662.800
RUNOFF	1.432	5199.5986
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.005102	18.52133
AVERAGE HEAD ON TOP OF LAYER 2	12.000	
DRAINAGE COLLECTED FROM LAYER 6	0.00760	27.59428
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00033
AVERAGE HEAD ON TOP OF LAYER 7	0.056	
MAXIMUM HEAD ON TOP OF LAYER 7	0.111	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	1.9 FEET	
SNOW WATER	0.79	2855.3328

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5010

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1350

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

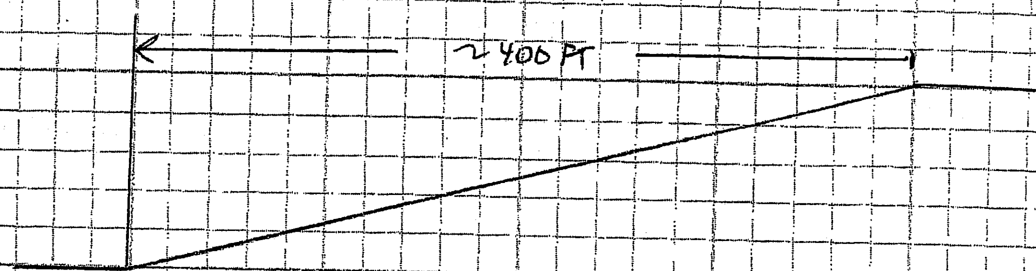
FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	3.6917	0.3076
2	10.2480	0.4270
3	4.4683	0.3724
4	525.6000	0.2920
5	3.7813	0.3151
6	0.3904	0.0325
7	0.0000	0.0000
8	5.1240	0.4270
SNOW WATER	0.000	

****
****

Golder Associates	SUBJECT Norcal / Hay Road Landfill		
	Job No. 013-7249	Made by 18f	Date 11/01
	Ref.	Checked	Sheet 1 of 1
		Reviewed	

Cover Geocomposite Drainage Capacity: Verify adequate subsurface drainage



Max. Flow:

① From HELP – Peak Infiltration is 0.96-inches/day

② Let infiltration limit ~ say 5×10^{-5} cm/s = 1.7 inches ⇐ Higher value

1.7 inches/day ⇒ 1.7 inches $\times \frac{1\ FT}{12\ inch} \times \frac{7.48\ gall}{1\ ft^3} \times$ 400 FT $\times$ 1 FT width $\times \frac{1\ day}{(60 \times 24)\ min}$

Max Flow = 0.3 gpm

Capacity ult. of Tendrain geocomp. ≈ 3 gpm at $i = 0.25$ and $\sigma_n \leq 250$ psf
See graph

$q_{all} = \frac{q_{ult}}{FS_{in} * FS_{cr} * FS_{cc} * FS_{BC}}$ (Ref. Tendrain design manual)

FS_{in} = FS of intrusion use 1.5
FS_{cr} = FS of Creep use 1.4
FS_{cc} = FS of chem. clogging use 1.5
FS_{BC} = FS of Biol. clogging use 1.5

} low normal loads & infiltration (not leachate)

$q_{allow} = \frac{3}{1.5 \times 1.4 \times 1.5 \times 1.5} = 0.63$

0.63 > 0.3 gpm – OK

Appendix C

Erosion Calculations

HCP
Rev. Ret

013-7249

APPENDIX C

COVER SOIL EROSION CALCULATIONS

C.1 INTRODUCTION

Soil loss potential at the Hay Road Sanitary Landfill site due to water erosion was evaluated using the Revised Universal Soil Equation (RUSLE), developed by the U.S. Department of Agriculture, which considers soil and vegetation type as well as physical and climatic features of the landfill area. A brief discussion of this method is given below.

C.2 SOIL LOSS EVALUATION

The RUSLE can be used to evaluate landfill cover soil loss. This equation may be stated as:

A = R K LS C P, Where

A = Average annual soil loss, in tons per acre per year

R = Rainfall and runoff erosivity index

K = Soil erodibility factor

LS = Hill slope length and steepness factor

C = Cover-management factor

For the purpose of soil loss analysis, the landfill was divided into lots based upon the average slopes of the final cover and surface drainage characteristics as shown in Figure C-1. the results of the analysis are shown in Table C-1.

The RUSLE factors for the Hay Road Sanitary Landfill were assigned as follows:

R = 20 Index for the Vacaville area from USDA erosivity factor iso-erodent map, which best represents weather conditions at the site. (see attached rainfall erosivity index map)

K = .31 It is assumed that the textural class of the final cover material will be of a "silty clay" and will contain less than 0.5 % organic.

LS Dependent upon the length and average gradient of areas under consideration. Values range from 0.75 to 6.82 for this application.

C = 0.03 "C" represents the effects of plants, soil cover, soil biomass (roots and incorporated residue), and soil-disturbing activities on soil loss. A value of 0.03 is associated with the presence of California annual grass.

P = 1.0 "P" accounts for reduction of erosion due to land management practices and is conservatively assumed to be 1.0 (highest value) for the entire landfill site.

Using the values listed above, we estimate the average soil loss depth due to water erosion to be 0.0035 inch per year in the presence of vegetation.

C.3 DISCUSSION

Based on the above soil erosion analysis, the average soil loss depth for a soil density of 100 pounds per cubic foot is about 0.0035 inch per year or 0.76 ton/acre/year for the entire vegetated landfill site. Over the 30-year period, the average soil loss over the entire site is conservatively estimated at approximately 0.105 inches. The 30-year loss is less than the USEPA's maximum allowable soil loss of 2 tons per acre per year.

TABLE C-1
SOIL LOSS ESTIMATES
HAY ROAD SANITARY LANDFILL

Area No.	Average Area (acres)	Slope* Length (ft)	Average** gradient (%)	R	K	LS	C	P	Soil Loss (tons/acre/year)	Soil Loss (tons/year)	Soil Loss (CY/year)	Soil Loss (inches/year)
1	19	800	5	20	0.31	0.75	0.03	1	0.14	2.65	1.64	0.0006
2	12	800	5	20	0.31	0.75	0.03	1	0.14	1.67	1.03	0.0006
3	14	800	5	20	0.31	0.75	0.03	1	0.14	1.95	1.21	0.0006
4	15	800	5	20	0.31	0.75	0.03	1	0.14	2.09	1.29	0.0006
5	24	900	5	20	0.31	6.82	0.03	1	1.27	30.44	18.79	0.0058
6	22	800	5	20	0.31	6.62	0.03	1	1.23	27.09	16.72	0.0057
7	155	200***	25	20	0.31	4.61	0.03	1	0.86	132.91	82.04	0.0039
Total	261								Weighted average 0.76	198.81	122.72	Weighted average 0.0035
										30 year cover loss (inch):		0.1049

* Length measured along the slope.
** Corresponds to a H:V slope (Horizontal:Vertical).
*** Slope length between benches.

Golder Associates	SUBJECT Cover Erosion		
	Job No. 053-7433	Made by [initials]	Date 4/24/07
	Ref.	Checked [initials]	Sheet 1 of 1
		Reviewed	

Calculation Addendum

The preceding erosion calculations were completed in 2001 for a cover system with a max. elevation of 165 ft msl. The erosion calculations were not updated for the 215 FT MSL Cover based on the following

- The side-slope geometry with benches every 50 feet is still the same. Thus, the unit erosion rate of 0.86 tons/ac/year is still valid. This is well below the maximum of 2.0 tons/acre/yr provided in EPA Guidelines.

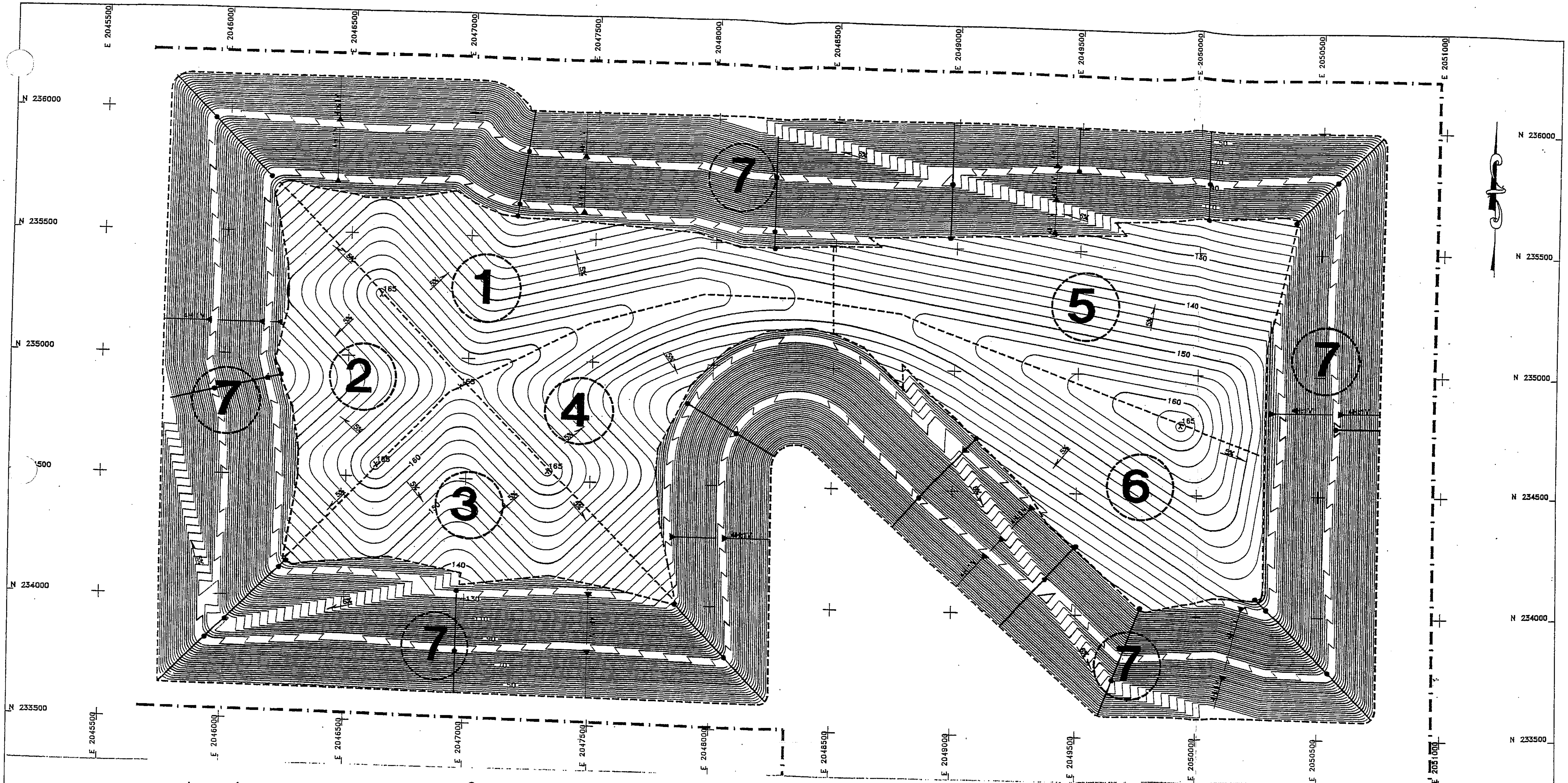
- The maximum drainage length on the top of the cover is considerably shorter (~500 feet). Therefore peak unit erosion will be less than 0.14 tons/acre/yr by inspection of Table C-1.

An Approximate new annual erosion estimate can be completed by conservatively multiplying 0.14 tons/acre/yr by the top deck area of 036 acres and adding 0.86 tons/ac/yr × the side-slope area of 225 acres:

$$0.14 \text{ tons/ac/yr} * 36\text{ac} + 0.86 \text{ tons/ac/yr} * 225 \text{ ac}$$

$$5.04 \text{ tons/yr} + 193.5 \text{ tons/yr} = 198.5 \text{ tons/yr}$$

Note: this is approx. the same as Table C-1 total



* Note: Above cover is for the 165-ft MSl cover.
See attached addendum that addresses
215-ft MSl cover.

FIGURE **C-1**

DRAINAGE AREAS
HAY ROAD SANITARY LANDFILL

NORCAL/B&J LANDFILL PCPMP/CA

Golder Associates

Appendix D

Settlement and LCRS Calculations

Golder Associates

Subject: NWSHRL - Final Cover Settlement Calculations		
Job No.: 053-7433 Ref:	Made by: WRC Checked: [signature] Reviewed: [signature]	Date: 2/17/2005 Sheet: 1 of 3

OBJECTIVE:

To evaluate post-settlement cover grades to ensure drainage grades are maintained.

The critical cases (Segments A & B) occur on the top of the cover where the typical cover grade is 5%. Segments A and B are located along the swale where the grades are approximately 3% or slightly greater, refer to sheets 2 and 3.

APPROACH:

The following assumptions are made:

1) Primary Settlements are complete;
2) Secondary Compression index = 0.05; and
3) Average time after primary settlements are complete is 6 months.

* $\Delta S = C_a * H * \log(t_2/t_1)$

Evaluate cover settlement for 30 year period (Post-Closure min. 30 years) for critical section ; t_1 = 6 months (0.5 years); t_2 = 30+0.5 = 30.5 years.

CALCULATIONS:

Segment A:

Initial grade of cover along section is 3% (typical 5%)
Post-settlement grade:

$H_1 \Rightarrow \Delta S = (0.05)(196-36.5) * \log(30.5/0.5) = 14.23$ ft

$H_2 \Rightarrow \Delta S = (0.05)(215-42) * \log(30.5/0.5) = 15.44$ ft

Distance between point 1and 2 = 630 feet,

Final Grade = $\left(\frac{(215-15.44)-(196-14.23)}{630}\right) * 100 = 2.8\ \%$ ✓ (ok)

Segment B

Initial grade of cover along section is 3.3% (typical 5%).
Post-settlement grade:

$H_2 = \Delta S = (0.05)(215-42) * \log(30.5/0.5) = 15.44$ ft

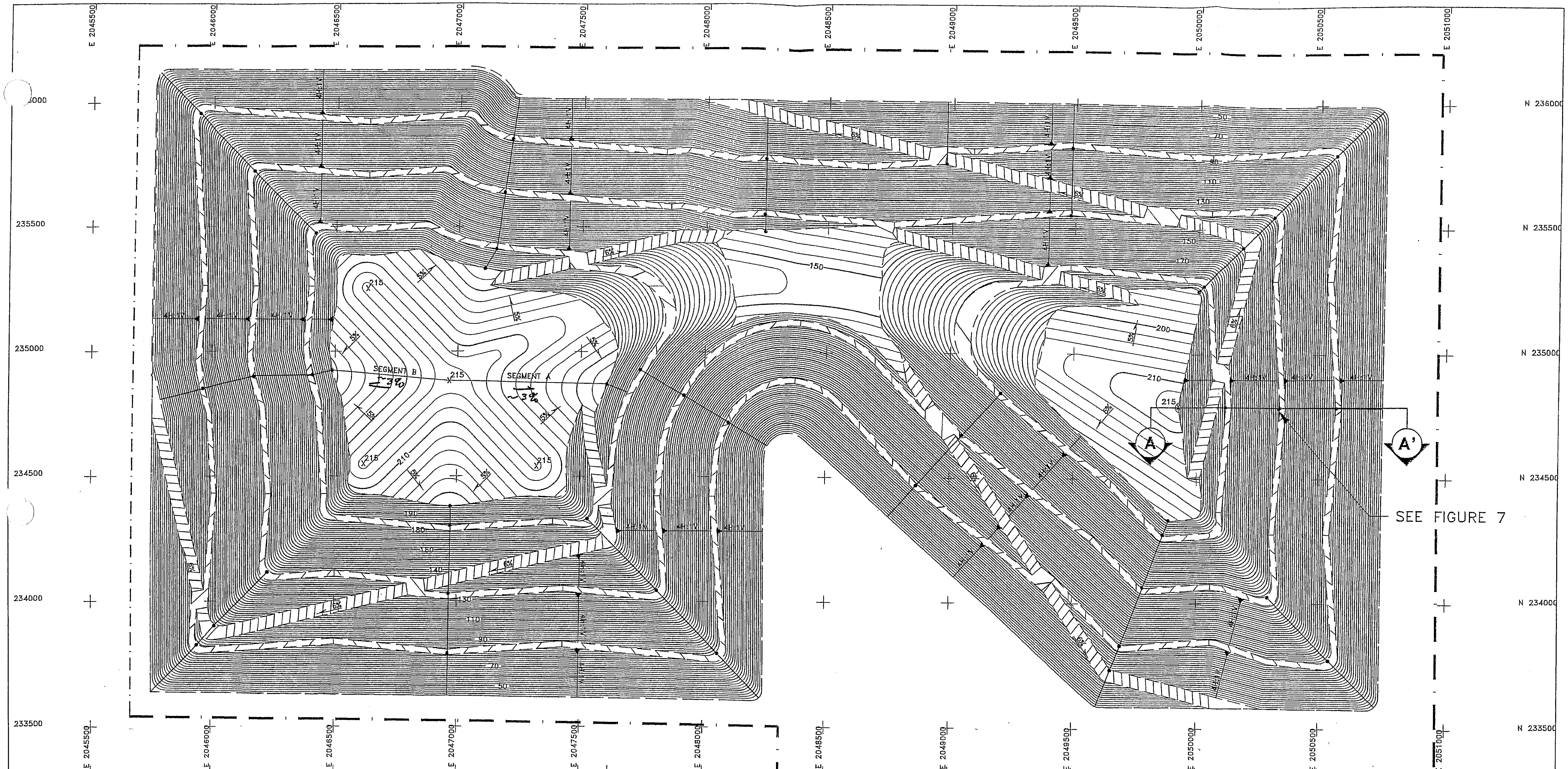
$H_3 = \Delta S = (0.05)(199.28-38) * \log(30.5/0.5) = 14.40$ ft

Distance between point 2 and 3 = 475 feet,

Final Grade = $\left(\frac{(215-15.44)-(199.28-14.40)}{475}\right) * 100 = 3.1\%$ ✓ (ok)

CONCLUSION:

Post-settlement of grades are maintained facilitating drainage.



LEGEND:

- PROPERTY LINE
- PARCEL LINE
- DOWNDRAIN WITH INLET-LOCATIONS
- 2H:1V SLOPE INDICATOR
- 2% GRADE INDICATOR

SHEET 2 OF 3

COVER SETTLEMENT CALCULATION

NORCAL/HAY ROAD PCPCMP/CA

Golder Associates

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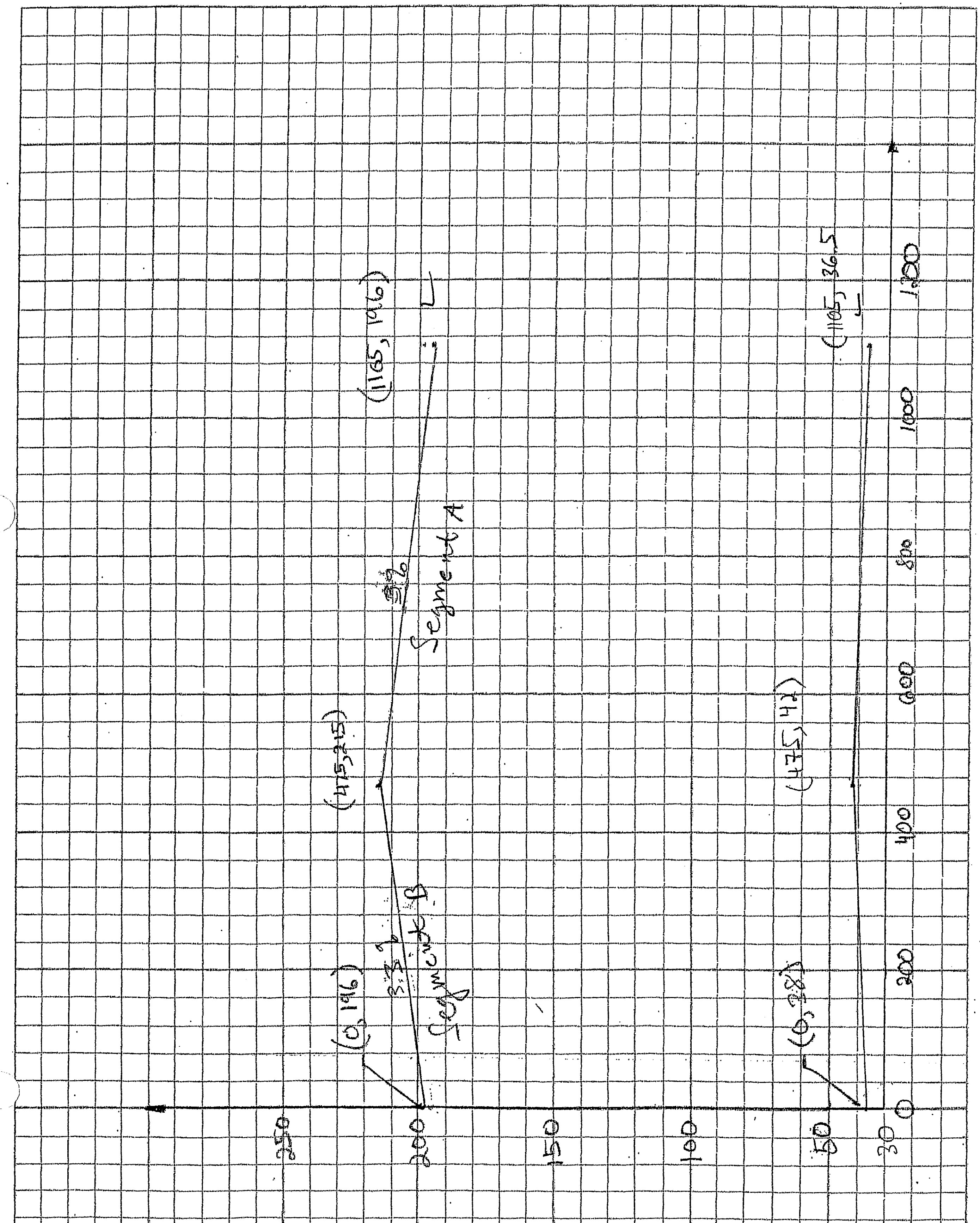
SUBJECT NWSHRL : JTD Update 2005		
Job No. 053-7433	Made by WRC	Date 2/17/05
Ref.	Checked KOA	Sheet 3 of 3
	Reviewed KOA	



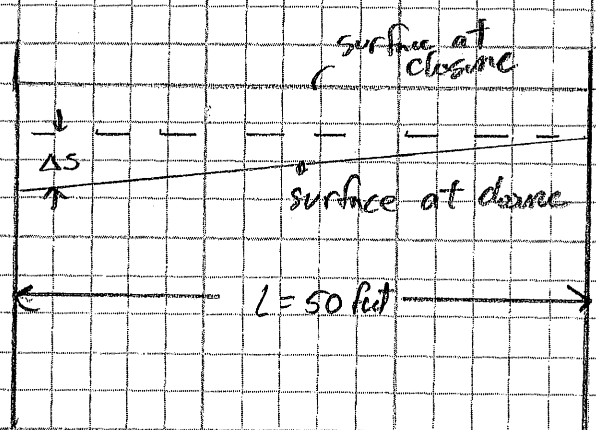
Golder Associates

SUBJECT Settlement		
Job No. 053-7433 Ref.	Made by KGH Checked WRC Reviewed	Date 11/03 Sheet 1 of 1

Differential Settlement:

Objective: Evaluate a hypothetical variation in modified secondary compression index to estimate differential settlement and resulting tensile strain.

Assume C_{se} ranges from 0.02 to 0.05 for the full landfill depth (~185 feet) over a horizontal distance of 50 feet (This is a dramatic 2.5 X change in material properties over a short horizontal distance)



$$\Delta_S = 185\, C_{se_1} \log\left(\frac{t_2}{t_1}\right) - 185\, C_{se_2} \log\left(\frac{t_2}{t_1}\right)$$

Use $t_2 = 30$ yrs, $t_1 = 0.5$ yrs

$C_{se_1} = 0.05$

$C_{se_2} = 0.02$

$$\Delta_S = (185) * (.05) * 1.78 - 185\,(.02)(1.78)$$
$= 9.8$ feet ~ 10 feet

New length $= \sqrt{50^2 + 10^2} = 51.0$

tensile strain $= \dfrac{51 - 50}{50} \sim 2\%$

Golder Associates	SUBJECT Settlement Analysis for Vertical Expansion		
	Job No. 033-7359 Ref.	Made by APM Checked KSA Reviewed KSA	Date 11/12/03 Sheet 1 of 6

Objective: To evaluate the effect of subgrade settlements due to the additional refuse weights on the design grade of the base liner drainage system (flowline).

Approach:

Settlement of the native subgrade soils determined by Terzaghi 1-D consolidation theory.

i.e. **Primary Consolidation**

(a) If $\sigma_{v_0}' = \sigma_p$

$$S = \frac{C_c}{1+e_0} H \log \frac{\sigma_{v_0}' + \Delta\sigma_v}{\sigma_{v_0}'}$$

(b) If $\sigma_{v_0}' + \Delta\sigma_v < \sigma_p'$

$$S = \frac{C_r}{1+e_0} H \log \frac{\sigma_{v_0}' + \Delta\sigma_v}{\sigma_{v_0}'}$$

(c) If $\sigma_{v_0}' < \sigma_p' < \sigma_{v_0}' + \Delta\sigma_v$

$$S = \frac{C_r}{1+e_0} H \frac{\sigma_p'}{\sigma_{v_0}'} + \frac{C_c}{1+e_0} H \log \frac{\sigma_{v_0}' + \Delta\sigma_v}{\sigma_p'}$$

Secondary Settlement

$$S = \frac{C_\alpha}{1+e_0} H \log(t_2/t_1)$$

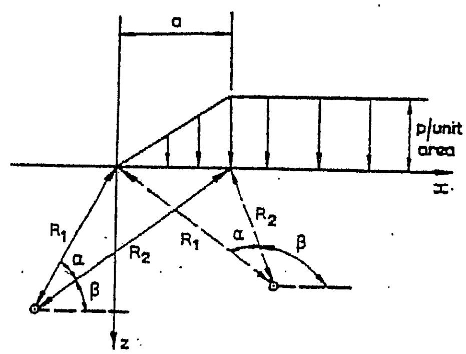
Settlements were calculated assuming the fill material & ultimate height of refuse were applied to the native subgrade soils. Existing fill & refuse along with settlement that was occurred to date was not considered in our analysis.

Golder Associates

SUBJECT Settlement Analysis for Vert. Expansion		
Job No. 033-7359	Made by APM	Date 11/12/03
Ref.	Checked KGM	Sheet 2 of 6
	Reviewed KGM	

The additional vertical stress ($\Delta\sigma_V$) imposed on the compressible soils by the refuse and fill material (if applicable) was calculated for vertical "embankment" loading conditions.

VERTICAL "EMBANKMENT" LOADING (Fig.3.12, Gray, 1936).



Influence factors were obtained from values of stress originally presented by Jurgenson (1934).

Using the attached table, the $\Delta\sigma_V$ was determined at the top of the compressible soils & at a depth of 150 feet.

1. Change in Stress at Top of Compressible Soils

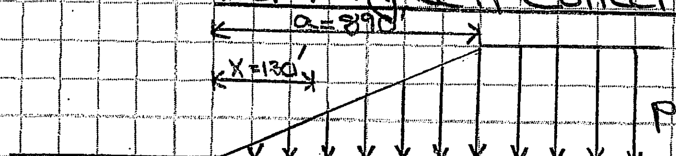
a. For Maximum Height of Refuse

$x/a = 1.0$

$z/a = 0$

$\therefore \sigma_z/p_{eo}' = \underline{1.000}$

b. For Adjacent Collection Sump



$x/a = 0.1461$

$z/a = 0$

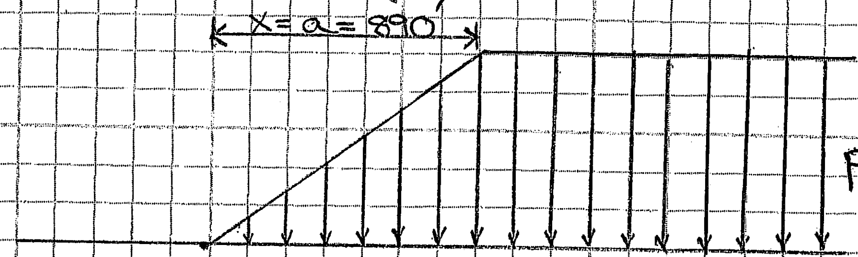
$\sigma_z/p_{eo}' = \frac{0.2500 - 0}{0.25} = \frac{x}{0.1461}$

$= \underline{0.1461}$

Golder Associates	SUBJECT Settlement Analysis for Vert. Expansion	
Job No. 033-7359 Ref.	Made by APM Checked KOS Reviewed KOS	Date 11/12/03 Sheet 3 of 6

2. Change in Stress at a Depth of 150 feet

a. For Maximum Height of Refuse



At a depth of 150 feet: $z/a = 150/890 = 0.1685$

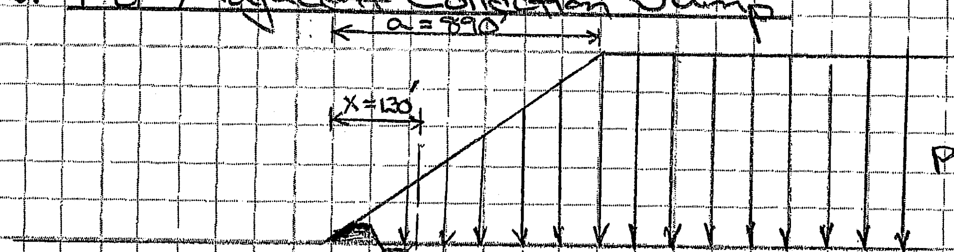
For $x/a = 1.0$, σ_z/p is interpolated as follows:

$$\frac{(1.000 - 0.9220)}{0.25} = \frac{x}{0.1685}$$

$$x = 0.0526$$

$$\therefore \sigma_z/p_{@150'} = 1.000 - 0.0526 = 0.9474$$

b. For Adjacent Collection Sump



$x/a = 130/890 = 0.1461$

Therefore, σ_z/p must be interpolated using the influence factors (Jurgenson, 1934) for $x/a = 0$ and $x/a = 0.25$

For $x/a = 0$: $\frac{(0.0780 - 0)}{0.25} = \frac{x}{0.1685}$ $x = 0.0526$

$$\therefore \sigma_z/p_{@150'} = 0.0526$$

For $x/a = 0.25$: $\frac{(0.2643 - 0.2500)}{0.25} = \frac{x}{0.1685}$ $x = 0.0096$

$$\therefore \sigma_z/p_{@150'} = 0.2500 + 0.0096 = 0.2596$$

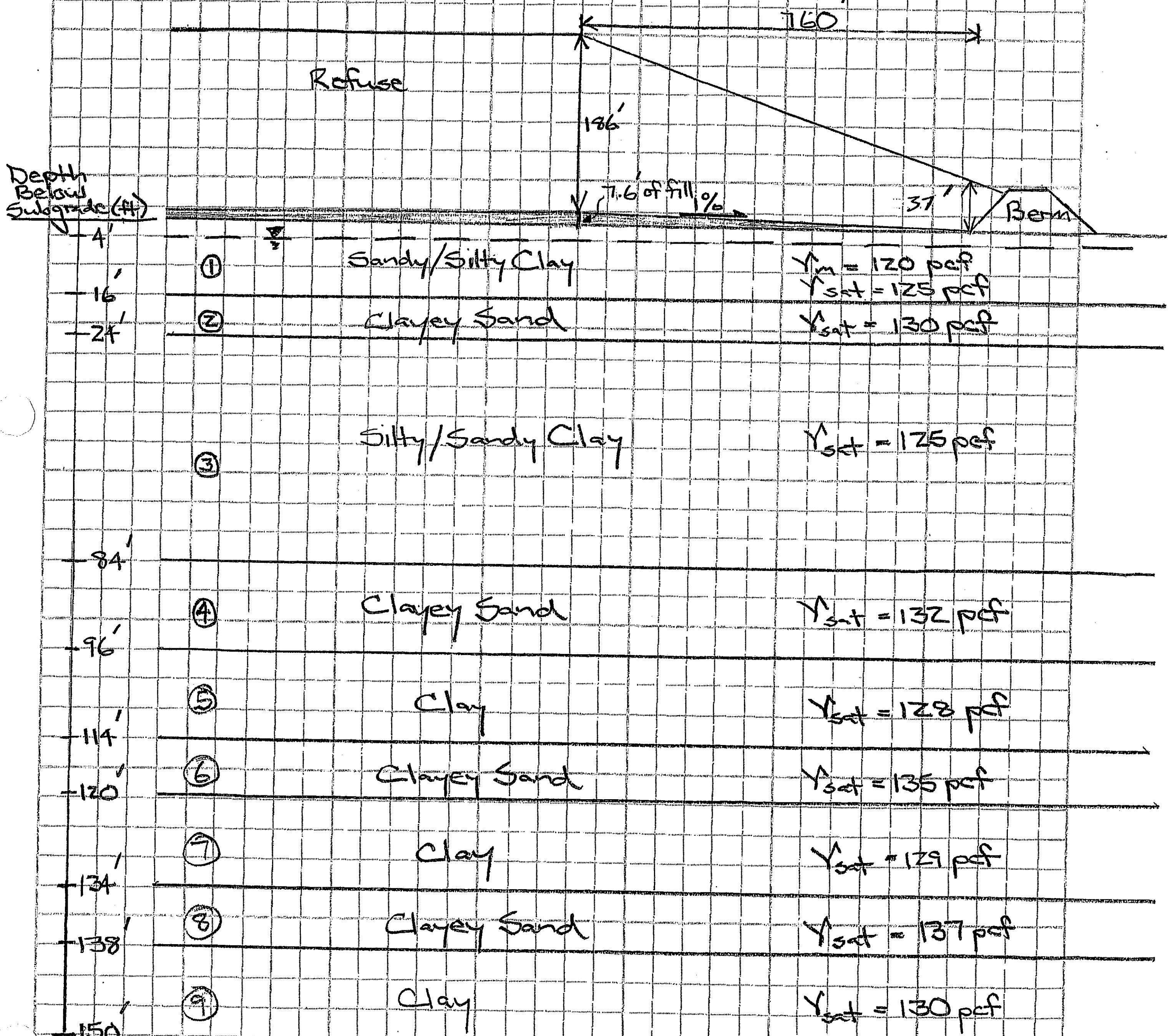
For $x/a = 0.1461$

$$\frac{(0.2596 - 0.0526)}{0.25} = \frac{x}{0.1461}$$

$$x = 0.1210$$

$\therefore \sigma_z/p$ ...

The following cross-section & soil profile was used in our settlement analysis:



Note: Section A-A' on the attached sheet was used to develop the cross section.

Based on consolidation data by EMCON (1991) & Golder (2001) and engineering judgement, the following settlement parameters were used in our analysis:

Soil Layer	e_o	C_c	C_r
①	0.620	0.160	0.030
②	0.480	0.050	0.000
③	0.570	0.190	0.020
④	0.450	0.050	0.000
⑤	0.560	0.140	0.015
⑥	0.420	0.035	0.000
⑦	0.550	0.110	0.013
⑧	0.380	0.020	0.000
⑨	0.530	0.090	0.009

Results of Settlement Analyses

Total settlements were calculated for the refuse with unit weights of 60 pcf & 70 pcf. The attached spreadsheets summarize the results and assumptions.

A. For Refuse @ 60 pcf

① Adjacent Collection Sump:

Total Settlement – 1.911 feet

② Maximum Height of Refuse

Total Settlement – [illegible] feet

Golder Associates	SUBJECT Settlement Analysis for Vert. Expansion		
	Job No. 033-7359 Ref.	Made by APM Checked [initials] Reviewed [initials]	Date 11/12/03 Sheet 6 of 6

B. For Refuse @ 70 pcf

① Adjacent Collection Sump:

Total Settlement – 2.129 feet

② Maximum Height of Refuse

Total Settlement – 7.860 feet

Conclusions:

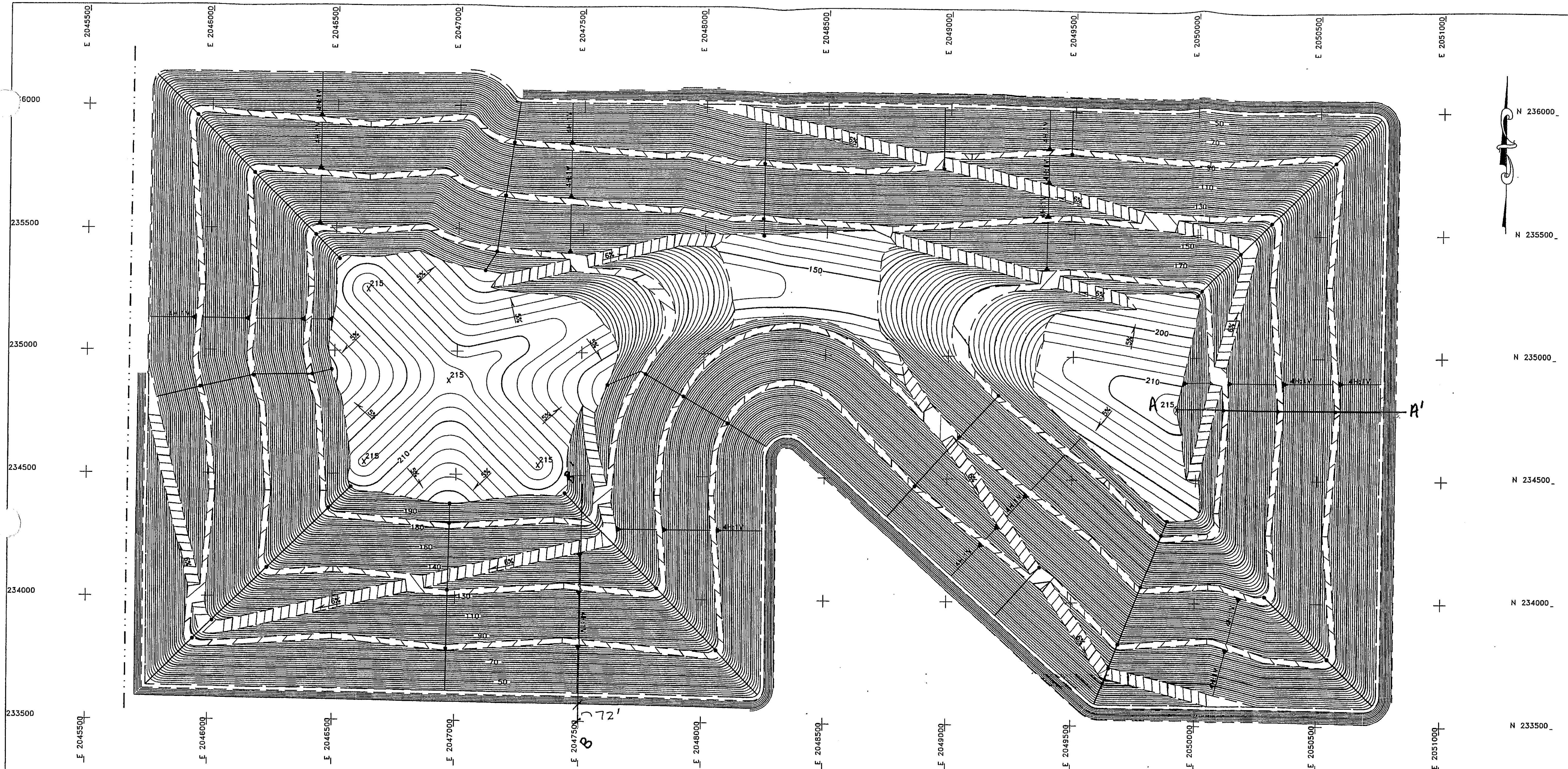
Based on the total settlements calculated the design grade of the flowline will decrease as follows:

① For Refuse @ 60 pcf

1.911 – (7.414 – 7.6)/760 = 0.276%

② For Refuse @ 70 pcf

2.129 – (7.860 – 7.6)/760 = 0.246%



LEGEND:

PROPERTY LINE
PARCEL LINE
DOWNDRAIN
2H:1V SLOPE INDICATOR
2% GRADE INDICATOR

A / 0 2
DETAIL/SECTION DESIGNATION
DRAWING WHERE SECTION/DETAIL IS LOCATED
DRAWING WHERE SECTION/DETAIL IS REFERENCED

0 400 800
FEET

REV.	DATE	DESCRIPTION	DRN BY	RVW BY

Golder Associates
1009 Enterprise Way
Suite 350
Roseville, CA 95678
Tel: (916) 786-2424
Fax: (916) 786-2434

PROJECT NO.: 033-7324 TASK NO.: 5

PROJECT:
PROPOSED VERTICAL EXPANSION
HAY ROAD SANITARY LANDFILL

SHEET TITLE:
PROPOSED FINAL GRADING PLAN

NORCAL WASTE SYSTEMS
HAY ROAD LANDFILL, INC.
6426 HAY ROAD
VACAVILLE, CALIFORNIA 95688
TEL: (707) 678-4718
FAX: (707) 678-5695

SHEET: 1 OF 1
DRAWING NO. 1
REV. 0

Settlement Adjacent Collection Sump

(Soil Profile - 150' deep, Unit Weight of Refuse - 60 pcf)

Depth below Surface (ft)	Depth below Water Table (ft)	Material Type	USCS Symbol	Unit Weight (pcf)	σ_{vo}' (psf)	C_c	C_{ce}	C_r	C_{re}	C_α	Max. Past Preconsolidation Pressure, σ_p' (psf)	Initial Void Ratio, e_o	Vertical Stress Due to Load, $\Delta\sigma_v$ (psf)	Primary Settlement (in.)	Secondary Settlement (in.)	Total Settlement (in.)	Total Settlement (ft.)
1	0	Sandy Clay	CL	120	120.0	0.160	0.099	0.030	0.019	0.008	504	0.620	1764.0	1.634	0.101	1.735	0.145
3	0			120	360.0	0.160	0.099	0.030	0.019	0.008	1493	0.620	1768.5	0.640	0.101	0.741	0.062
5	1			125	547.6	0.160	0.099	0.030	0.019	0.008	2241	0.620	1773.0	0.308	0.101	0.409	0.034
7	3			125	672.8	0.160	0.099	0.030	0.019	0.008	2717	0.620	1777.5	0.010	0.101	0.111	0.009
9	5	Silty Clay	CL	125	798.0	0.160	0.099	0.030	0.019	0.008	3179	0.620	1781.9	0.009	0.101	0.110	0.009
11	7			125	923.2	0.160	0.099	0.030	0.019	0.008	3628	0.620	1786.4	0.009	0.101	0.109	0.009
13	9			125	1048.4	0.160	0.099	0.030	0.019	0.008	4064	0.620	1790.9	0.008	0.101	0.109	0.009
15	11			125	1173.6	0.160	0.099	0.030	0.019	0.008	4485	0.620	1795.4	0.007	0.101	0.108	0.009
17	13	Clayey Sand	SC	130	1308.8	0.050	0.034	0.000	0.000	0.003	4932	0.480	1799.9	0.000	0.000	0.000	0.000
19	15			130	1444.0	0.050	0.034	0.000	0.000	0.003	5363	0.480	1804.4	0.000	0.000	0.000	0.000
21	17			130	1579.2	0.050	0.034	0.000	0.000	0.003	5780	0.480	1808.9	0.000	0.000	0.000	0.000
23	19			130	1714.4	0.050	0.034	0.000	0.000	0.003	6182	0.480	1813.3	0.000	0.000	0.000	0.000
25	21	Silty Clay	CL	125	1839.6	0.190	0.121	0.020	0.013	0.0095	6534	0.570	1817.8	0.004	0.123	0.127	0.011
27	23			125	1964.8	0.190	0.121	0.020	0.013	0.0095	6562	0.570	1822.3	0.004	0.123	0.127	0.011
29	25			125	2090.0	0.190	0.121	0.020	0.013	0.0095	6542	0.570	1826.8	0.003	0.123	0.127	0.011
31	27			125	2215.2	0.190	0.121	0.020	0.013	0.0095	6468	0.570	1831.3	0.003	0.123	0.127	0.011
33	29			125	2340.4	0.190	0.121	0.020	0.013	0.0095	6342	0.570	1835.8	0.003	0.123	0.127	0.011
35	31			125	2465.6	0.190	0.121	0.020	0.013	0.0095	6164	0.570	1840.3	0.003	0.123	0.126	0.011
37	33			125	2590.8	0.190	0.121	0.020	0.013	0.0095	5933	0.570	1844.7	0.003	0.123	0.126	0.011
39	35			125	2716.0	0.190	0.121	0.020	0.013	0.0095	5649	0.570	1849.2	0.003	0.123	0.126	0.011
41	37			125	2841.2	0.190	0.121	0.020	0.013	0.0095	5313	0.570	1853.7	0.003	0.123	0.126	0.011
43	39			125	2966.4	0.190	0.121	0.020	0.013	0.0095	4924	0.570	1858.2	0.003	0.123	0.126	0.011
45	41			125	3091.6	0.190	0.121	0.020	0.013	0.0095	4483	0.570	1862.7	0.175	0.123	0.299	0.025
47	43			125	3216.8	0.190	0.121	0.020	0.013	0.0095	3989	0.570	1867.2	0.335	0.123	0.458	0.038
49	45			125	3342.0	0.190	0.121	0.020	0.013	0.0095	3843	0.570	1871.7	0.403	0.123	0.527	0.044
51	47	Sandy Clay	CL	125	3467.2	0.190	0.121	0.020	0.013	0.0095	3467	0.570	1876.2	0.546	0.123	0.669	0.056
53	49			125	3592.4	0.190	0.121	0.020	0.013	0.0095	3592	0.570	1880.6	0.531	0.123	0.654	0.055
55	51			125	3717.6	0.190	0.121	0.020	0.013	0.0095	3718	0.570	1885.1	0.517	0.123	0.641	0.053
57	53			125	3842.8	0.190	0.121	0.020	0.013	0.0095	3843	0.570	1889.6	0.504	0.123	0.628	0.052
59	55			125	3968.0	0.190	0.121	0.020	0.013	0.0095	3968	0.570	1894.1	0.492	0.123	0.616	0.051
61	57			125	4093.2	0.190	0.121	0.020	0.013	0.0095	4093	0.570	1898.6	0.481	0.123	0.604	0.050
63	59			125	4218.4	0.190	0.121	0.020	0.013	0.0095	4218	0.570	1903.1	0.470	0.123	0.593	0.049
65	61			125	4343.6	0.190	0.121	0.020	0.013	0.0095	4344	0.570	1907.6	0.459	0.123	0.583	0.049
67	63			125	4468.8	0.190	0.197	0.020	0.018	0.0095	4469	0.570	1912.0	0.731	0.123	0.855	0.071
69	65	Clay	CL	125	4594.0	0.190	0.121	0.020	0.013	0.0095	4594	0.570	1916.5	0.440	0.123	0.563	0.047
71	67			125	4719.2	0.190	0.121	0.020	0.013	0.0095	4719	0.570	1921.0	0.431	0.123	0.554	0.046
73	69			125	4844.4	0.190	0.121	0.020	0.013	0.0095	4844	0.570	1925.5	0.422	0.123	0.546	0.045
75	71			125	4969.6	0.190	0.121	0.020	0.013	0.0095	4970	0.570	1930.0	0.414	0.123	0.537	0.045
77	73			125	5094.8	0.190	0.121	0.020	0.013	0.0095	5095	0.570	1934.5	0.406	0.123	0.529	0.044
79	75			125	5220.0	0.190	0.121	0.020	0.013	0.0095	5220	0.570	1939.0	0.398	0.123	0.522	0.043
81	77			125	5345.2	0.190	0.121	0.020	0.013	0.0095	5345	0.570	1943.4	0.391	0.123	0.515	0.043
83	79			125	5470.4	0.190	0.121	0.020	0.013	0.0095	5470	0.570	1947.9	0.384	0.123	0.508	0.042
85	81	Clayey Sand	SC	132	5609.6	0.050	0.034	0.000	0.000	0.003	5610	0.450	1952.4	0.107	0.035	0.142	0.012
87	83			132	5748.8	0.050	0.034	0.000	0.000	0.003	5749	0.450	1956.9	0.105	0.035	0.140	0.012
89	85			132	5888.0	0.050	0.034	0.000	0.000	0.003	5888	0.450	1961.4	0.103	0.035	0.138	0.012
91	87			132	6027.2	0.050	0.034	0.000	0.000	0.003	6027	0.450	1965.9	0.101	0.035	0.137	0.011
93	89			132	6166.4	0.050	0.034	0.000	0.000	0.003	6166	0.450	1970.4	0.100	0.035	0.135	0.011
95	91			132	6305.6	0.050	0.034	0.000	0.000	0.003	6306	0.450	1974.8	0.098	0.035	0.133	0.011
97	93	Clay	CL	128	6436.8	0.140	0.090	0.015	0.010	0.0070	6437	0.560	1979.3	0.251	0.091	0.342	0.029
99	95			128	6568.0	0.140	0.090	0.015	0.010	0.0070	6568	0.560	1983.8	0.247	0.091	0.338	0.028
101	97			128	6699.2	0.140	0.090	0.015	0.010	0.0070	6699	0.560	1988.3	0.243	0.091	0.335	0.028
103	99			128	6830.4	0.140	0.090	0.015	0.010	0.0070	6830	0.560	1992.8	0.239	0.091	0.331	0.028
105	101			128	6961.6	0.140	0.090	0.015	0.010	0.0070	6962	0.560	1997.3	0.236	0.091	0.327	0.027
107	103			128	7092.8	0.140	0.090	0.015	0.010	0.0070	7093	0.560	2001.8	0.233	0.091	0.324	0.027
109	105			128	7224.0	0.140	0.090	0.015	0.010	0.0070	7224	0.560	2006.2	0.229	0.091	0.321	0.027
111	107			128	7355.2	0.140	0.090	0.015	0.010	0.0070	7355	0.560	2010.7	0.226	0.091	0.318	0.026
113	109			128	7486.4	0.140	0.090	0.015	0.010	0.0070	7486	0.560	2015.2	0.223	0.091	0.314	0.026
115	111	Clayey Sand	SC	135	7631.6	0.035	0.025	0.000	0.000	0.002	7632	0.420	2019.7	0.060	0.025	0.085	0.007
117	113			135	7776.8	0.035	0.025	0.000	0.000	0.002	7777	0.420	2024.2	0.059	0.025	0.085	0.007
119	115			135	7922.0	0.035	0.025	0.000	0.000	0.002	7922	0.420	2028.7	0.059	0.025	0.084	0.007
121	117	Clay	CL	129	8055.2	0.110	0.071	0.013	0.008	0.0055	8055	0.550	2033.2	0.166	0.072	0.239	0.020
123	119			129	8188.4	0.110	0.071	0.013	0.008	0.0055	8188	0.550	2037.6	0.164	0.072	0.237	0.020
125	121			129	8321.6	0.110	0.071	0.013	0.008	0.0055	8322	0.550	2042.1	0.162	0.072	0.235	0.020
127	123			129	8454.8	0.110	0.071	0.013	0.008	0.0055	8455	0.550	2046.6	0.160	0.072	0.233	0.019
129	125			129	8588.0	0.110	0.071	0.013	0.008	0.0055	8588	0.550	2051.1	0.158	0.072	0.231	0.019
131	127			129	8721.2	0.110	0.071	0.013	0.008	0.0055	8721	0.550	2055.6	0.157	0.072	0.229	0.019
133	129			129	8854.4	0.110	0.071	0.013	0.008	0.0055	8854	0.550	2060.1	0.155	0.072	0.227	0.019
135	131	Clayey Sand	SC	137	9003.6	0.020	0.014	0.000	0.000	0.001	9004	0.380	2064.6	0.031	0.015	0.046	0.004
137	133			137	9152.8	0.020	0.014	0.000	0.000	0.001	9153	0.380	2069.0	0.031	0.015	0.046	0.004
139	135	Clay	CL	130	9288.0	0.090	0.059	0.009	0.006	0.0045	9288	0.530	2073.5	0.124	0.060	0.184	0.015
141	137			130	9423.2	0.090	0.059	0.009	0.006	0.0045	9423	0.530	2078.0	0.122	0.060	0.182	0.015
143	139			130	9558.4	0.090	0.059	0.009	0.006	0.0045	9558	0.530	2082.5	0.121	0.060	0.181	0.015
145	141			130	9693.6	0.090	0.059	0.009	0.006	0.0045	9694	0.530	2087.0	0.120	0.060	0.180	0.015
147	143			130	9828.8	0.090	0.059	0.009	0.006	0.0045	9829	0.530	2091.5	0.118	0.060	0.178	0.015
149	145			130	9964.0	0.090	0.059	0.009	0.006	0.0045	9964	0.530	2096.0	0.117	0.060	0.177	0.015
													TOTAL	16.416	6.512	22.928	1.911

**Assumptions made:

1) Effective vertical stress calculated for 2 ft. increments at the center of mass
2) Unit weights listed are assumed typical values
3) Settlement parameters used are based on values reported by EMCON & Golder and engineering judgement
4) Based on consolidation tests performed by EMCON and Golder, the native soils within the upper 50 feet are overconsolidated. OCRs ranging from 4.2 to 1.2 have been assigned to the soils within the upper 50 feet for estimation of the maximum past preconsolidation pressures used in the settlement analysis. Below a depth of 50 feet, the soils are assumed to be normally consolidated. This assumption underestimates σp', and therefore overestimates the calculated settlements.
5) Groundwater was assumed to be at a depth of 4 feet below subgrade
6) For settlement calculations, Ho = 2ft.
7) The vertical stress ($\Delta\sigma_v$) applied to the subgrade adjacent to the collection sump was calculated for semi-finite embankment loading conditions using influence factors originally presented by Jurgenson (1934). The change in vertical stress was assumed to increase/decrease linearly with depth.
8) **Primary Settlement** (1) If $\sigma_{vo}' = \sigma_p'$, then $S = C_{ce}*Ho(\log10((\sigma_{vo}' + \Delta\sigma_v)/\sigma_{vo}'))$; (2) If $\sigma_{vo}' + \Delta\sigma_v < \sigma_p'$, then $S = C_{re}*H_o(\log10((\sigma_{vo}'+\Delta\sigma_v)/\sigma_{vo}'))$; or (3) If $\sigma_{vo}' < \sigma_p' < \sigma_{vo}' + \Delta\sigma_v$, then $S = C_{re}*H_o(\log10(\sigma_p'/\sigma_{vo}')) + C_{ce}*H_o(\log10((\sigma_{vo}'+\Delta\sigma_v)/\sigma_p'))$
9) **Secondary Settlement** = $(C_\alpha/(1+e_o))*H_o(\log10\Delta t)$. Assume $C_\alpha = 0.05*C_c$, $\Delta t = 50$ yrs

Settlement at Maximum Height of Refuse

(Soil Profile - 150' deep, Unit Weight of Refuse - 60 pcf)

Depth below Surface (ft)	Depth below Water Table (ft)	Material Type	USCS Symbol	Unit Weight (pcf)	σ_{vo}' (psf)	C_c	$C_{c\varepsilon}$	C_r	$C_{r\varepsilon}$	C_α	Max. Past Preconsolidation Pressure, σ_p' (psf)	Initial Void Ratio, e_o	Vertical Stress Due to Load, $\Delta\sigma_v$ (psf)	Primary Settlement (in.)	Secondary Settlement (in.)	Total Settlement (in.)	Total Settlement (ft.)
1	0	Sandy Clay	CL	120	120.0	0.160	0.099	0.030	0.019	0.008	504	0.620	12072.0	3.557	0.101	3.657	0.305
3	0			120	360.0	0.160	0.099	0.030	0.019	0.008	1493	0.620	12063.4	2.456	0.101	2.557	0.213
5	1			125	547.6	0.160	0.099	0.030	0.019	0.008	2241	0.620	12054.8	2.050	0.101	2.151	0.179
7	3			125	672.8	0.160	0.099	0.030	0.019	0.008	2717	0.620	12046.3	1.859	0.101	1.959	0.163
9	5	Silty Clay	CL	125	798.0	0.160	0.099	0.030	0.019	0.008	3179	0.620	12037.7	1.703	0.101	1.804	0.150
11	7			125	923.2	0.160	0.099	0.030	0.019	0.008	3628	0.620	12029.1	1.574	0.101	1.675	0.140
13	9			125	1048.4	0.160	0.099	0.030	0.019	0.008	4064	0.620	12020.5	1.464	0.101	1.565	0.130
15	11			125	1173.6	0.160	0.099	0.030	0.019	0.008	4485	0.620	12011.9	1.369	0.101	1.469	0.122
17	13	Clayey Sand	SC	130	1308.8	0.050	0.034	0.000	0.000	0.003	4932	0.480	12003.4	0.350	0.034	0.384	0.032
19	15			130	1444.0	0.050	0.034	0.000	0.000	0.003	5363	0.480	11994.8	0.323	0.034	0.358	0.030
21	17			130	1579.2	0.050	0.034	0.000	0.000	0.003	5780	0.480	11986.2	0.300	0.034	0.335	0.028
23	19			130	1714.4	0.050	0.034	0.000	0.000	0.003	6182	0.480	11977.6	0.280	0.034	0.314	0.026
25	21	Silty Clay	CL	125	1839.6	0.190	0.121	0.020	0.013	0.0095	6534	0.570	11969.0	1.112	0.123	1.235	0.103
27	23			125	1964.8	0.190	0.121	0.020	0.013	0.0095	6562	0.570	11960.4	1.109	0.123	1.232	0.103
29	25			125	2090.0	0.190	0.121	0.020	0.013	0.0095	6542	0.570	11951.9	1.115	0.123	1.238	0.103
31	27			125	2215.2	0.190	0.121	0.020	0.013	0.0095	6468	0.570	11943.3	1.130	0.123	1.254	0.104
33	29			125	2340.4	0.190	0.121	0.020	0.013	0.0095	6342	0.570	11934.7	1.156	0.123	1.279	0.107
35	31			125	2465.6	0.190	0.121	0.020	0.013	0.0095	6164	0.570	11926.1	1.191	0.123	1.315	0.110
37	33			125	2590.8	0.190	0.121	0.020	0.013	0.0095	5933	0.570	11917.5	1.238	0.123	1.361	0.113
39	35			125	2716.0	0.190	0.121	0.020	0.013	0.0095	5649	0.570	11909.0	1.297	0.123	1.420	0.118
41	37			125	2841.2	0.190	0.121	0.020	0.013	0.0095	5313	0.570	11900.4	1.370	0.123	1.494	0.124
43	39			125	2966.4	0.190	0.121	0.020	0.013	0.0095	4924	0.570	11891.8	1.460	0.123	1.584	0.132
45	41			125	3091.6	0.190	0.121	0.020	0.013	0.0095	4483	0.570	11883.2	1.571	0.123	1.694	0.141
47	43			125	3216.8	0.190	0.121	0.020	0.013	0.0095	3989	0.570	11874.6	1.707	0.123	1.830	0.153
49	45			125	3342.0	0.190	0.121	0.020	0.013	0.0095	3843	0.570	11866.1	1.754	0.123	1.877	0.156
51	47	Sandy Clay	CL	125	3467.2	0.190	0.121	0.020	0.013	0.0095	3467	0.570	11857.5	1.875	0.123	1.998	0.166
53	49			125	3592.4	0.190	0.121	0.020	0.013	0.0095	3592	0.570	11848.9	1.839	0.123	1.963	0.164
55	51			125	3717.6	0.190	0.121	0.020	0.013	0.0095	3718	0.570	11840.3	1.806	0.123	1.929	0.161
57	53			125	3842.8	0.190	0.121	0.020	0.013	0.0095	3843	0.570	11831.7	1.773	0.123	1.897	0.158
59	55			125	3968.0	0.190	0.121	0.020	0.013	0.0095	3968	0.570	11823.2	1.742	0.123	1.866	0.155
61	57			125	4093.2	0.190	0.121	0.020	0.013	0.0095	4093	0.570	11814.6	1.712	0.123	1.836	0.153
63	59			125	4218.4	0.190	0.121	0.020	0.013	0.0095	4218	0.570	11806.0	1.684	0.123	1.807	0.151
65	61			125	4343.6	0.190	0.121	0.020	0.013	0.0095	4344	0.570	11797.4	1.656	0.123	1.779	0.148
67	63			125	4468.8	0.190	0.197	0.020	0.018	0.0095	4469	0.570	11788.8	2.652	0.123	2.775	0.231
69	65	Clay	CL	125	4594.0	0.190	0.121	0.020	0.013	0.0095	4594	0.570	11780.2	1.603	0.123	1.727	0.144
71	67			125	4719.2	0.190	0.121	0.020	0.013	0.0095	4719	0.570	11771.7	1.578	0.123	1.702	0.142
73	69			125	4844.4	0.190	0.121	0.020	0.013	0.0095	4844	0.570	11763.1	1.554	0.123	1.677	0.140
75	71			125	4969.6	0.190	0.121	0.020	0.013	0.0095	4970	0.570	11754.5	1.531	0.123	1.654	0.138
77	73			125	5094.8	0.190	0.121	0.020	0.013	0.0095	5095	0.570	11745.9	1.508	0.123	1.631	0.136
79	75			125	5220.0	0.190	0.121	0.020	0.013	0.0095	5220	0.570	11737.3	1.486	0.123	1.610	0.134
81	77			125	5345.2	0.190	0.121	0.020	0.013	0.0095	5345	0.570	11728.8	1.465	0.123	1.588	0.132
83	79			125	5470.4	0.190	0.121	0.020	0.013	0.0095	5470	0.570	11720.2	1.444	0.123	1.568	0.131
85	81	Clayey Sand	SC	132	5609.6	0.050	0.034	0.000	0.000	0.003	5610	0.450	11711.6	0.405	0.035	0.440	0.037
87	83			132	5748.8	0.050	0.034	0.000	0.000	0.003	5749	0.450	11703.0	0.399	0.035	0.434	0.036
89	85			132	5888.0	0.050	0.034	0.000	0.000	0.003	5888	0.450	11694.4	0.393	0.035	0.428	0.036
91	87			132	6027.2	0.050	0.034	0.000	0.000	0.003	6027	0.450	11685.9	0.387	0.035	0.423	0.035
93	89			132	6166.4	0.050	0.034	0.000	0.000	0.003	6166	0.450	11677.3	0.382	0.035	0.417	0.035
95	91			132	6305.6	0.050	0.034	0.000	0.000	0.003	6306	0.450	11668.7	0.376	0.035	0.412	0.034
97	93	Clay	CL	128	6436.8	0.140	0.090	0.015	0.010	0.0070	6437	0.560	11660.1	0.967	0.091	1.058	0.088
99	95			128	6568.0	0.140	0.090	0.015	0.010	0.0070	6568	0.560	11651.5	0.954	0.091	1.046	0.087
101	97			128	6699.2	0.140	0.090	0.015	0.010	0.0070	6699	0.560	11643.0	0.942	0.091	1.034	0.086
103	99			128	6830.4	0.140	0.090	0.015	0.010	0.0070	6830	0.560	11634.4	0.930	0.091	1.022	0.085
105	101			128	6961.6	0.140	0.090	0.015	0.010	0.0070	6962	0.560	11625.8	0.919	0.091	1.010	0.084
107	103			128	7092.8	0.140	0.090	0.015	0.010	0.0070	7093	0.560	11617.2	0.907	0.091	0.999	0.083
109	105			128	7224.0	0.140	0.090	0.015	0.010	0.0070	7224	0.560	11608.6	0.896	0.091	0.988	0.082
111	107			128	7355.2	0.140	0.090	0.015	0.010	0.0070	7355	0.560	11600.0	0.886	0.091	0.977	0.081
113	109			128	7486.4	0.140	0.090	0.015	0.010	0.0070	7486	0.560	11591.5	0.875	0.091	0.966	0.081
115	111	Clayey Sand	SC	135	7631.6	0.035	0.025	0.000	0.000	0.0018	7632	0.420	11582.9	0.237	0.025	0.262	0.022
117	113			135	7776.8	0.035	0.025	0.000	0.000	0.0018	7777	0.420	11574.3	0.234	0.025	0.259	0.022
119	115			135	7922.0	0.035	0.025	0.000	0.000	0.0018	7922	0.420	11565.7	0.231	0.025	0.256	0.021
121	117	Clay	CL	129	8055.2	0.110	0.071	0.013	0.008	0.0055	8055	0.550	11557.1	0.658	0.072	0.731	0.061
123	119			129	8188.4	0.110	0.071	0.013	0.008	0.0055	8188	0.550	11548.6	0.651	0.072	0.723	0.060
125	121			129	8321.6	0.110	0.071	0.013	0.008	0.0055	8322	0.550	11540.0	0.643	0.072	0.716	0.060
127	123			129	8454.8	0.110	0.071	0.013	0.008	0.0055	8455	0.550	11531.4	0.636	0.072	0.709	0.059
129	125			129	8588.0	0.110	0.071	0.013	0.008	0.0055	8588	0.550	11522.8	0.629	0.072	0.702	0.058
131	127			129	8721.2	0.110	0.071	0.013	0.008	0.0055	8721	0.550	11514.2	0.623	0.072	0.695	0.058
133	129			129	8854.4	0.110	0.071	0.013	0.008	0.0055	8854	0.550	11505.7	0.616	0.072	0.688	0.057
135	131	Clayey Sand	SC	137	9003.6	0.020	0.014	0.000	0.000	0.0010	9004	0.380	11497.1	0.124	0.015	0.139	0.012
137	133			137	9152.8	0.020	0.014	0.000	0.000	0.0010	9153	0.380	11488.5	0.123	0.015	0.138	0.011
139	135	Clay	CL	130	9288.0	0.090	0.059	0.009	0.006	0.0045	9288	0.530	11479.9	0.493	0.060	0.553	0.046
141	137			130	9423.2	0.090	0.059	0.009	0.006	0.0045	9423	0.530	11471.3	0.488	0.060	0.548	0.046
143	139			130	9558.4	0.090	0.059	0.009	0.006	0.0045	9558	0.530	11462.7	0.483	0.060	0.543	0.045
145	141			130	9693.6	0.090	0.059	0.009	0.006	0.0045	9694	0.530	11454.2	0.478	0.060	0.538	0.045
147	143			130	9828.8	0.090	0.059	0.009	0.006	0.0045	9829	0.530	11445.6	0.473	0.060	0.533	0.044
149	145			130	9964.0	0.090	0.059	0.009	0.006	0.0045	9964	0.530	11437.0	0.469	0.060	0.529	0.044
													TOTAL	82.316	6,649	88.965	7.414

**Assumptions made:

1) Effective vertical stress calculated for 2 ft. increments at the center of mass
2) Unit weights listed are assumed typical values
3) Settlement parameters used are based on values reported by EMCON & Golder and engineering judgement
4) Based on consolidation tests performed by EMCON and Golder, the native soils within the upper 50 feet are overconsolidated. OCRs ranging from 4.2 to 1.2 have been assigned to the soils within the upper 50 feet for estimation of the maximum past preconsolidation pressures used in the settlement analysis. Below a depth of 50 feet, the soils are assumed to be normally consolidated. This assumption underestimates σp', and therefore overestimates the calculated settlements.
5) Groundwater was assumed to be at a depth of 4 feet below subgrade
6) For settlement calculations, Ho = 2ft.
7) The vertical stress ($\Delta\sigma_v$) applied to the subgrade due to the load of the refuse and fill material is (186 ft)(60 pcf)+(7.6 ft)(120 pcf) = 12,072 psf. The change in vertical stress with depth was calculated for semi-finite embankment loading conditions using influence factors originally presented by Jurgenson (1934). The change in vertical stress was assumed to increase/decrease linearly with depth.
8) **Primary Settlement** (1) If $\sigma_{vo}' = \sigma_p'$, then $S = C_{c\varepsilon} * Ho(\log10((\sigma_{vo}' + \Delta\sigma_v)/\sigma_{vo}'))$; (2) If $\sigma_{vo}' + \Delta\sigma_v < \sigma_p'$, then $S = C_{r\varepsilon} * H_o(\log10((\sigma_{vo}'+\Delta\sigma_v)/\sigma_{vo}'))$; or (3) If $\sigma_{vo}' < \sigma_p' < \sigma_{vo}' + \Delta\sigma_v$, then $S = C_{r\varepsilon} * H_o(\log10(\sigma_p'/\sigma_{vo}')) + C_{c\varepsilon} * H_o(\log10((\sigma_{vo}'+\Delta\sigma_v)/\sigma_p'))$
9) **Secondary Settlement** = $(C_\alpha/(1+e_o)) * H_o(\log10\Delta t)$. Assume $C_\alpha = 0.05 * C_c$, Δt = 50 yrs

Settlement Adjacent Collection Sump

(Soil Profile - 150' deep, Unit Weight of Refuse - 70 pcf)

Depth below Surface (ft)	Depth below Water Table (ft)	Material Type	USCS Symbol	Unit Weight (pcf)	σ_{vo}' (psf)	C_c	C_{ce}	C_r	C_{re}	C_α	Max. Past Preconsolidation Pressure, σ_p' (psf)	Initial Void Ratio, e_o	Vertical Stress Due to Load, $\Delta\sigma_v$ (psf)	Primary Settlement (in.)	Secondary Settlement (in.)	Total Settlement (in.)	Total Settlement (ft.)
1	0	Sandy Clay	CL	120	120.0	0.160	0.099	0.030	0.019	0.008	504	0.620	2035.0	1.773	0.101	1.873	0.156
3	0			120	360.0	0.160	0.099	0.030	0.019	0.008	1493	0.620	2040.2	0.764	0.101	0.864	0.072
5	1			125	547.6	0.160	0.099	0.030	0.019	0.008	2241	0.620	2045.4	0.422	0.101	0.523	0.044
7	3			125	672.8	0.160	0.099	0.030	0.019	0.008	2717	0.620	2050.5	0.272	0.101	0.373	0.031
9	5	Silty Clay	CL	125	798.0	0.160	0.099	0.030	0.019	0.008	3179	0.620	2055.7	0.010	0.101	0.111	0.009
11	7			125	923.2	0.160	0.099	0.030	0.019	0.008	3628	0.620	2060.9	0.009	0.101	0.110	0.009
13	9			125	1048.4	0.160	0.099	0.030	0.019	0.008	4064	0.620	2066.1	0.009	0.101	0.109	0.009
15	11			125	1173.6	0.160	0.099	0.030	0.019	0.008	4485	0.620	2071.2	0.008	0.101	0.109	0.009
17	13	Clayey Sand	SC	130	1308.8	0.050	0.034	0.000	0.000	0.003	4932	0.480	2076.4	0.000	0.000	0.000	0.000
19	15			130	1444.0	0.050	0.034	0.000	0.000	0.003	5363	0.480	2081.6	0.000	0.000	0.000	0.000
21	17			130	1579.2	0.050	0.034	0.000	0.000	0.003	5780	0.480	2086.8	0.000	0.000	0.000	0.000
23	19			130	1714.4	0.050	0.034	0.000	0.000	0.003	6182	0.480	2091.9	0.000	0.000	0.000	0.000
25	21	Silty Clay	CL	125	1839.6	0.190	0.121	0.020	0.013	0.0095	6534	0.570	2097.1	0.004	0.123	0.128	0.011
27	23			125	1964.8	0.190	0.121	0.020	0.013	0.0095	6562	0.570	2102.3	0.004	0.123	0.127	0.011
29	25			125	2090.0	0.190	0.121	0.020	0.013	0.0095	6542	0.570	2107.5	0.004	0.123	0.127	0.011
31	27			125	2215.2	0.190	0.121	0.020	0.013	0.0095	6468	0.570	2112.6	0.004	0.123	0.127	0.011
33	29			125	2340.4	0.190	0.121	0.020	0.013	0.0095	6342	0.570	2117.8	0.004	0.123	0.127	0.011
35	31			125	2465.6	0.190	0.121	0.020	0.013	0.0095	6164	0.570	2123.0	0.003	0.123	0.127	0.011
37	33			125	2590.8	0.190	0.121	0.020	0.013	0.0095	5933	0.570	2128.2	0.003	0.123	0.127	0.011
39	35			125	2716.0	0.190	0.121	0.020	0.013	0.0095	5649	0.570	2133.3	0.003	0.123	0.127	0.011
41	37			125	2841.2	0.190	0.121	0.020	0.013	0.0095	5313	0.570	2138.5	0.003	0.123	0.126	0.011
43	39			125	2966.4	0.190	0.121	0.020	0.013	0.0095	4924	0.570	2143.7	0.114	0.123	0.237	0.020
45	41			125	3091.6	0.190	0.121	0.020	0.013	0.0095	4483	0.570	2148.9	0.246	0.123	0.370	0.031
47	43			125	3216.8	0.190	0.121	0.020	0.013	0.0095	3989	0.570	2154.0	0.404	0.123	0.527	0.044
49	45			125	3342.0	0.190	0.121	0.020	0.013	0.0095	3843	0.570	2159.2	0.471	0.123	0.594	0.050
51	47	Sandy Clay	CL	125	3467.2	0.190	0.121	0.020	0.013	0.0095	3467	0.570	2164.4	0.612	0.123	0.735	0.061
53	49			125	3592.4	0.190	0.121	0.020	0.013	0.0095	3592	0.570	2169.6	0.596	0.123	0.719	0.060
55	51			125	3717.6	0.190	0.121	0.020	0.013	0.0095	3718	0.570	2174.8	0.581	0.123	0.704	0.059
57	53			125	3842.8	0.190	0.121	0.020	0.013	0.0095	3843	0.570	2179.9	0.567	0.123	0.690	0.058
59	55			125	3968.0	0.190	0.121	0.020	0.013	0.0095	3968	0.570	2185.1	0.553	0.123	0.677	0.056
61	57			125	4093.2	0.190	0.121	0.020	0.013	0.0095	4093	0.570	2190.3	0.541	0.123	0.664	0.055
63	59			125	4218.4	0.190	0.121	0.020	0.013	0.0095	4218	0.570	2195.5	0.529	0.123	0.652	0.054
65	61			125	4343.6	0.190	0.121	0.020	0.013	0.0095	4344	0.570	2200.6	0.517	0.123	0.640	0.053
67	63			125	4468.8	0.190	0.197	0.020	0.018	0.0095	4469	0.570	2205.8	0.824	0.123	0.947	0.079
69	65	Clay	CL	125	4594.0	0.190	0.121	0.020	0.013	0.0095	4594	0.570	2211.0	0.496	0.123	0.619	0.052
71	67			125	4719.2	0.190	0.121	0.020	0.013	0.0095	4719	0.570	2216.2	0.486	0.123	0.609	0.051
73	69			125	4844.4	0.190	0.121	0.020	0.013	0.0095	4844	0.570	2221.3	0.476	0.123	0.599	0.050
75	71			125	4969.6	0.190	0.121	0.020	0.013	0.0095	4970	0.570	2226.5	0.467	0.123	0.590	0.049
77	73			125	5094.8	0.190	0.121	0.020	0.013	0.0095	5095	0.570	2231.7	0.458	0.123	0.582	0.048
79	75			125	5220.0	0.190	0.121	0.020	0.013	0.0095	5220	0.570	2236.9	0.450	0.123	0.573	0.048
81	77			125	5345.2	0.190	0.121	0.020	0.013	0.0095	5345	0.570	2242.0	0.442	0.123	0.565	0.047
83	79			125	5470.4	0.190	0.121	0.020	0.013	0.0095	5470	0.570	2247.2	0.434	0.123	0.557	0.046
85	81	Clayey Sand	SC	132	5609.6	0.050	0.034	0.000	0.000	0.003	5610	0.450	2252.4	0.121	0.035	0.156	0.013
87	83			132	5748.8	0.050	0.034	0.000	0.000	0.003	5749	0.450	2257.6	0.119	0.035	0.154	0.013
89	85			132	5888.0	0.050	0.034	0.000	0.000	0.003	5888	0.450	2262.7	0.117	0.035	0.152	0.013
91	87			132	6027.2	0.050	0.034	0.000	0.000	0.003	6027	0.450	2267.9	0.115	0.035	0.150	0.012
93	89			132	6166.4	0.050	0.034	0.000	0.000	0.003	6166	0.450	2273.1	0.113	0.035	0.148	0.012
95	91			132	6305.6	0.050	0.034	0.000	0.000	0.003	6306	0.450	2278.3	0.111	0.035	0.146	0.012
97	93	Clay	CL	128	6436.8	0.140	0.090	0.015	0.010	0.0070	6437	0.560	2283.4	0.284	0.091	0.375	0.031
99	95			128	6568.0	0.140	0.090	0.015	0.010	0.0070	6568	0.560	2288.6	0.280	0.091	0.371	0.031
101	97			128	6699.2	0.140	0.090	0.015	0.010	0.0070	6699	0.560	2293.8	0.275	0.091	0.367	0.031
103	99			128	6830.4	0.140	0.090	0.015	0.010	0.0070	6830	0.560	2299.0	0.271	0.091	0.363	0.030
105	101			128	6961.6	0.140	0.090	0.015	0.010	0.0070	6962	0.560	2304.2	0.267	0.091	0.359	0.030
107	103			128	7092.8	0.140	0.090	0.015	0.010	0.0070	7093	0.560	2309.3	0.264	0.091	0.355	0.030
109	105			128	7224.0	0.140	0.090	0.015	0.010	0.0070	7224	0.560	2314.5	0.260	0.091	0.351	0.029
111	107			128	7355.2	0.140	0.090	0.015	0.010	0.0070	7355	0.560	2319.7	0.256	0.091	0.348	0.029
113	109			128	7486.4	0.140	0.090	0.015	0.010	0.0070	7486	0.560	2324.9	0.253	0.091	0.344	0.029
115	111	Clayey Sand	SC	135	7631.6	0.035	0.025	0.000	0.000	0.0018	7632	0.420	2330.0	0.068	0.025	0.094	0.008
117	113			135	7776.8	0.035	0.025	0.000	0.000	0.0018	7777	0.420	2335.2	0.067	0.025	0.093	0.008
119	115			135	7922.0	0.035	0.025	0.000	0.000	0.0018	7922	0.420	2340.4	0.066	0.025	0.092	0.008
121	117	Clay	CL	129	8055.2	0.110	0.071	0.013	0.008	0.0055	8055	0.550	2345.6	0.189	0.072	0.261	0.022
123	119			129	8188.4	0.110	0.071	0.013	0.008	0.0055	8188	0.550	2350.7	0.187	0.072	0.259	0.022
125	121			129	8321.6	0.110	0.071	0.013	0.008	0.0055	8322	0.550	2355.9	0.184	0.072	0.257	0.021
127	123			129	8454.8	0.110	0.071	0.013	0.008	0.0055	8455	0.550	2361.1	0.182	0.072	0.255	0.021
129	125			129	8588.0	0.110	0.071	0.013	0.008	0.0055	8588	0.550	2366.3	0.180	0.072	0.252	0.021
131	127			129	8721.2	0.110	0.071	0.013	0.008	0.0055	8721	0.550	2371.4	0.178	0.072	0.250	0.021
133	129			129	8854.4	0.110	0.071	0.013	0.008	0.0055	8854	0.550	2376.6	0.176	0.072	0.248	0.021
135	131	Clayey Sand	SC	137	9003.6	0.020	0.014	0.000	0.000	0.0010	9004	0.380	2381.8	0.035	0.015	0.050	0.004
137	133			137	9152.8	0.020	0.014	0.000	0.000	0.0010	9153	0.380	2387.0	0.035	0.015	0.050	0.004
139	135	Clay	CL	130	9288.0	0.090	0.059	0.009	0.006	0.0045	9288	0.530	2392.1	0.141	0.060	0.200	0.017
141	137			130	9423.2	0.090	0.059	0.009	0.006	0.0045	9423	0.530	2397.3	0.139	0.060	0.199	0.017
143	139			130	9558.4	0.090	0.059	0.009	0.006	0.0045	9558	0.530	2402.5	0.137	0.060	0.197	0.016
145	141			130	9693.6	0.090	0.059	0.009	0.006	0.0045	9694	0.530	2407.7	0.136	0.060	0.196	0.016
147	143			130	9828.8	0.090	0.059	0.009	0.006	0.0045	9829	0.530	2412.8	0.135	0.060	0.195	0.016
149	145			130	9964.0	0.090	0.059	0.009	0.006	0.0045	9964	0.530	2418.0	0.133	0.060	0.193	0.016
													TOTAL	19.038	6.512	25.550	2.129

**Assumptions made:

1) Effective vertical stress calculated for 2 ft. increments at the center of mass
2) Unit weights listed are assumed typical values
3) Settlement parameters used are based on values reported by EMCON & Golder and engineering judgement
4) Based on consolidation tests performed by EMCON and Golder, the native soils within the upper 50 feet are overconsolidated. OCRs ranging from 4.2 to 1.2 have been assigned to the soils within the upper 50 feet for estimation of the maximum past preconsolidation pressures used in the settlement analysis. Below a depth of 50 feet, the soils are assumed to be normally consolidated. This assumption underestimates σp', and therefore overestimates the calculated settlements.
5) Groundwater was assumed to be at a depth of 4 feet below subgrade
6) For settlement calculations, Ho = 2ft.
7) The vertical stress ($\Delta\sigma_v$) applied to the subgrade adjacent to the collection sump was calculated for semi-finite embankment loading conditions using influence factors originally presented by Jurgenson (1934). The change in vertical stress was assumed to increase/decrease linearly with depth.
8) **Primary Settlement** (1) If $\sigma_{vo}' = \sigma_p'$, then $S = C_{ce} * Ho(\log10((\sigma_{vo}' + \Delta\sigma_v)/\sigma_{vo}'))$; (2) If $\sigma_{vo}' + \Delta\sigma_v < \sigma_p'$, then $S = C_{re} * H_o(\log10((\sigma_{vo}' + \Delta\sigma_v)/\sigma_{vo}'))$; or (3) If $\sigma_{vo}' < \sigma_p' < \sigma_{vo}' + \Delta\sigma_v$, then $S = C_{re} * H_o(\log10(\sigma_p'/\sigma_{vo}')) + C_{ce} * H_o(\log10((\sigma_{vo}' + \Delta\sigma_v)/\sigma_p'))$
9) **Secondary Settlement** = $(C_\alpha/(1+e_o)) * H_o(\log10\Delta t)$. Assume $C_\alpha = 0.05 * C_c$, $\Delta t = 50$ yrs

Settlement at Maximum Height of Refuse

(Soil Profile - 150' deep, Unit Weight of Refuse - 70 pcf)

Depth below Surface (ft)	Depth below Water Table (ft)	Material Type	USCS Symbol	Unit Weight (pcf)	σ_{vo}' (psf)	C_c	C_{ce}	C_r	Cr_e	C_α	Max. Past Preconsolidation Pressure, σ_p' (psf)	Initial Void Ratio, e_o	Vertical Stress Due to Load, $\Delta\sigma_v$ (psf)	Primary Settlement (in.)	Secondary Settlement (in.)	Total Settlement (in.)	Total Settlement (ft.)
1	0	Sandy Clay	CL	120	120.0	0.160	0.099	0.030	0.019	0.008	504	0.620	13392.0	3.663	0.101	3.763	0.314
3	0			120	360.0	0.160	0.099	0.030	0.019	0.008	1493	0.620	13382.5	2.560	0.101	2.661	0.222
5	1			125	547.6	0.160	0.099	0.030	0.019	0.008	2241	0.620	13373.0	2.152	0.101	2.253	0.188
7	3			125	672.8	0.160	0.099	0.030	0.019	0.008	2717	0.620	13363.5	1.960	0.101	2.061	0.172
9	5	Silty Clay	CL	125	798.0	0.160	0.099	0.030	0.019	0.008	3179	0.620	13353.9	1.804	0.101	1.905	0.159
11	7			125	923.2	0.160	0.099	0.030	0.019	0.008	3628	0.620	13344.4	1.674	0.101	1.774	0.148
13	9			125	1048.4	0.160	0.099	0.030	0.019	0.008	4064	0.620	13334.9	1.563	0.101	1.663	0.139
15	11			125	1173.6	0.160	0.099	0.030	0.019	0.008	4485	0.620	13325.4	1.467	0.101	1.567	0.131
17	13	Clayey Sand	SC	130	1308.8	0.050	0.034	0.000	0.000	0.003	4932	0.480	13315.9	0.383	0.034	0.417	0.035
19	15			130	1444.0	0.050	0.034	0.000	0.000	0.003	5363	0.480	13306.4	0.356	0.034	0.391	0.033
21	17			130	1579.2	0.050	0.034	0.000	0.000	0.003	5780	0.480	13296.9	0.333	0.034	0.367	0.031
23	19			130	1714.4	0.050	0.034	0.000	0.000	0.003	6182	0.480	13287.3	0.312	0.034	0.347	0.029
25	21	Silty Clay	CL	125	1839.6	0.190	0.121	0.020	0.013	0.0095	6534	0.570	13277.8	1.226	0.123	1.350	0.112
27	23			125	1964.8	0.190	0.121	0.020	0.013	0.0095	6562	0.570	13268.3	1.222	0.123	1.346	0.112
29	25			125	2090.0	0.190	0.121	0.020	0.013	0.0095	6542	0.570	13258.8	1.227	0.123	1.351	0.113
31	27			125	2215.2	0.190	0.121	0.020	0.013	0.0095	6468	0.570	13249.3	1.242	0.123	1.365	0.114
33	29			125	2340.4	0.190	0.121	0.020	0.013	0.0095	6342	0.570	13239.8	1.266	0.123	1.389	0.116
35	31			125	2465.6	0.190	0.121	0.020	0.013	0.0095	6164	0.570	13230.3	1.301	0.123	1.424	0.119
37	33			125	2590.8	0.190	0.121	0.020	0.013	0.0095	5933	0.570	13220.7	1.346	0.123	1.470	0.122
39	35			125	2716.0	0.190	0.121	0.020	0.013	0.0095	5649	0.570	13211.2	1.405	0.123	1.528	0.127
41	37			125	2841.2	0.190	0.121	0.020	0.013	0.0095	5313	0.570	13201.7	1.477	0.123	1.600	0.133
43	39			125	2966.4	0.190	0.121	0.020	0.013	0.0095	4924	0.570	13192.2	1.566	0.123	1.690	0.141
45	41			125	3091.6	0.190	0.121	0.020	0.013	0.0095	4483	0.570	13182.7	1.676	0.123	1.799	0.150
47	43			125	3216.8	0.190	0.121	0.020	0.013	0.0095	3989	0.570	13173.2	1.811	0.123	1.934	0.161
49	45			125	3342.0	0.190	0.121	0.020	0.013	0.0095	3843	0.570	13163.7	1.857	0.123	1.980	0.165
51	47	Sandy Clay	CL	125	3467.2	0.190	0.121	0.020	0.013	0.0095	3467	0.570	13154.2	1.977	0.123	2.100	0.175
53	49			125	3592.4	0.190	0.121	0.020	0.013	0.0095	3592	0.570	13144.6	1.941	0.123	2.064	0.172
55	51			125	3717.6	0.190	0.121	0.020	0.013	0.0095	3718	0.570	13135.1	1.907	0.123	2.030	0.169
57	53			125	3842.8	0.190	0.121	0.020	0.013	0.0095	3843	0.570	13125.6	1.873	0.123	1.997	0.166
59	55			125	3968.0	0.190	0.121	0.020	0.013	0.0095	3968	0.570	13116.1	1.841	0.123	1.965	0.164
61	57			125	4093.2	0.190	0.121	0.020	0.013	0.0095	4093	0.570	13106.6	1.811	0.123	1.934	0.161
63	59			125	4218.4	0.190	0.121	0.020	0.013	0.0095	4218	0.570	13097.1	1.781	0.123	1.905	0.159
65	61			125	4343.6	0.190	0.121	0.020	0.013	0.0095	4344	0.570	13087.6	1.753	0.123	1.876	0.156
67	63			125	4468.8	0.190	0.197	0.020	0.018	0.0095	4469	0.570	13078.0	2.808	0.123	2.932	0.244
69	65	Clay	CL	125	4594.0	0.190	0.121	0.020	0.013	0.0095	4594	0.570	13068.5	1.699	0.123	1.822	0.152
71	67			125	4719.2	0.190	0.121	0.020	0.013	0.0095	4719	0.570	13059.0	1.673	0.123	1.796	0.150
73	69			125	4844.4	0.190	0.121	0.020	0.013	0.0095	4844	0.670	13049.5	1.648	0.123	1.772	0.148
75	71			125	4969.6	0.190	0.121	0.020	0.013	0.0095	4970	0.570	13040.0	1.624	0.123	1.747	0.146
77	73			125	5094.8	0.190	0.121	0.020	0.013	0.0095	5095	0.570	13030.5	1.601	0.123	1.724	0.144
79	75			125	5220.0	0.190	0.121	0.020	0.013	0.0095	5220	0.570	13021.0	1.578	0.123	1.702	0.142
81	77			125	5345.2	0.190	0.121	0.020	0.013	0.0095	5345	0.570	13011.4	1.556	0.123	1.680	0.140
83	79			125	5470.4	0.190	0.121	0.020	0.013	0.0095	5470	0.570	13001.9	1.535	0.123	1.658	0.138
85	81	Clayey Sand	SC	132	5609.6	0.050	0.034	0.000	0.000	0.003	5610	0.450	12992.4	0.431	0.035	0.466	0.039
87	83			132	5748.8	0.050	0.034	0.000	0.000	0.003	5749	0.450	12982.9	0.425	0.035	0.460	0.038
89	85			132	5888.0	0.050	0.034	0.000	0.000	0.003	5888	0.450	12973.4	0.418	0.035	0.454	0.038
91	87			132	6027.2	0.050	0.034	0.000	0.000	0.003	6027	0.450	12963.9	0.412	0.035	0.448	0.037
93	89			132	6166.4	0.050	0.034	0.000	0.000	0.003	6166	0.450	12954.4	0.407	0.035	0.442	0.037
95	91			132	6305.6	0.050	0.034	0.000	0.000	0.003	6306	0.450	12944.8	0.401	0.035	0.436	0.036
97	93	Clay	CL	128	6436.8	0.140	0.090	0.015	0.010	0.0070	6437	0.560	12935.3	1.031	0.091	1.122	0.094
99	95			128	6568.0	0.140	0.090	0.015	0.010	0.0070	6568	0.560	12925.8	1.018	0.091	1.109	0.092
101	97			128	6699.2	0.140	0.090	0.015	0.010	0.0070	6699	0.560	12916.3	1.005	0.091	1.096	0.091
103	99			128	6830.4	0.140	0.090	0.015	0.010	0.0070	6830	0.560	12906.8	0.993	0.091	1.084	0.090
105	101			128	6961.6	0.140	0.090	0.015	0.010	0.0070	6962	0.560	12897.3	0.981	0.091	1.072	0.089
107	103			128	7092.8	0.140	0.090	0.015	0.010	0.0070	7093	0.560	12887.8	0.969	0.091	1.060	0.088
109	105			128	7224.0	0.140	0.090	0.015	0.010	0.0070	7224	0.560	12878.2	0.957	0.091	1.049	0.087
111	107			128	7355.2	0.140	0.090	0.015	0.010	0.0070	7355	0.560	12868.7	0.946	0.091	1.038	0.086
113	109			128	7486.4	0.140	0.090	0.015	0.010	0.0070	7486	0.560	12859.2	0.935	0.091	1.027	0.086
115	111	Clayey Sand	SC	135	7631.6	0.035	0.025	0.000	0.000	0.0018	7632	0.420	12849.7	0.254	0.025	0.279	0.023
117	113			135	7776.8	0.035	0.025	0.000	0.000	0.0018	7777	0.420	12840.2	0.250	0.025	0.276	0.023
119	115			135	7922.0	0.035	0.025	0.000	0.000	0.0018	7922	0.420	12830.7	0.247	0.025	0.273	0.023
121	117	Clay	CL	129	8055.2	0.110	0.071	0.013	0.008	0.0055	8055	0.550	12821.2	0.704	0.072	0.777	0.065
123	119			129	8188.4	0.110	0.071	0.013	0.008	0.0055	8188	0.550	12811.6	0.697	0.072	0.769	0.064
125	121			129	8321.6	0.110	0.071	0.013	0.008	0.0055	8322	0.550	12802.1	0.689	0.072	0.761	0.063
127	123			129	8454.8	0.110	0.071	0.013	0.008	0.0055	8455	0.550	12792.6	0.682	0.072	0.754	0.063
129	125			129	8588.0	0.110	0.071	0.013	0.008	0.0055	8588	0.550	12783.1	0.674	0.072	0.747	0.062
131	127			129	8721.2	0.110	0.071	0.013	0.008	0.0055	8721	0.550	12773.6	0.667	0.072	0.740	0.062
133	129			129	8854.4	0.110	0.071	0.013	0.008	0.0055	8854	0.550	12764.1	0.660	0.072	0.733	0.061
135	131	Clayey Sand	SC	137	9003.6	0.020	0.014	0.000	0.000	0.0010	9004	0.380	12754.6	0.133	0.015	0.148	0.012
137	133			137	9152.8	0.020	0.014	0.000	0.000	0.0010	9153	0.380	12745.0	0.132	0.015	0.147	0.012
139	135	Clay	CL	130	9288.0	0.090	0.059	0.009	0.006	0.0045	9288	0.530	12735.5	0.529	0.060	0.589	0.049
141	137			130	9423.2	0.090	0.059	0.009	0.006	0.0045	9423	0.530	12726.0	0.524	0.060	0.584	0.049
143	139			130	9558.4	0.090	0.059	0.009	0.006	0.0045	9558	0.530	12716.5	0.519	0.060	0.579	0.048
145	141			130	9693.6	0.090	0.059	0.009	0.006	0.0045	9694	0.530	12707.0	0.514	0.060	0.574	0.048
147	143			130	9828.8	0.090	0.059	0.009	0.006	0.0045	9829	0.530	12697.5	0.509	0.060	0.568	0.047
149	145			130	9964.0	0.090	0.059	0.009	0.006	0.0045	9964	0.530	12688.0	0.504	0.060	0.564	0.047
													TOTAL	87.671	6.649	94.321	7.860

**Assumptions made:

1) Effective vertical stress calculated for 2 ft. increments at the center of mass
2) Unit weights listed are assumed typical values
3) Settlement parameters used are based on values reported by EMCON & Golder and engineering judgement
4) Based on consolidation tests performed by EMCON and Golder, the native soils within the upper 50 feet are overconsolidated. OCRs ranging from 4.2 to 1.2 have been assigned to the soils within the upper 50 feet for estimation of the maximum past preconsolidation pressures used in the settlement analysis. Below a depth of 50 feet, the soils are assumed to be normally consolidated. This assumption underestimates σp', and therefore overestimates the calculated settlements.
5) Groundwater was assumed to be at a depth of 4 feet below subgrade
6) For settlement calculations, Ho = 2ft.
7) The vertical stress ($\Delta\sigma_v$) applied to the subgrade due to the load of the refuse is (186 ft)(70 pcf)+(7.6 ft)(120 pcf) = 13,932 psf. The change in vertical stress with depth was calculated for semi-finite embankment loading conditions using influence factors originally presented by Jurgenson (1934). The change in vertical stress was assumed to increase/decrease linearly with depth.
8) **Primary Settlement** (1) If $\sigma_{vo}' = \sigma_p'$, then $S = C_{ce}*Ho(\log10((\sigma_{vo}' + \Delta\sigma_v)/\sigma_{vo}'))$; (2) If $\sigma_{vo}' + \Delta\sigma_v < \sigma_p'$, then $S = C_{re}*H_o(\log10((\sigma_{vo}'+\Delta\sigma_v)/\sigma_{vo}'))$; or (3) If $\sigma_{vo}' < \sigma_p' < \sigma_{vo}' + \Delta\sigma_v$, then $S = C_{re}*H_o(\log10(\sigma_p'/\sigma_{vo}')) + C_{ce}*H_o(\log10((\sigma_{vo}'+\Delta\sigma_v)/\sigma_p'))$
9) **Secondary Settlement** = $(C_\alpha/(1+e_o))*H_o(\log10\Delta t)$. Assume $C_\alpha = 0.05*C_c$, Δt = 50 yrs

Golder Associates	SUBJECT Pipe Flow Capacity		
	Job No. 033-7359 Ref.	Made by KGA Checked WRC Reviewed	Date 12/2/03 Sheet 1 of 2

Check Pipe Flow Capacity after Settlement

Using Manning's equation:

$$Q_{pipe} = \frac{1.49}{n} * A * \left(\frac{A}{P}\right)^{2/3} * S^{1/2}$$

n = roughness coefficient ~ 0.01 for PE pipes (smooth wall)
A = Flow Area
P = hydraulic radius
S = slope

From attached chart, a 4" I.D. pipe @ 0.24% slope has a maximum flow capacity of 0.12 cfs (Note: a 4" HDPE pipe has a slightly smaller I.D.)

Operational leachate generation rates are expected to be about 29 gallons/Acre/day (Golder 2003 - Liner Performance Demonstration Report). For a typical 14 Acre Cell/drainage Area serviced by a single LCRS line, the max. anticipated flow is:

$$Q_{leachate} = 15\,AC * 29\,\frac{gallons}{AC}/day$$

$$= 435 \text{ gallons/day} = 0.3 \text{ gpm}$$

$$= 58.1 \text{ cf/day}$$

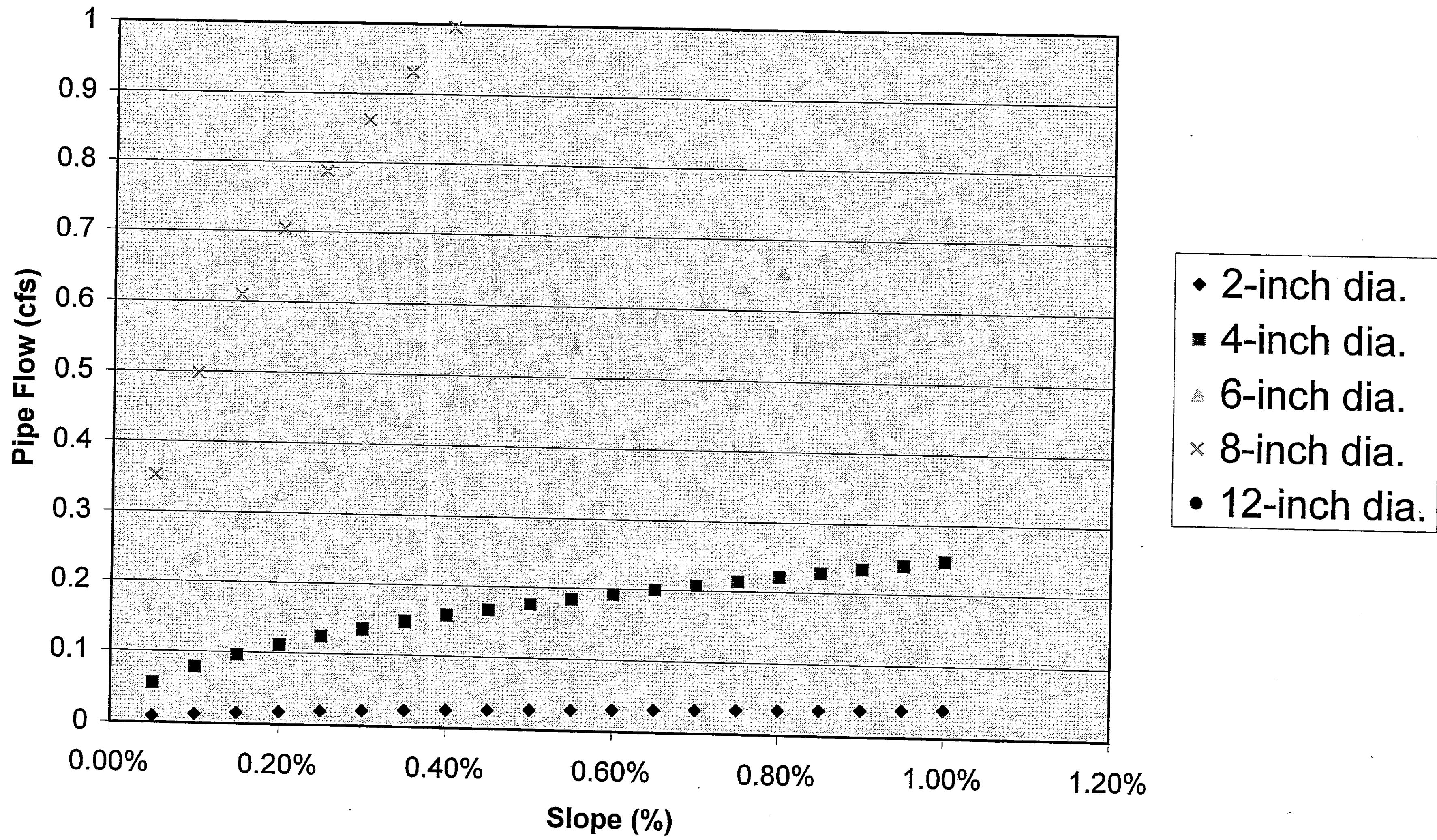
$$= 0.00067 \text{ cfs}$$

Thus $FS = \frac{Q_{pipe}}{Q_{leachate}} = \frac{0.12 \text{ cfs}}{0.00067 \text{ cfs}} = 179$

∴ FS is far greater than the regulatory min. of 2

p. 2/2 ✓

HDPE PIPE FLOW CAPACITY



Subject: Leachate Collection Pipe Structural Integrity - HRL		
Job No.: 033-7359 Ref:	Made by: KH Checked: WRC	Date: Oct. 2003 Sheet: 1 of 7

OBJECTIVE: To verify structural capacity of future 4", SDR HDPE LCRS pipe based on proposed fill grades.

APPROACH: The design method in the Driscopipe design manual is used to assess the structural stability of the leachate collection pipes with respect to wall crushing, wall buckling, and ring deflection. This methodology is also described in Sherma & Lewis (1994).

GIVEN:

Pipe Properties

SDR	11	or	15	or	17
OD =	4 in				
Allowable Long-term Stress (S_{allow}) =	1500 psi				
Perforations (No./row/ft) =	2				
Diam. Of Perforation =	0.25 in				
No. of rows	4				

Applied Loading

Depth of Cover =	185 ft	
Unit weight (γ) =	70 pcf	Using conservatively high unit weight for Hay Rd
External Pressure (P_t) =	12950 psf ✓	
=	90 psi ✓	

Backfill Material Properties

Type: Clean, rounded gravel
Relative Density = >70%
Soil Modulus = 5800 psi (from Table 1. Ref 2 and 3) ✓

REFERENCES:

(1) Driscopipe Systems Design, Phillips Driscopipe, 1996
(2) Guidelines for HDPE Pipes in Deep Fills, Plexco Pipe, Jan. 1998
(3) "Replacing E' with the Constrained Modulus in Flexible Pipe Design," published paper by Timothy J. McGrath, Principal, Simpson & Heger Inc., Consulting Engineers, 297 Broadway, Arlington, MA 02174

CALCULATIONS:

Design for Crushing

Wall stress in pipe must be less than allowable compressive stress(FS>1)

Wall stress in pipe (S) = $(SDR-1)*(P_t/2)$

Factor of Safety = S_{allow}/S

SDR	S (psi)	FS
11	449.65	3.3 ✓
15	629.51	2.4
17	719.44	2.1

Design for Wall Buckling

Wall stress in pipe must be less than critical buckling stress

Critical Collapse Pressure (P_{cr}) = $2.32*E/(SDR)^3$

Critical Buckling Pressure (P_{cb}) = $0.8*(E'*Pcr)$^0.5

Factor of Safety = P_{cb}/P_t

E = Long-term Young's Modulus

Typically, E is obtained from a chart in Ref 1. However, for high loading conditions this is overly conservative. As the pipe is compressed, the stress acting on the pipe reduces. Therefore, the manufacturer recommends using a minimum long-term modulus of 30,000 psi.

Assume E = 30,000 psi

SDR	P_{cr} (psi)	P_{cb} (psi)	FS
11	52.29 ✓	440.6 ✓	4.9 ✓
15	20.62 ✓	276.7 ✓	3.1
17	14.17 ✓	229.3 ✓	2.5

Design for Ring Deflection

Vertical ring strain of pipe must be less than allowable ring strain

Ring strain in Pipe (ε_w) = P_t/E'

Allow. Ring Strain (ε_a) = (0.25)(0.01)SDR x 100

Factor of Safety = $\varepsilon_a/\varepsilon_w$

SDR	e_w (%)	ε_a (%)	FS
11	1.55 ✓	2.75 ✓	1.8 ✓
15	1.55 ✓	3.75 ✓	2.4 ✓
17	1.55 ✓	4.25 ✓	2.7 ✓

Note: FS>1.0 acceptable

CONCLUSIONS: SDR 11 for 4-in dia. pipes acceptable and will perform well under the proposed loads.

Golder Associates	Subject: Leachate Collection Pipe Structural Integrity - HRL		
	Job No.: 033-7359 Ref:	Made by: KH Checked: WRC	Date: Oct. 2003 Sheet: 4 of 7

OBJECTIVE: To verify structural capacity of future 4", SDR HDPE LCRS pipe based on proposed fill grades.

APPROACH: The design method in the Driscopipe design manual is used to assess the structural stability of the leachate collection pipes with respect to wall crushing, wall buckling, and ring deflection. This methodology is also described in Sherma & Lewis (1994).

GIVEN:

Pipe Properties

SDR	15	or	17	or	21
OD =	4 in				
Allowable Long-term Stress (S_{allow}) =	1500 psi				
Perforations (No./row/ft) =	2				
Diam. Of Perforation =	0.25 in				
No. of rows	4				

Applied Loading

Depth of Cover =	180 ft	
Unit weight (γ) =	70 pcf	Using conservatively high unit weight for Hay Rd
External Pressure (P_t) =	12600 psf ✓	
=	88 psi ✓	

Backfill Material Properties

Type:	Clean, rounded gravel	
Relative Density =	>70%	
Soil Modulus =	5800 psi	(from Table 1. Ref 2 and 3)

REFERENCES:

(1) Driscopipe Systems Design, Phillips Driscopipe, 1996
(2) Guidelines for HDPE Pipes in Deep Fills, Plexco Pipe, Jan. 1998
(3) "Replacing E' with the Constrained Modulus in Flexible Pipe Design," published paper by Timothy J. McGrath, Principal, Simpson & Heger Inc., Consulting Engineers, 297 Broadway, Arlington, MA 02174

CALCULATIONS:

Design for Crushing

Wall stress in pipe must be less than allowable compressive stress(FS>1)

Wall stress in pipe (S) = (SDR-1)*(P_t/2)

Factor of Safety = S_{allow}/S

SDR	S (psi)	FS
15	612.50 ✓	2.4 ✓
17	700.00 ✓	2.1 ✓
21	875.00 ✓	1.7 ✓

Design for Wall Buckling

Wall stress in pipe must be less than critical buckling stress

Critical Collapse Pressure (P_{cr}) = 2.32*E/(SDR)^3

Critical Buckling Pressure (P_{cb}) = 0.8*(E'*Pcr)^0.5

Factor of Safety = P_{cb}/P_t

E = Long-term Young's Modulus

Typically, E is obtained from a chart in Ref 1. However, for high loading conditions this is overly conservative. As the pipe is compressed, the stress acting on the pipe reduces. Therefore, the manufacturer recommends using a minimum long-term modulus of 30,000 psi.

Assume E = 30,000 psi

SDR	P_{cr} (psi)	P_{cb} (psi)	FS
15	20.62	276.7	3.2 ✓
17	14.17	229.3	2.6 ✓
21	7.52	167.0	1.9 ✓

Subject: Leachate Collection Pipe Structural Integrity - HRL		
Job No.: 033-7359 Ref:	Made by: [illegible] Checked: [illegible]	Date: Oct. 2003 Sheet: 6 of 7

Design for Ring Deflection

Vertical ring strain of pipe must be less than allowable ring strain

Ring strain in Pipe (ε_w) = P_t/E'

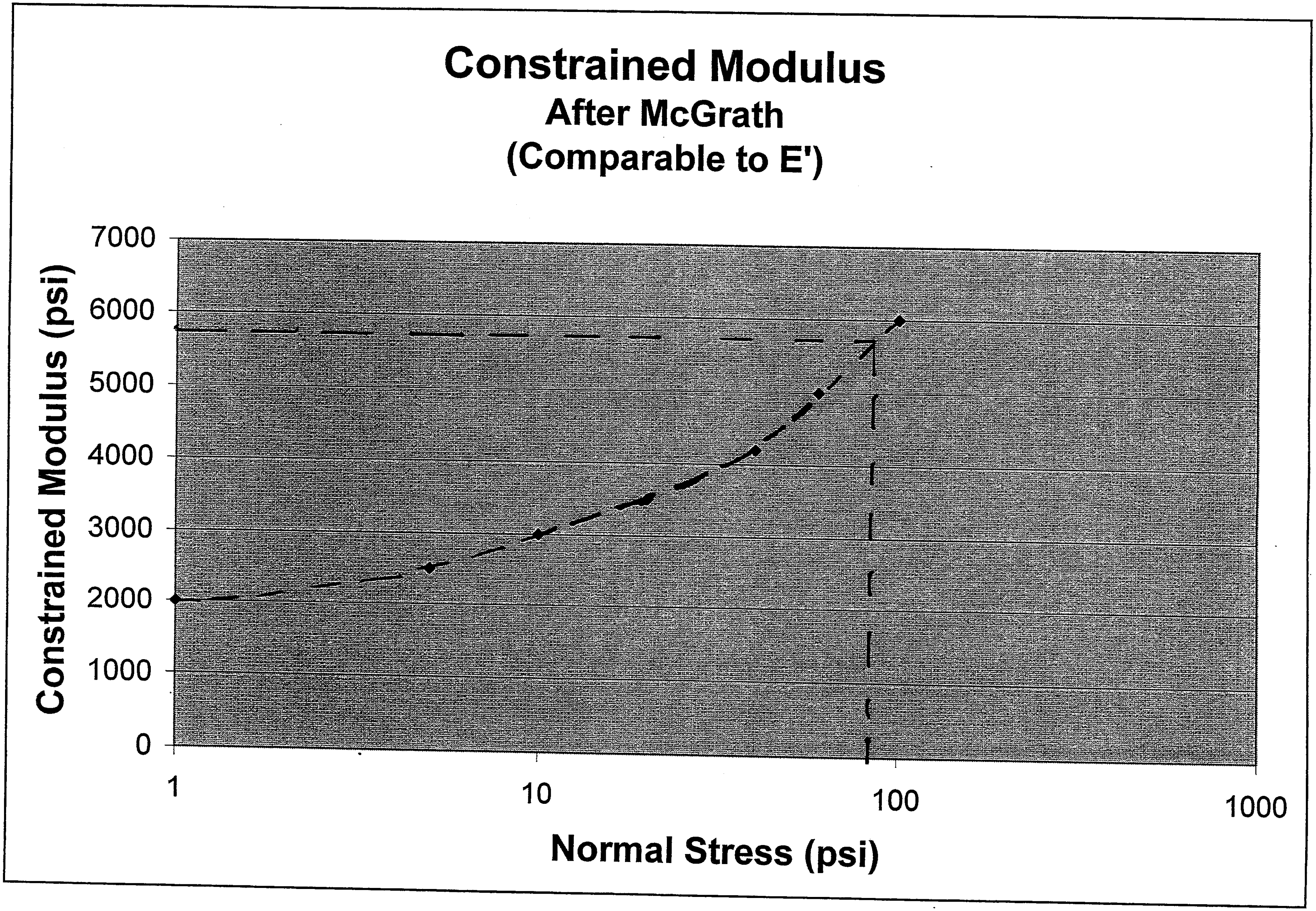
Allow. Ring Strain (ε_a) = (0.25)(0.01)SDR x 100

Factor of Safety = $\varepsilon_a/\varepsilon_w$

SDR	e_w (%)	ε_a (%)	FS
15	1.51 ✓	3.75 ✓	2.5 ✓
17	1.51 ✓	4.25 ✓	2.8 ✓
21	1.51 ✓	5.25 ✓	3.5 ✓

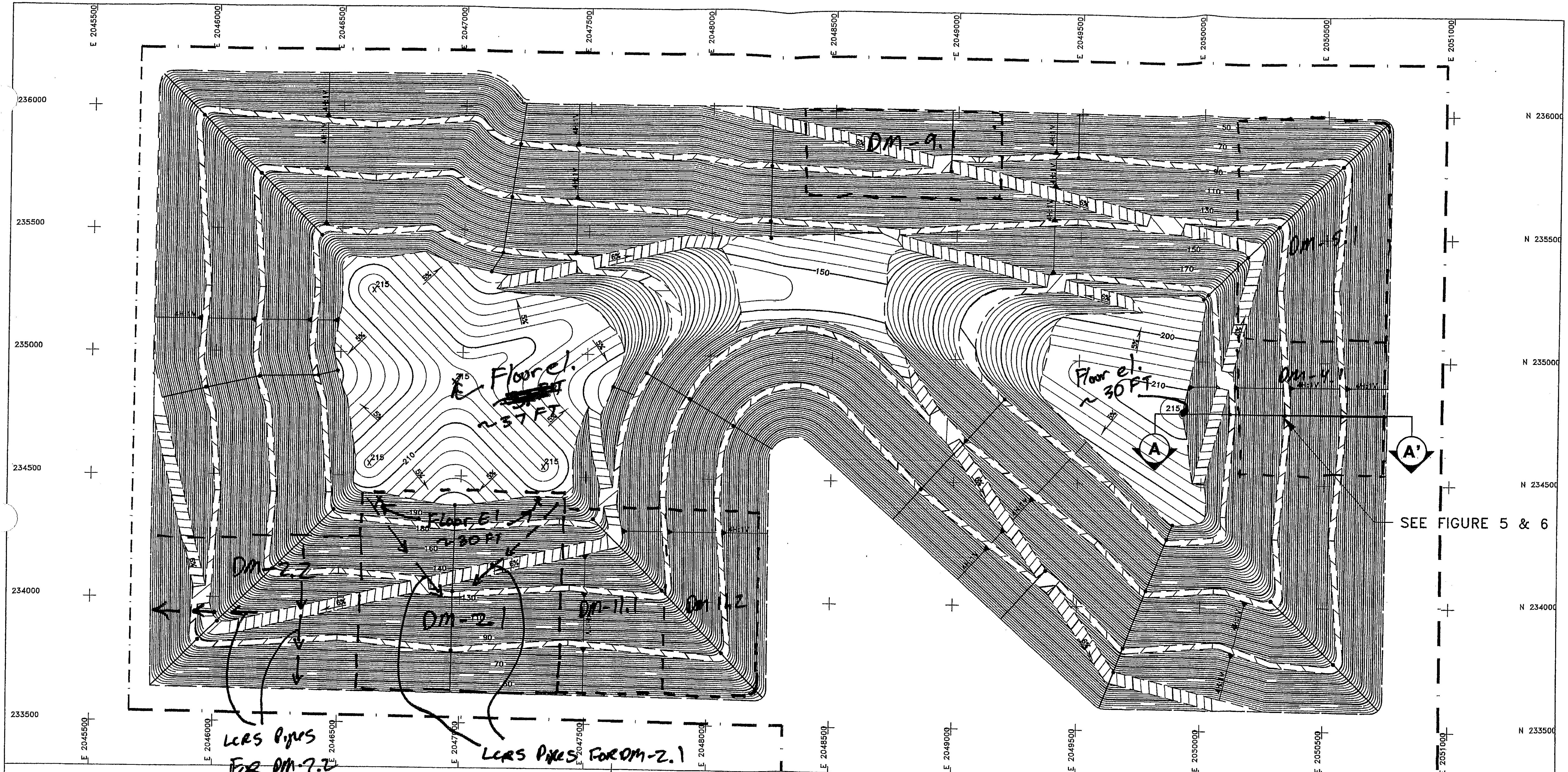
Note: FS>1.0 acceptable

CONCLUSIONS: SDR 15 to 21 will perform well for the proposed grading plan.



Constrained Modulus
After McGrath
(Comparable to E')
Constrained Modulus (psi)
7000
6000
5000
4000
3000
2000
1000
0
1
10
100
1000
Normal Stress (psi)

p.7/7



LEGEND:

(heavy dash-dot line)	PROPERTY LINE
(dash-dot line)	PARCEL LINE
(line with dots)	DOWNDRAIN WITH INLET-LOCATIONS
2H:1V	SLOPE INDICATOR
2%	GRADE INDICATOR

0 400 800
FEET

- Max. Waste Thickness ~~HT~~ - (215-30) = 185 FT Near/Along Section A-A'
- DM-2.2: Max. waste HT along/Above Pipe ~ 160 FT
- DM-2.1: Max. Waste HT along/Above pipe ~ 208 FT (say 210 FT)
Therefore Thickness ~ (210-30)FT = 180 FT

FIGURE **4**

OPTIMIZED CONCEPTUAL FINAL GRADING PLAN

NORCAL/NWSHRL COVER OPTIMIZATION/CA

DWG ID: jraub | N:\Projects\033-7359 (Norcal - Hay Road Vertical Expansion)\Figures\Fig 3 - June 02 Concept Final.dwg | 10-23-3 10:57 | xrf: NONE

Golder Associates

Appendix E

Slope Stability Calculations

SLOPE STABILITY SUMMARY SHEET
(AS REQUESTED BY SOLANO COUNTY)

OBJECTIVE: The overall objective of the slope stability analyses is to demonstrate that the proposed final grading plan with a maximum elevation of 215 feet msl complies with the requirements of Title 27. To demonstrate compliance with Title 27, a static Factor of Safety of 1.5 or greater is required. In addition, seismically-induced slope movements must be sufficiently small that critical environmental controls are not adversely damaged. The current state of the practice in California is to limit seismically-induced to 12-inches or less to ensure that critical landfill controls are not adversely damaged.

METHODS AND ASSUMPTIONS: The methods and key assumptions are discussed in the first page of the calculation package and in the text of the Preliminary Closure and Postclosure Maintenance Plan (PCPMP).

FAILURE MODES EVALUATED: The attached calculations address potential failure through the foundation soils and potential slippage along the liner system.

RESULTS AND CONCLUSIONS: Using conservative assumptions, the potential failure mode through the foundation soils has a static FS > 2.0 and seismically induced slope movements are less than 1-inch. It is also noted that this is not the critical failure mode because potential slippage along the liner system had lower factors of safety. The static FS for slippage along the liner was 1.53 or greater. The maximum computed seismically induced slope movement was 2.6 inches.

These values meet or exceed the criteria established to demonstrate compliance with Title 27. Furthermore, as discussed with Solano County, it is noted that the leachate lines are oriented perpendicular to the perimeter of the landfill, and therefore, the leachate lines would be subject to tension and/or compression loads, which is a more favorable loading condition than shear loads. Therefore, the computed seismically induced slope movements will not adversely damage the leachate collection lines, liner system, or other environmental controls.

COMPARISON TO PREVIOUS COVER GRADING PLAN:

The previous cover grading plan with a maximum elevation of 165 feet msl had a minimum static FS of 1.62 with seismically induced movements of approximately 5-inches. The new cover has a slightly reduced static FS of 1.53 and lower seismically induced movements of less than 3-inches. The reduced seismically induced movements is attributed the higher attenuation of seismic ground accelerations that often occurs in thicker refuse masses.

SUBJECT – Hay Road Vertical Expansion		
Job No. 033-7359	Made by WRC Checked [signature] Reviewed by [signature]	Date 4 Nov 03 Sheet 1/1

Objective: Perform slope stability calculations required for the Hay Road Vertical Expansion design. Slope conditions for foundation slope stability and refuse slope stability were analyzed in order to verify the stability of the grading plan associated with the expansion. Both static and seismic stability runs were performed resulting in static factors of safety and permanent displacements respectively for the different slope conditions analyzed.

Methodology: A minimum static factor of safety equal to 1.5 is the design criteria specified by CCR Title 27 for Class II landfills. Permanent displacements of less than 12-inches are the accepted maximum value for liner systems in the State of California. These design criteria were used to verify that the slope conditions as a result of the vertical expansion would be acceptable.

The computer software package SLIDE (v. 3.047) was used to perform stability calculations. Global factors of safety were calculated using Bishop's Simplified Method and block type failures associated with the refuse mass were calculated using Spencer's Method.

Effective stress conditions were accessed for foundation slope stability. Drained shear strength was characterized by an internal friction angle of 32 degrees with no cohesion (Emcon, 1993).

For refuse slope stability, the critical liner component interface was assumed to have an internal friction angle of 9 degrees with no cohesion (Geosyntec 1995). The refuse mass was assigned a unit weight of 70 pcf based on waste density calculations performed by Golder and an internal friction angle of 30 degrees with 200 psf cohesion, which is in the range of values developed by Singh and Murphy (1990) and Kavazanjian (1995).

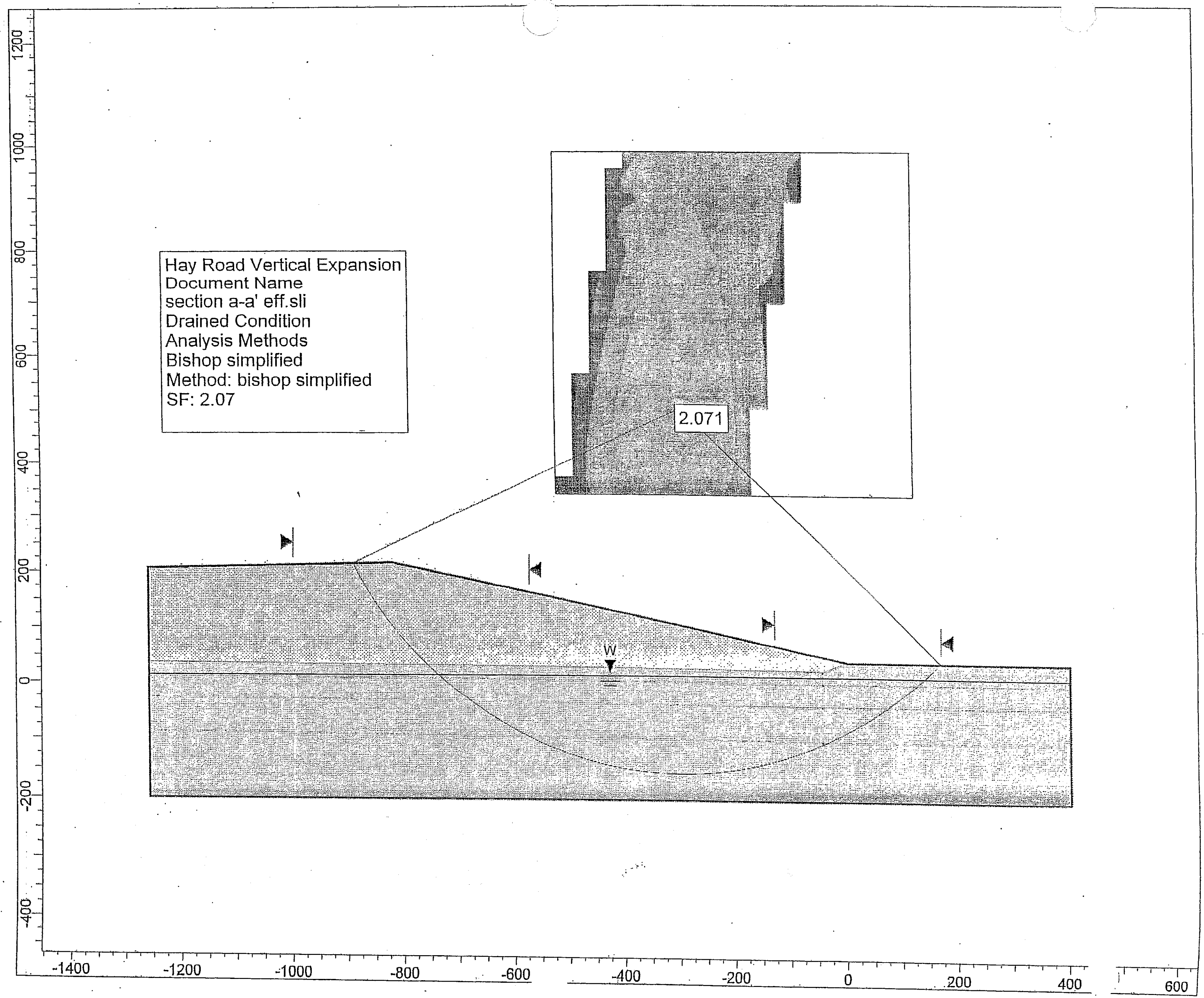
Permanent displacements resulting from pseudo-static seismic stability calculations were estimated using the simplified method developed by Bray et. al. (1998). A series of seismic charts presented in Bray et. al. (1998) was used to calculate the permanent displacements for each condition analyzed (See Attachment 2).

The design earthquake, maximum credible earthquake (MCE), results from a blind thrust fault along the Central Valley Coastal Range (Geosyntec, 1995). The hypocentral distance is 13 km with a moment magnitude (Mw) of 7.0 and a peak bedrock acceleration of 0.35g.

Solution: Slope stability calculations were performed on two sections, Sections A-A' and B-B' (See Figure 4). Foundation or global stability was verified for both sections using drained shear strength parameters. Refuse slope stability was examined for both sections. Included in this package are the SLIDE outputs for static and pseudo-static slope stability.

Results: Minimum static factor of safety were calculated for foundation slope stability, and for refuse slope stability on sections A-A' and B-B'. All static factors of safety were equal to or greater than the required value of 1.5. The maximum permanent displacement calculated for the various sections was approximately 3-inches, which is below the maximum accepted value of 12-inches.

Conclusions: The results of this calculations package verify that the slope configurations for the vertical expansion at Hay Road comply with CCR Title 27 and accepted practices in the State of California for slope stability.


Hay Road Vertical Expansion
Document Name
section a-a' eff.sli
Drained Condition
Analysis Methods
Bishop simplified
Method: bishop simplified
SF: 2.07
2.071
W
1200
1000
800
600
400
200
0
-200
-400
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600

Slide Analysis Information

Document Name

section a-a' eff.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Water Pressure Type: Water Surfaces
Data Output: Standard

Analysis Methods

Analysis Methods used:
Ordinary
Bishop simplified
Janbu simplified
Janbu corrected

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Radius increment: 10
Minimum Elevation: Not Defined
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack

Loading

Seismic Load Coefficient (Horizontal): 0.06
Seismic Load Coefficient (Vertical): 0

Material Properties

Material: Refuse
Strength Type: Mohr-Coulomb
Unit Weight: 70 lb/ft3
Cohesion: 200 psf
Friction Angle: 30 degrees
Water Surface: None
Hu value: 1

Material: Liner
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 13 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Hu value: 1

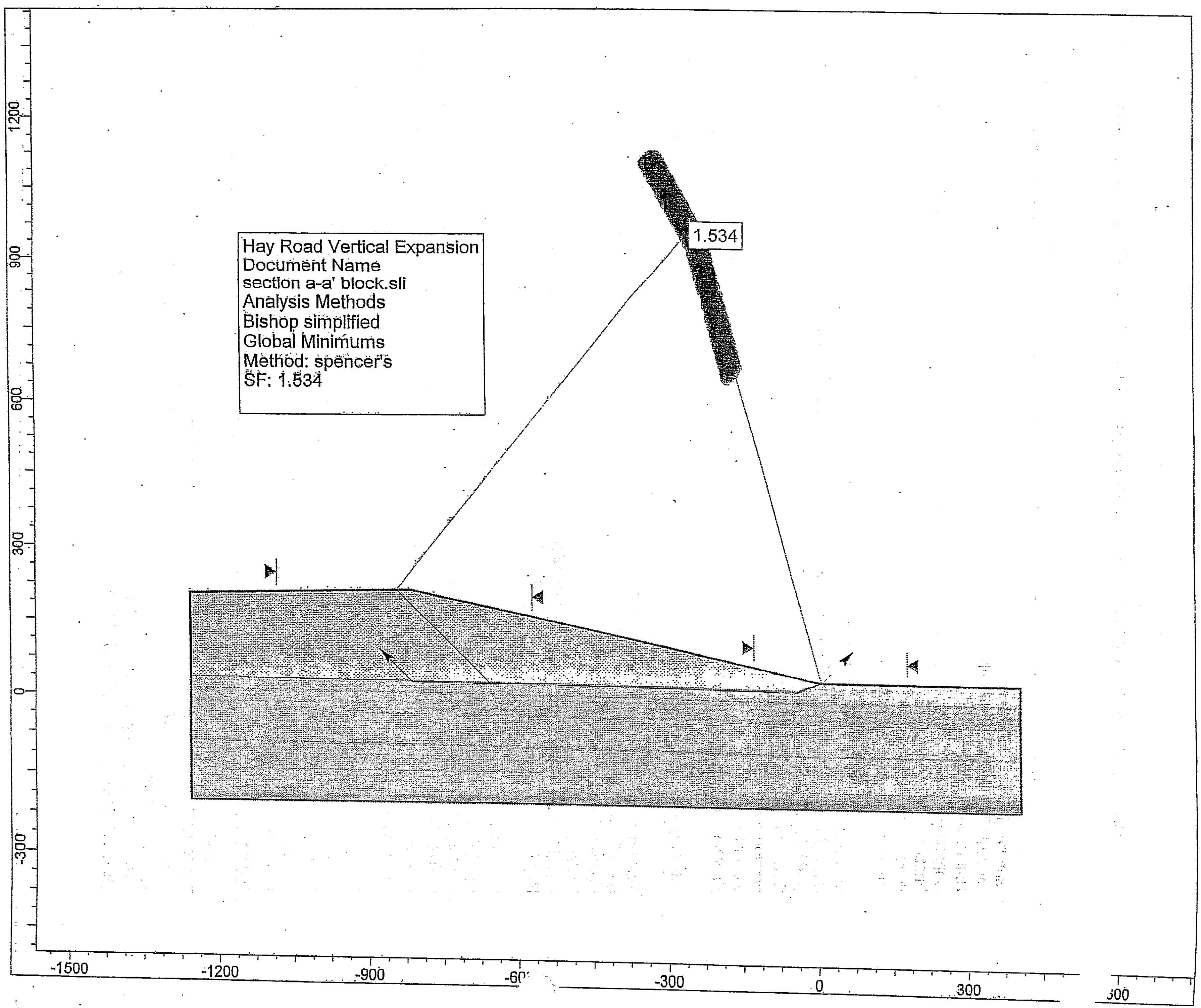
Global Minimums

Method: ordinary
SF: 1.31022
Center: -268.643, 341.086
Radius: 529.477
Left Slip Surface Endpoint: -780.593, 205.983
Right Slip Surface Endpoint: 166.895, 40

Method: bishop simplified
SF: 2.07093
Center: -300.86, 502.172
Radius: 657.569
Left Slip Surface Endpoint: -891.643, 213.429
Right Slip Surface Endpoint: 166.895, 40

Method: janbu simplified
SF: 1.76501
Center: -300.86, 405.52
Radius: 593.633
Left Slip Surface Endpoint: -862.78, 214.09
Right Slip Surface Endpoint: 166.895, 40

Method: janbu corrected
SF: 1.91828
Center: -300.86, 405.52
Radius: 593.633
Left Slip Surface Endpoint: -862.78, 214.09
Right Slip Surface Endpoint: 166.895, 40


Hay Road Vertical Expansion
Document Name
section a-a' block.sli
Analysis Methods
Bishop simplified
Global Minimums
Method: spencer's
SF: 1.534
1.534
1200
900
600
300
0
-300
-1500
-1200
-900
-300
0
300

Slide Analysis Information

Document Name

section a-a' block.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Water Pressure Type: Water Surfaces
Data Output: Standard

Analysis Methods

Analysis Methods used:
Ordinary
Bishop simplified
Janbu simplified
Spencer
Janbu corrected

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 1000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 135
Left Projection Angle (End Angle): 135
Right Projection Angle (Start Angle): 45
Right Projection Angle (End Angle): 45

Loading

Seismic Load Coefficient (Horizontal): 0
Seismic Load Coefficient (Vertical): 0

Material Properties

Material: Refuse
Strength Type: Mohr-Coulomb
Unit Weight: 70 lb/ft3

Cohesion: 200 psf
Friction Angle: 30 degrees
Water Surface: None
Hu value: 1

Material: Liner
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 9 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1500 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-2
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1400 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-3
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 2100 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-4
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 3000 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Global Minimums

Method: ordinary
SF: 1.45418
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423

Right Slip Surface Endpoint: 0.922535, 40

Method: bishop simplified
SF: 1.50322
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method: janbu simplified
SF: 1.45346
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method: spencer
SF: 1.53371
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method: janbu corrected
SF: 1.54644
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method Statistics

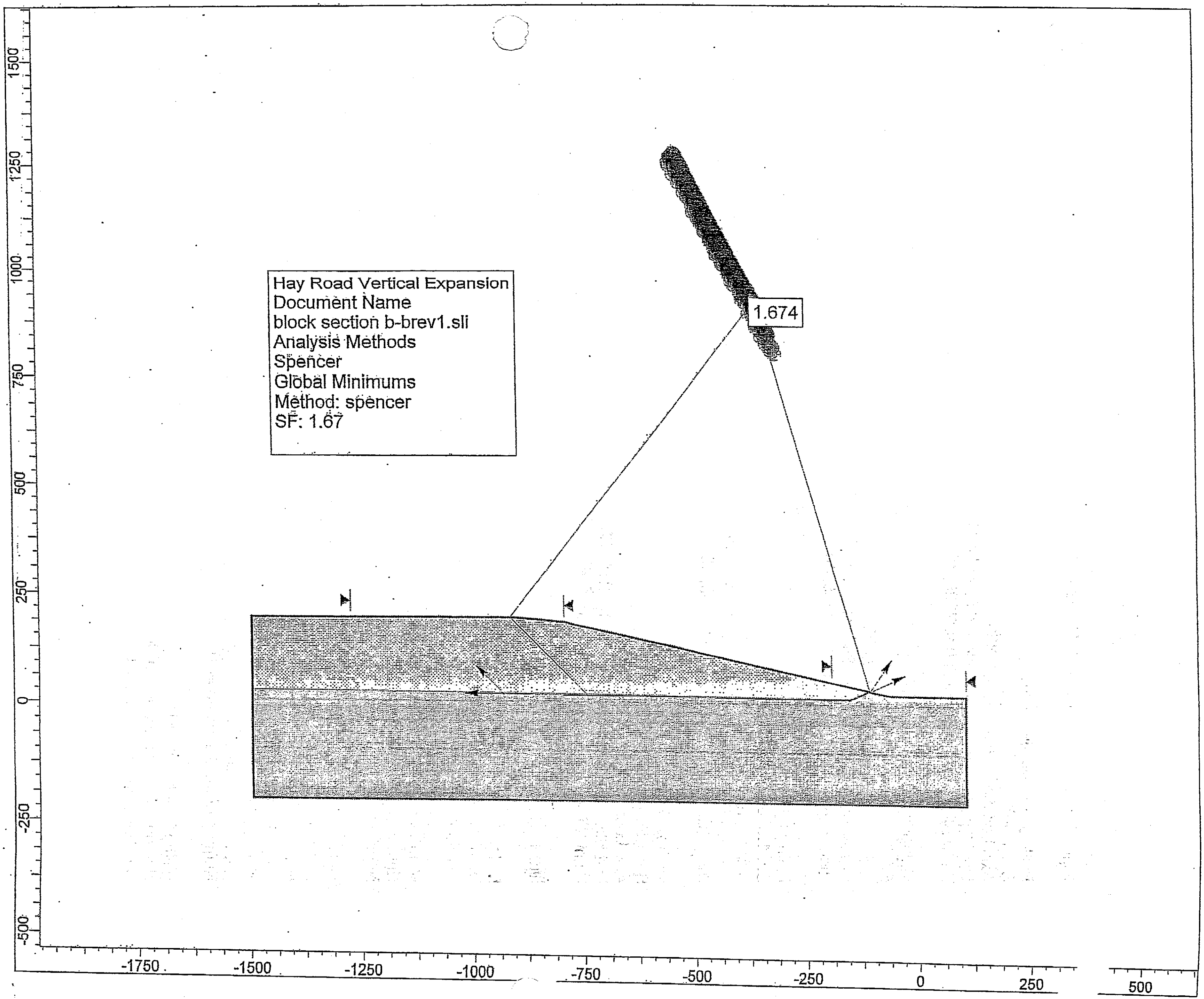
Method: ordinary
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: bishop simplified
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: janbu simplified
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: spencer
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: janbu corrected
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0


Hay Road Vertical Expansion
Document Name
block section b-brev1.sli
Analysis Methods
Spencer
Global Minimums
Method: spencer
SF: 1.67
1.674
1500
1250
1000
750
500
250
0
-250
-500
-1750
-1500
-1250
-1000
-750
-500
-250
0
250
500

Slide Analysis Information

Document Name

block section b-brev1.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Water Pressure Type: Water Surfaces
Data Output: Standard

Analysis Methods

Analysis Methods used:
Ordinary
Bishop simplified
Janbu simplified
Spencer
Janbu corrected

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 1000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 135
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): 25
Right Projection Angle (End Angle): 55

Loading

Seismic Load Coefficient (Horizontal): 0
Seismic Load Coefficient (Vertical): 0

Material Properties

Material: Refuse
Strength Type: Mohr-Coulomb
Unit Weight: 70 lb/ft3

Cohesion: 200 psf
Friction Angle: 30 degrees
Water Surface: None
Hu value: 1

Material: Liner
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 9 degrees
Water Surface: None
Hu value: 1

Material: Subsurface 1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1500 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface 2
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1400 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: subsurface 3
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 2100 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface 4
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 3000 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Global Minimums

Method: ordinary
SF: 1.52364
Axis Location: -356.269, 872.602
Left Slip Surface Endpoint: -883.557, 192.376

Right Slip Surface Endpoint: -128.461, 42.6353

Method: bishop simplified
SF: 1.6252
Axis Location: -356.269, 872.602
Left Slip Surface Endpoint: -883.557, 192.376
Right Slip Surface Endpoint: -128.461, 42.6353

Method: janbu simplified
SF: 1.57239
Axis Location: -356.269, 872.602
Left Slip Surface Endpoint: -883.557, 192.376
Right Slip Surface Endpoint: -128.461, 42.6353

Method: spencer
SF: 1.67418
Axis Location: -364.282, 921.839
Left Slip Surface Endpoint: -921.198, 195
Right Slip Surface Endpoint: -116.96, 40.2031

Method: janbu corrected
SF: 1.67418
Axis Location: -356.269, 872.602
Left Slip Surface Endpoint: -883.557, 192.376
Right Slip Surface Endpoint: -128.461, 42.6353

Method Statistics

Method: ordinary
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: bishop simplified
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: janbu simplified
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: spencer
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: janbu corrected
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Simplified Seismic Design Procedure

Bray, Rathje, Augello, Merry, 1998

Application:	Foundation Slope Stability: Effective Stress Analysis
Project:	Hay Road Vertical Expansion
Section:	A-A'
Date:	11/3/2003

Potential Failure through Foundation Soil

Design EQ Event

Mag. =	7
Ep. Distance =	10 km
MHA =	0.35 g
Waste Depth =	29 m (average)
Ky =	0.3

Determine:

Tm =	0.53 s
D5-95 =	14 s
NRF =	1.045

Calc:

Sh =	230 m/s
Ts =	0.504
Ts/Tm =	0.952

Determine:

MHEA/MHA/NRF =	0.55

Calculate:

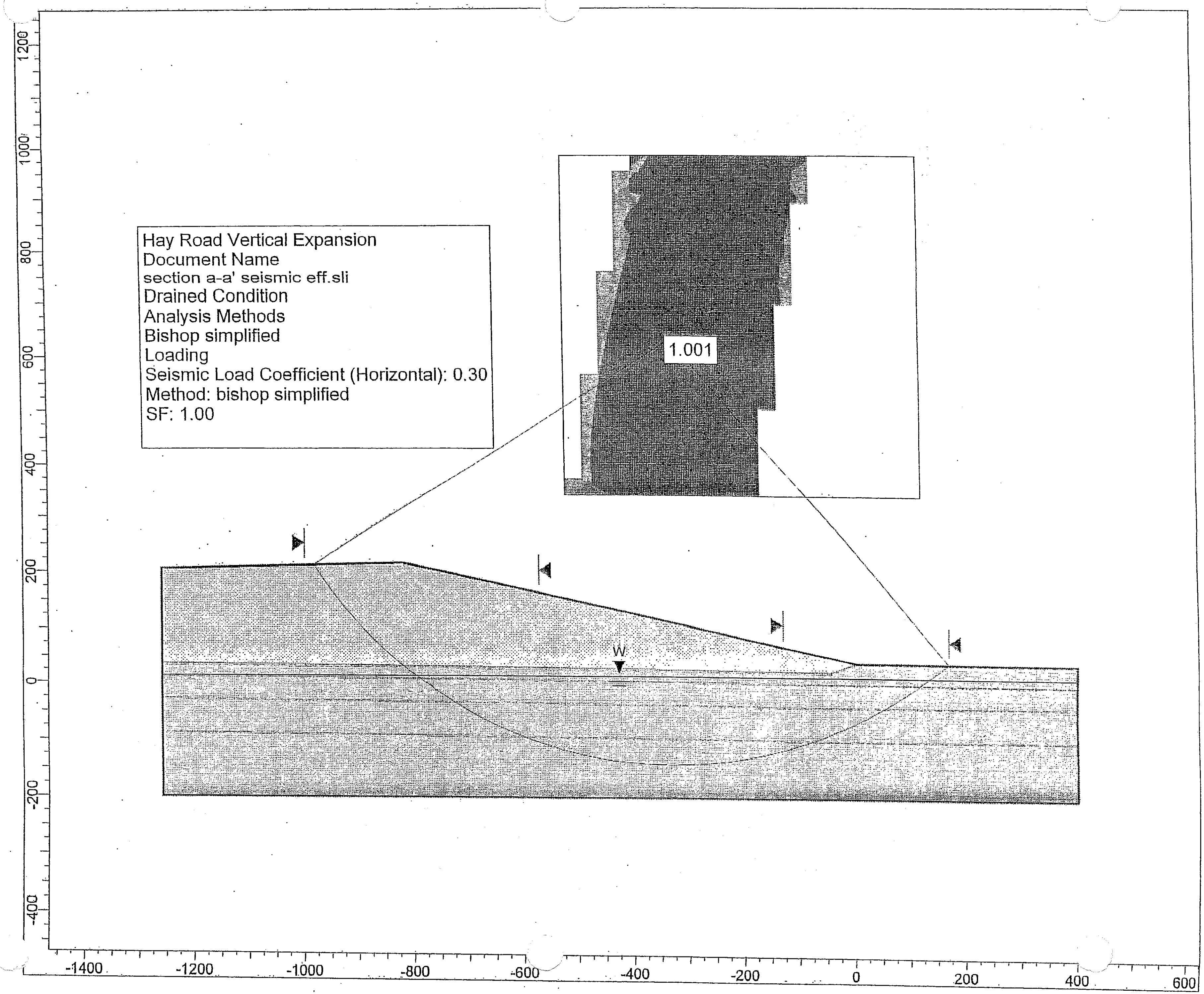
MHEA =	0.201163
ky/MHEA =	1.491332

Determine

U/MHA/D5-95 =	1 mm/s

Calculate:

Displacement =	2.8 mm
=	0.1 in.



Hay Road Vertical Expansion
Document Name
section a-a' seismic eff.sli
Drained Condition
Analysis Methods
Bishop simplified
Loading
Seismic Load Coefficient (Horizontal): 0.30
Method: bishop simplified
SF: 1.00
1.001
W
1200
1000
800
600
400
200
0
-200
-400
-1400
-1200
-1000
-800
-600
-400
-200
0
200
400
600

Slide Analysis Information

Document Name

section a-a' seismic eff.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Water Pressure Type: Water Surfaces
Data Output: Standard

Analysis Methods

Analysis Methods used:
Ordinary
Bishop simplified
Janbu simplified
Janbu corrected

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Circular
Radius increment: 10
Minimum Elevation: Not Defined
Composite Surfaces: Disabled
Reverse Curvature: Create Tension Crack

Loading

Seismic Load Coefficient (Horizontal): 0.3
Seismic Load Coefficient (Vertical): 0

Material Properties

Material: Refuse
Strength Type: Mohr-Coulomb
Unit Weight: 60 lb/ft3
Cohesion: 200 psf
Friction Angle: 30 degrees
Water Surface: None
Hu value: 1

Material: Liner
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 13 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 32 degrees
Water Surface: Water Table
Hu value: 1

Global Minimums

Method: ordinary
SF: 0.584976
Center: -268.643, 341.086
Radius: 529.477
Left Slip Surface Endpoint: -780.593, 205.983
Right Slip Surface Endpoint: 166.895, 40

Method: bishop simplified
SF: 1.00055
Center: -333.077, 631.04
Radius: 774.145
Left Slip Surface Endpoint: -983.569, 211.326
Right Slip Surface Endpoint: 166.895, 40

Method: janbu simplified
SF: 0.882495
Center: -333.077, 566.606
Radius: 726.144
Left Slip Surface Endpoint: -966.589, 211.714
Right Slip Surface Endpoint: 166.895, 40

Method: janbu corrected
SF: 0.953459
Center: -333.077, 566.606
Radius: 726.144
Left Slip Surface Endpoint: -966.589, 211.714
Right Slip Surface Endpoint: 166.895, 40

Method Statistics

Method: ordinary
Number of Valid Surfaces: 2626

Simplified Seismic Design Procedure

Bray, Rathje, Augello, Merry, 1998

Application:	Refuse Slope Stability	
Project:	Hay Road Vertical Expansion	
Section:	A-A'	
Date:	11/3/2003	

Potential Failure along liner

Design EQ Event

Mag. =	7	
Ep. Distance =	10	km
MHA =	0.35	g
Waste Depth =	29	m (average)
Ky =	0.086	

Determine:

Tm =	0.52	s
D5-95 =	14	s
NRF =	1.045	

Calc:

Sh =	235	m/s
Ts =	0.494	
Ts/Tm =	0.949	

Determine:

MHEA/MHA/NRF =	0.55

Calculate:

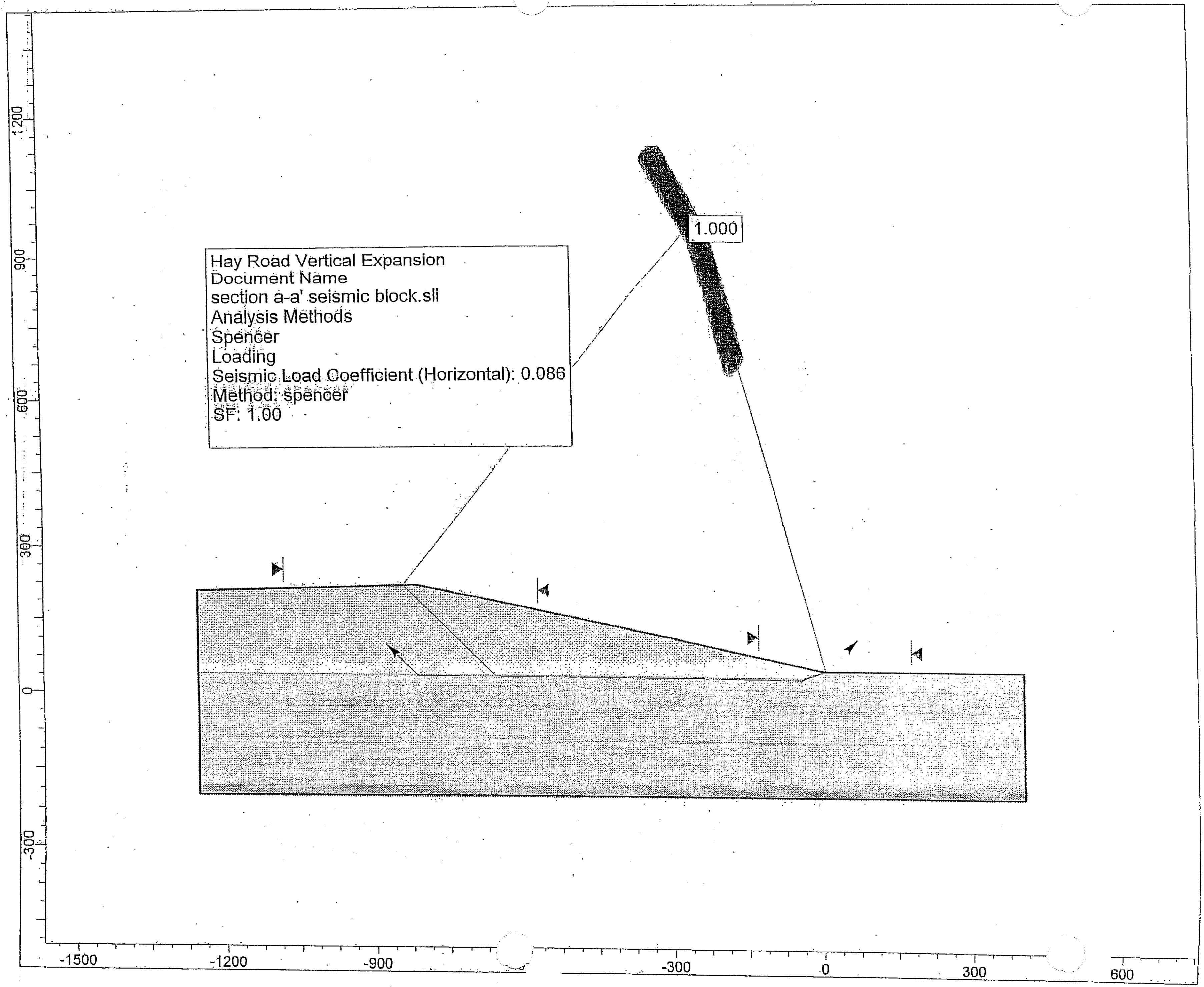
MHEA =	0.201163
ky/MHEA =	0.427515

Determine

U/MHA/D5-95 =	23	mm/s

Calculate:

Displacement =	64.8	mm
=	2.6	in.



1.000
Hay Road Vertical Expansion
Document Name
section a-a' seismic block.sli
Analysis Methods
Spencer
Loading
Seismic Load Coefficient (Horizontal): 0.086
Method: spencer
SF: 1.00
1200
900
600
300
0
-300
-1500
-1200
-900
-300
0
300
600

Slide Analysis Information

Document Name

section a-a' seismic block.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Water Pressure Type: Water Surfaces
Data Output: Standard

Analysis Methods

Analysis Methods used:
Ordinary
Bishop simplified
Janbu simplified
Spencer
Janbu corrected

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 1000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 135
Left Projection Angle (End Angle): 135
Right Projection Angle (Start Angle): 45
Right Projection Angle (End Angle): 45

Loading

Seismic Load Coefficient (Horizontal): 0.086
Seismic Load Coefficient (Vertical): 0

Material Properties

Material: Refuse
Strength Type: Mohr-Coulomb
Unit Weight: 70 lb/ft3

Cohesion: 200 psf
Friction Angle: 30 degrees
Water Surface: None
Hu value: 1

Material: Liner
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 9 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1500 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-2
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1400 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-3
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 2100 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface-4
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 3000 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Global Minimums

Method: ordinary
SF: 0.9358
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423

Right Slip Surface Endpoint: 0.922535, 40

Method: bishop simplified
SF: 0.990099
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method: janbu simplified
SF: 0.953749
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method: spencer
SF: 0.999916
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method: janbu corrected
SF: 1.01476
Axis Location: -249.225, 976.353
Left Slip Surface Endpoint: -848.219, 214.423
Right Slip Surface Endpoint: 0.922535, 40

Method Statistics

Method: ordinary
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: bishop simplified
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: janbu simplified
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: spencer
Number of Valid Surfaces: 999
Number of Invalid Surfaces: 1
Error Codes: -111

Method: janbu corrected
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Simplified Seismic Design Procedure

Bray, Rathje, Augello, Merry, 1998

Application:	Refuse Slope Stability
Project:	Hay Road Vertical Expansion
Section:	B-B'
Date:	11/3/2003

Design EQ Event

Mag. =	7
Ep. Distance =	10 km
MHA =	0.35 g
Waste Depth =	29 m (average)
Ky =	0.106

Determine:

Tm =	0.52 s
D5-95 =	14 s
NRF =	1.045

Calc:

Sh =	235 m/s
Ts =	0.494
Ts/Tm =	0.949

Determine:

MHEA/MHA/NRF =	0.55

Calculate:

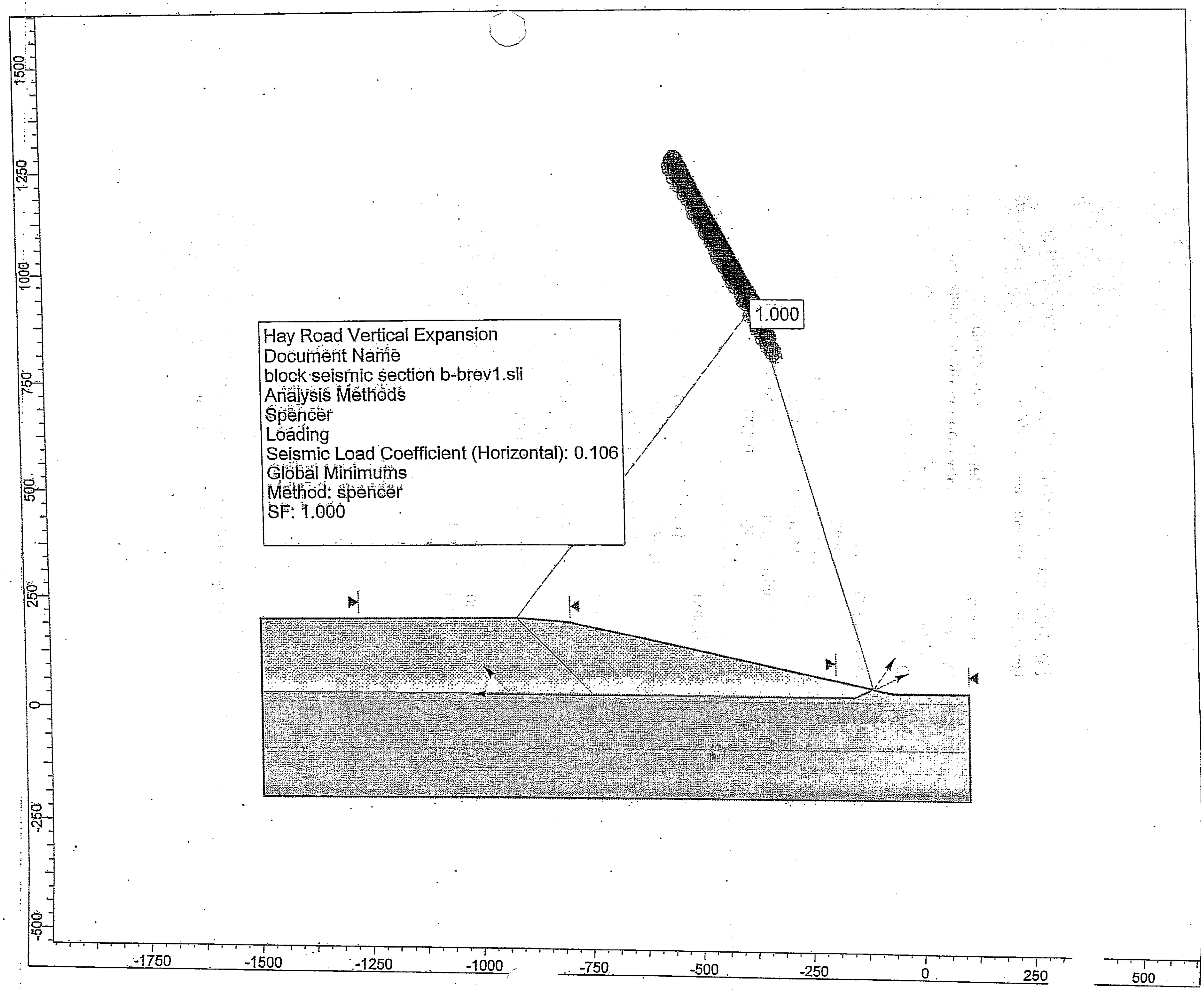
MHEA =	0.201163
ky/MHEA =	0.526937

Determine

U/MHA/D5-95 =	10 mm/s

Calculate:

Displacement =	28.2 mm
=	1.1 in.



1.000
Hay Road Vertical Expansion
Document Name
block seismic section b-brev1.sli
Analysis Methods
Spencer
Loading
Seismic Load Coefficient (Horizontal): 0.106
Global Minimums
Method: spencer
SF: 1.000
1500
1250
1000
750
500
250
0
-250
-500
-1750
-1500
-1250
-1000
-750
-500
-250
0
250
500

Slide Analysis Information

Document Name

block seismic section b-brev1.sli

Project Settings

Project Title: SLIDE - An Interactive Slope Stability Program
Failure Direction: Left to Right
Units of Measurement: Imperial Units
Pore Fluid Unit Weight: 62.4 lb/ft3
Water Pressure Type: Water Surfaces
Data Output: Standard

Analysis Methods

Analysis Methods used:
Ordinary
Bishop simplified
Janbu simplified
Spencer
Janbu corrected

Number of slices: 25
Tolerance: 0.005
Maximum number of iterations: 50

Surface Options

Surface Type: Non-Circular Block Search
Number of Surfaces: 1000
Pseudo-Random Surfaces: Enabled
Convex Surfaces Only: Disabled
Left Projection Angle (Start Angle): 135
Left Projection Angle (End Angle): 180
Right Projection Angle (Start Angle): 25
Right Projection Angle (End Angle): 55

Loading

Seismic Load Coefficient (Horizontal): 0.106
Seismic Load Coefficient (Vertical): 0

Material Properties

Material: Refuse
Strength Type: Mohr-Coulomb
Unit Weight: 70 lb/ft3

Right Slip Surface Endpoint: -128.461, 42.6353

Method: bishop simplified
SF: 0.983395
Axis Location: -364.282, 921.839
Left Slip Surface Endpoint: -921.198, 195
Right Slip Surface Endpoint: -116.96, 40.2031

Method: janbu simplified
SF: 0.943951
Axis Location: -364.282, 921.839
Left Slip Surface Endpoint: -921.198, 195
Right Slip Surface Endpoint: -116.96, 40.2031

Method: spencer
SF: 1.00016
Axis Location: -364.282, 921.839
Left Slip Surface Endpoint: -921.198, 195
Right Slip Surface Endpoint: -116.96, 40.2031

Method: janbu corrected
SF: 1.00417
Axis Location: -364.282, 921.839
Left Slip Surface Endpoint: -921.198, 195
Right Slip Surface Endpoint: -116.96, 40.2031

Method Statistics

Method: ordinary
Number of Valid Surfaces: 1000
Number of Invalid Surfaces: 0

Method: bishop simplified
Number of Valid Surfaces: 982
Number of Invalid Surfaces: 18
Error Codes: -112

Method: janbu simplified
Number of Valid Surfaces: 976
Number of Invalid Surfaces: 24
Error Codes: -112

Method: spencer
Number of Valid Surfaces: 976
Number of Invalid Surfaces: 24
Error Codes: -112

Method: janbu corrected
Number of Valid Surfaces: 976
Number of Invalid Surfaces: 24
Error Codes: -112

Cohesion: 200 psf
Friction Angle: 30 degrees
Water Surface: None
Hu value: 1

Material: Liner
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 0 psf
Friction Angle: 9 degrees
Water Surface: None
Hu value: 1

Material: Subsurface 1
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1500 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface 2
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 1400 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: subsurface 3
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 2100 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Material: Subsurface 4
Strength Type: Mohr-Coulomb
Unit Weight: 120 lb/ft3
Cohesion: 3000 psf
Friction Angle: 0 degrees
Water Surface: None
Hu value: 1

Global Minimums

Method: ordinary
SF: 0.907803
Axis Location: -356.269, 872.602
Left Slip Surface Endpoint: -883.557, 192.376

Charts From Bray et.al 1/4

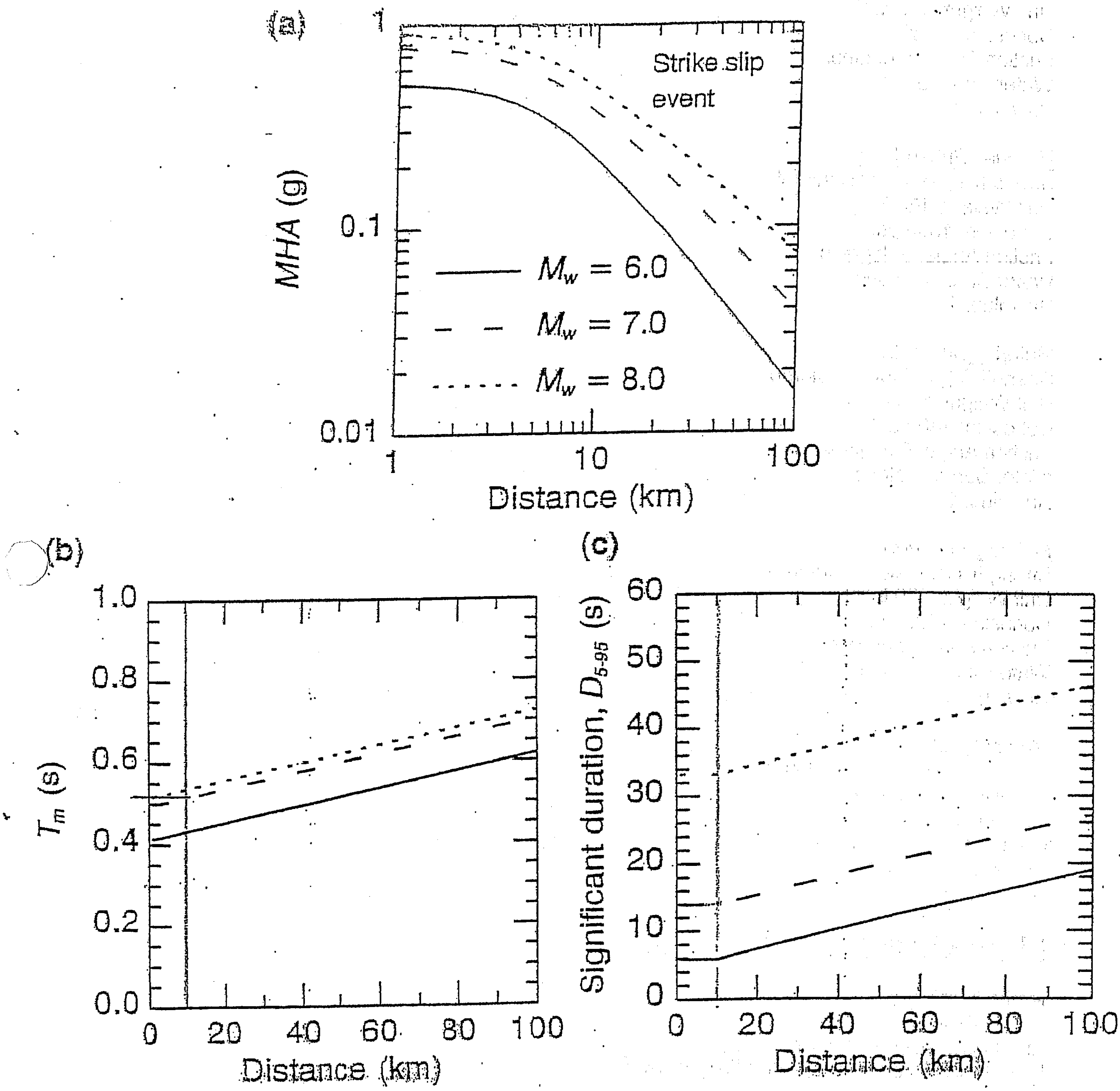


Figure 2. Simplified characterization of earthquake rock motions: (a) intensity, *MHA* for strike-slip faults (for reverse faults, use $1.3 \times MHA$ for $M_w \geq 6.4$ and $1.64 \times MHA$ for $M_w = 6.0$, with linear interpolation for $6.0 < M_w < 6.4$) (Abrahamson and Silva 1997); (b) frequency content, T_m (Rathje et al. 1998); (c) duration, $D_{5\text{-}95}$ (Abrahamson and Silva 1996).

Attachment 2. Source: Bray et. al., "Seismic Design for Lined Solid-Waste

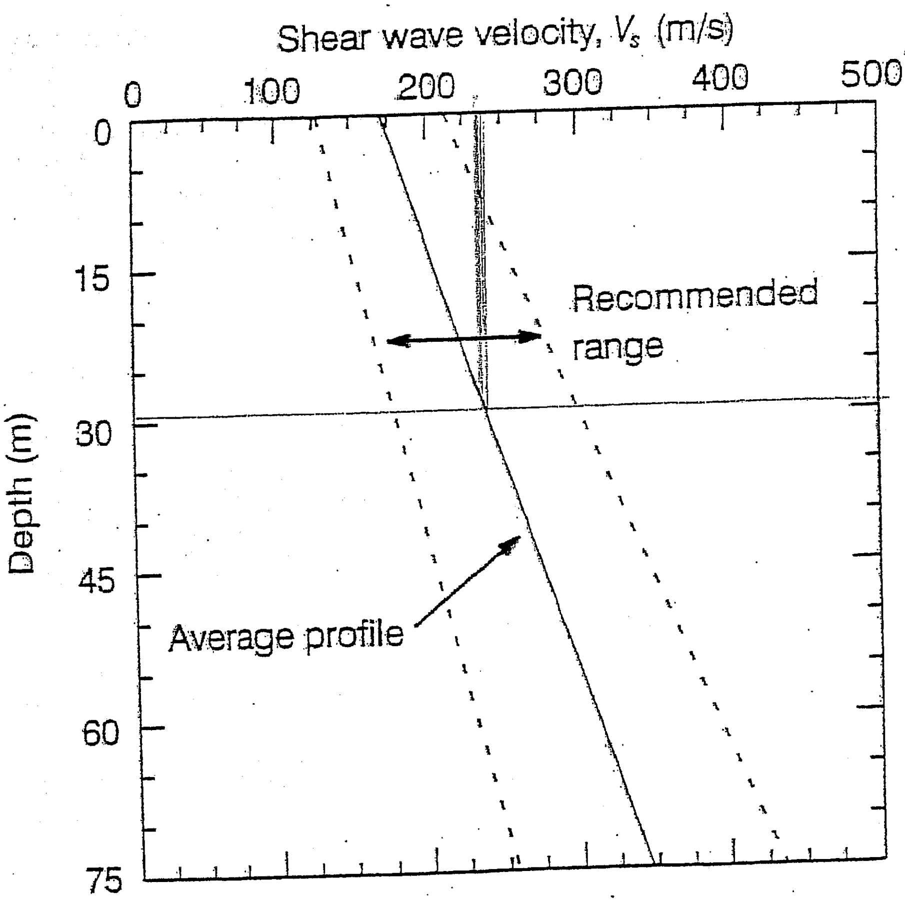


Figure 3. **Shear wave velocity profiles for municipal solid-waste (after Kavazanjian et al. 1996).**

Attachment 2.

Source: Bray et. al., "Seismic Design for Lined Solid-Waste Landfills," *Geosynthetics International,* Vol. 5, Nos. 1-2, 1998.

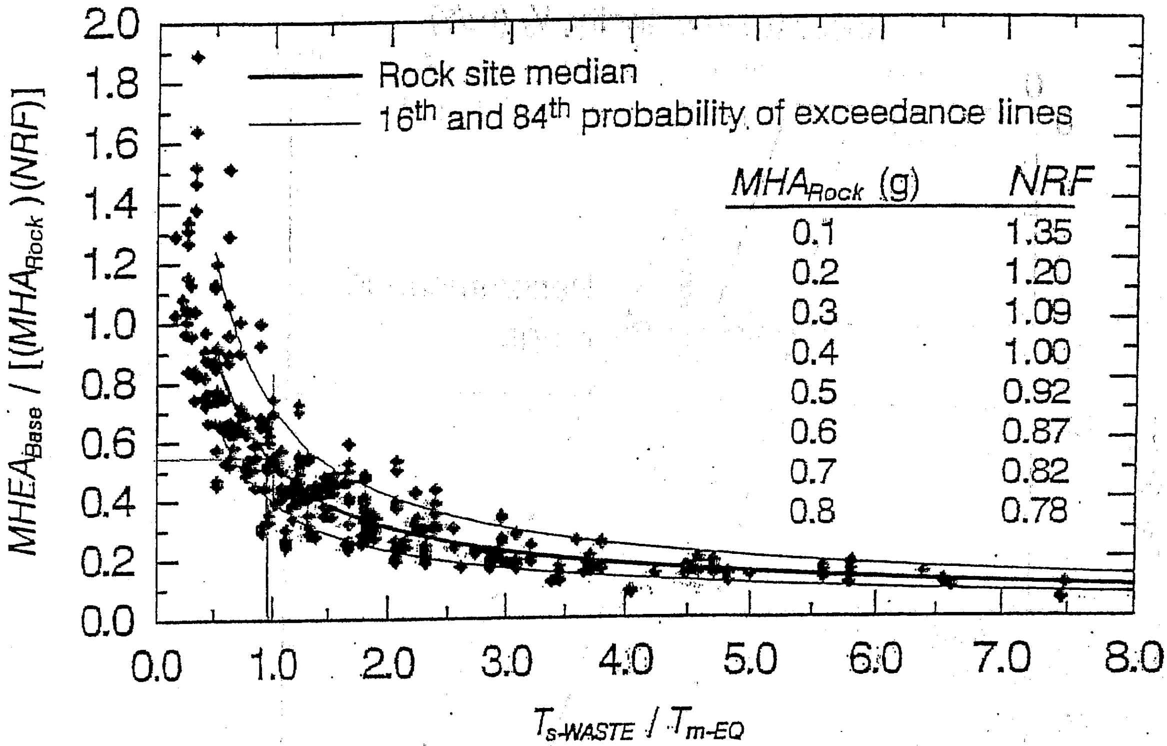


Figure 6. Normalized maximum horizontal equivalent acceleration for base sliding versus normalized fundamental period of waste fill (adapted from Bray and Rathje 1998).

Source: Bray et. al., "Seismic Design for Lined Solid-Waste Landfills," *Geosynthetics International*, Vol. 5, Nos. 1-2, 1998.

4/4

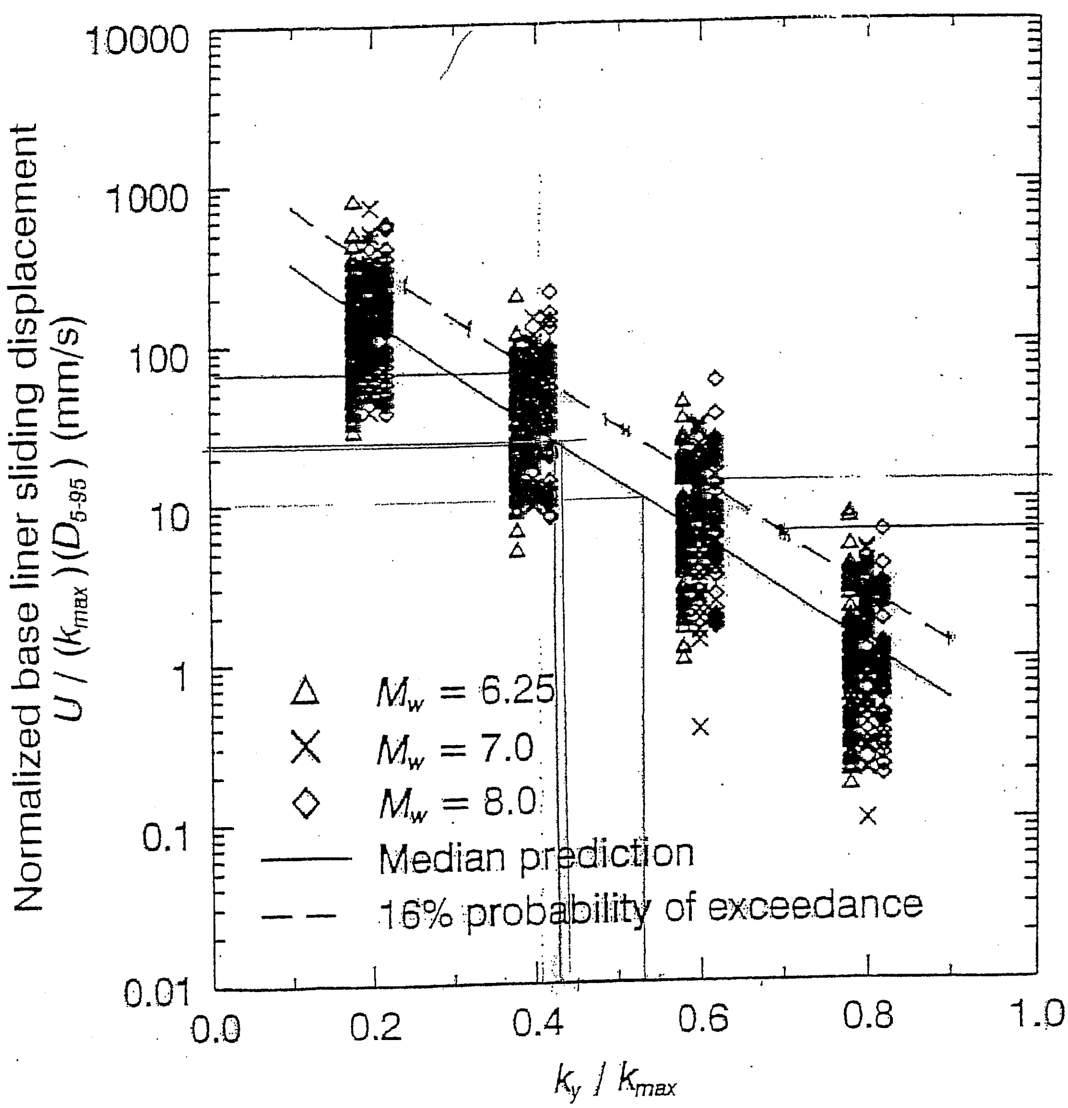


Figure 11. Normalized base liner sliding displacements (from Bray and Rathje 1998).

Attachment 2.

Source: Bray et. al., "Seismic Design for Lined Solid-Waste Landfills," *Geosynthetics International*, Vol. 5, Nos. 1-2, 1998.

Appendix F

Conceptual Surface Water Drainage Calculations

Surface Water Runoff and Drainage Calculations for the Final Cover Grading Plan at Hay Road Landfill

The purpose of this calculations package was to perform a surface water hydrologic study of the revised final cover grading plan for the Norcal Waste Systems Hay Road Landfill. The results of that analysis are presented below.

This analysis was done to estimate the peak discharges resulting from the site's design storm event, the 1000-year, 24-hour storm. Peak discharge was estimated at various points around the site and those values were used to size downdrains and verify the capacity of the existing perimeter conveyance channel.

Final Cover Grading Plan

The current permitted final cover grading plan in shown on Drawing 2 of the JTD. The final cover has top deck portions, which are sloped at 5-percent. Slopes connecting the outer top decks to the middle top deck are sloped at 9-percent. The diversion berm around the perimeter of the top deck is graded to drain from 1 to 4 percent. The side-slopes of the final cover are inclined at 4H:1V. The access ramps are sloped at 6-percent and the benches are graded at 2-percent towards drainage inlets located at low points on the benches.

Runoff from the top-deck will flow to low points on the cover and will be conveyed down the side-slopes through downdrains. Runoff from the side-slopes is collected at low points along the benches and conveyed through downdrains to the perimeter conveyance channel.

The perimeter conveyance channel is a trapezoidal ditch that will carry runoff from the site to the A-1 Channel located in the southeast corner of the site. There are two perimeter conveyance channels, one extending around the north perimeter of the site and one to the south. Outflow from the downdrains will empty into the conveyance channels and flow to the A-1 channel.

Currently drainage from the site is discharged into the Bird Sanctuary. At the time of closure runoff will be diverted to the A-1 channel that runs parallel to the site on the north and east sides. The perimeter conveyance channel grades range from 0.22 % to 0.03 %. The existing side-slopes vary, it is assumed for this analysis that the side-slopes will be shaped to approximately 2H:1V as part of the final closure plan.

Precipitation

The final cover grading plan and the runoff conveyance system are required to manage the 1000-year, 24-hour design storm event. Intensity, Duration, Frequency (IDF) curves were developed using site specific rainfall data. The curves are presented in Figure 2. The site is expected to receive 5.39-inches of precipitation resulting from the design storm. The IDF curve for the design event was used to calculate Rainfall Intensity, I, used in the Rational Method to estimate peak discharge.

Methodology

The Rational Method was used to estimate peak discharge and model the flow regime of the conveyance channel during the design storm event. The Rational Method is a function of watershed area, runoff potential, and rainfall intensity. To estimate rainfall intensity the time required for overland flow the most remote portion of each watershed is calculated. This term is called Time to Concentration (tc).

The Federal Aviation Administration (FAA) developed an equation for tc for larger uniformly graded watersheds with overland travel lengths greater than 300-feet. The FAA equation for tc was formulated for use with the Rational Equation. In this equation tc is a function of overland travel length, slope, and runoff potential or conversely infiltration.

Infiltration

The Rational Method uses a runoff coefficient, C, to gage infiltration and runoff potential. A C value was selected for both the top deck and the side-slopes of the final cover. C is dependent on soil surface texture, slope, and storm recurrence interval, refer to Attachment 1. A C value of 0.4 was selected for the top deck and a value of 0.5 for the side-slopes. These values are consistent with those used at other landfills in California with similar cover systems and soil types.

Watershed Delineation

The final cover grading plan was divided into two watersheds, north and south. Within each half of the cover system the watersheds were further divided into 8 basins. Depending on whether a particular basin had a runoff contribution from the top-deck the basins were further divided into two or three sub-basins. The sub-basins were placed in three groups, A (top-deck areas), B (sides-slope areas flowing to downdrains, and C (side-slope areas flowing directly to the conveyance channel). All the sub-basins are listed in Table 1 and shown on Figure 1.

Peak Discharge (HEC-HMS)

Peak discharge was estimated for each of the 40 sub-basins using the Rational Method. The input parameters used for the Rational Method include tc, watershed area, C, grade, slope length, collector length, and collector velocity. The calculated peak discharges and related parameters for each sub-basin are presented in Table 1. A sample calculation using the Rational method is presented in Attachment 2. The development of flow velocity for the benches and perimeter conveyance channels are presented in Attachment 3.

Downdrains

Downdrain locations were identified on the final cover grades to develop storm water management. Downdrain inlets were located at the low points on the final cover grades to collect runoff and drain flow to the perimeter conveyance channel.

The downdrains were assumed to be HDPE pipe, corrugated on the outside and smooth on the inside. The pipes were assigned a Manning's roughness coefficient of 0.015.

The hydraulics program developed by Dodson and Associates (1989) for pipe culverts with inlet head control was used to size the downdrains. Inlet head was limited to four vertical feet based on the assumed depth of the drop inlets and the cover thickness along the benches. The resulting pipe inside diameters and expected inlet heads for the final cover downdrains are presented in Table 2. The outputs from the software analysis are presented in Attachment 4.

Perimeter Conveyance Channel

Storm water runoff from the final cover will be diverted around the site via a conveyance channel to the A-1 channel in the southeast corner of the site. The perimeter channel consists of two trapezoidal shaped ditches that start in the middle of the west side of the site and proceed around the north and south perimeters of the landfill and empty into the A-1 Channel, refer to Drawing 2.

Runoff from the downdrains enters the conveyance channel at eight points along the northern end of the channel and at eight points along the southern end of the channel. The peak discharge at each point was estimated using Rational Method.

The flow gradients around the site are shallow with a minimum of 0.03 % and maximum of 0.31 %. It is assumed that the channel side-slopes will be shaped to approximately 2H:1V as part of the final cover system grading plan. The channel was assumed to be grass-lined and assigned a Manning's roughness coefficient of 0.024, Gupta (1995).

The hydraulics software program FlowMaster, Version 3.13, which uses Manning's equation to calculate open channel flow, was used to calculate the depth of flow in the perimeter conveyance channels. These results are presented in Table 3. The software generated outputs are presented in Attachment 5.

Results

The resulting peak discharges estimated for each sub-basin are presented in Table 1. The largest peak discharge to a downdrain inlet was at the bottom of sub-basin 2-B on the north side of the watershed with a magnitude of approximately 27 cfs. The downdrain inside diameters ranged from 12-inches to 30-inches, refer to Table 2.

Peak discharge into the perimeter conveyance channel was estimated at points along the north end of the channel and at points along the south end of the channel. The largest flows were found to be at the end of each channel as they enter the A-1 channel. The peak outflow from the north channel was found to be approximately 75 cfs and approximately 97 cfs from the south channel.

The perimeter conveyance channel is assumed to have a maximum depth of 3-feet. The width of the conveyance channel was sized to allow a maximum flow depth of 2.5-feet. This leaves one-half foot of available freeboard. The conveyance channel along the north side of the site was found to have a maximum base width of 10-feet at Point 4 and 11-feet on the south side at Point 8, refer to Figure 1.

Conclusions

A hydrologic analysis of the existing permitted final cover grading plan at Hay Road Landfill was done to assess the performance of the final cover's ability to manage storm water runoff during the design event, the 1000-year, 24-hour storm. This analysis was performed to estimate peak discharge for the re-graded final cover grading plan and develop a conceptual storm water management system for the final cover.

The required downdrain diameters for the final cover system were found to be of typical diameter for a cover of this size. The perimeter conveyance channel will manage the outflows from the final cover maintaining a maximum flow depth of 2.5-feet allowing for 0.5-feet of freeboard. The maximum base widths of the conveyance channel, 10-feet on the north and 11-feet on the south, are consistent with the design widths previously estimated for the Final Cover Drainage Plan.

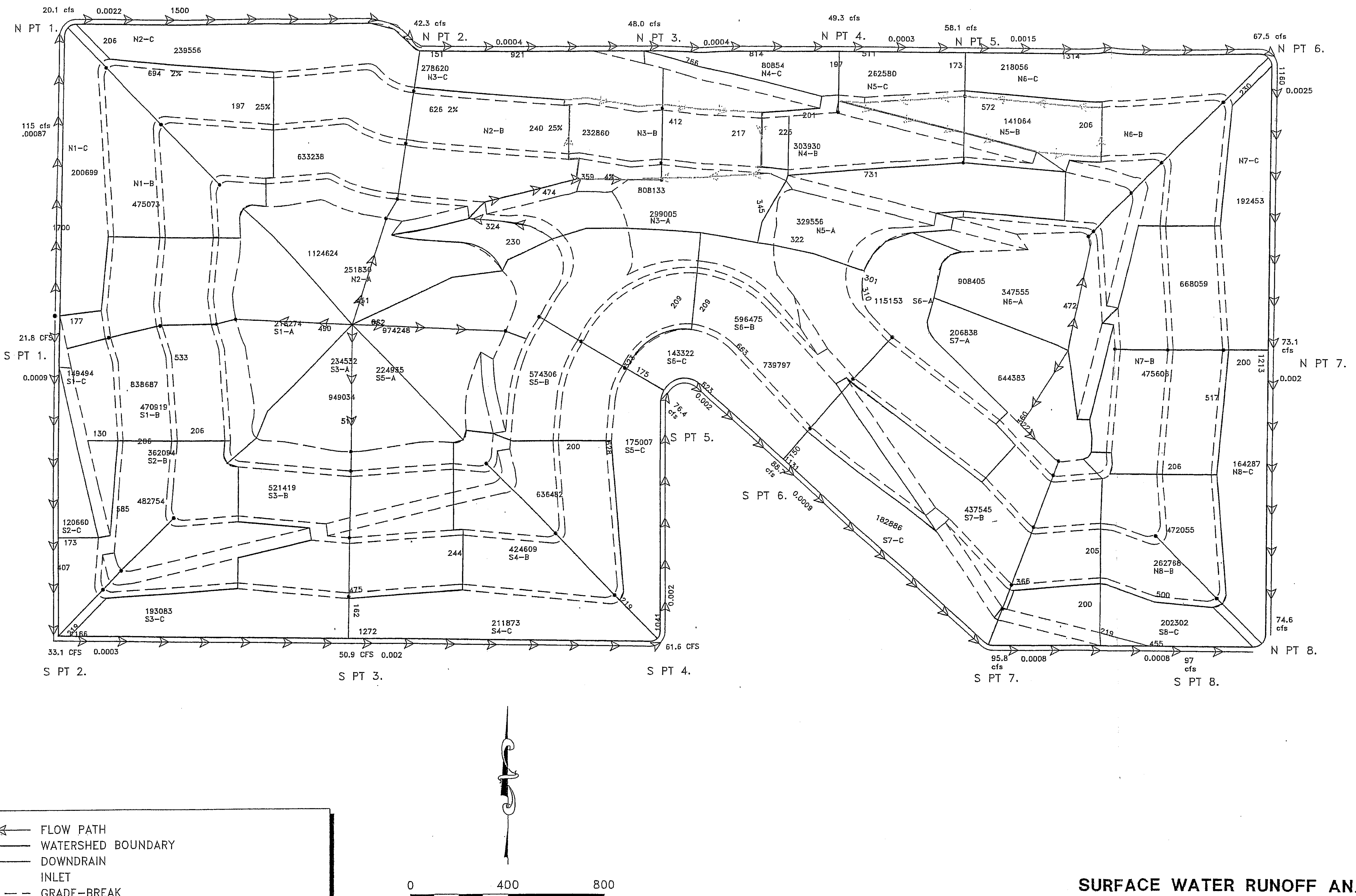
References

FlowMaster I Version 3.13, 1990, Software program, Haestad Methods, Inc.

Gupta, R. S., *Hydrology and Hydraulic Systems*, Waveland Press Inc., Prospect Heights, Illinois, 1995.

Dodson and Associates Inc., " Hydrocalc Hydraulics: Pipe Culvert Analysis Program, Version 1.7," © 1989.

FIGURES



LEGEND:

- FLOW PATH
- WATERSHED BOUNDARY
- DOWNDRAIN
- INLET
- GRADE-BREAK

FIGURE 1

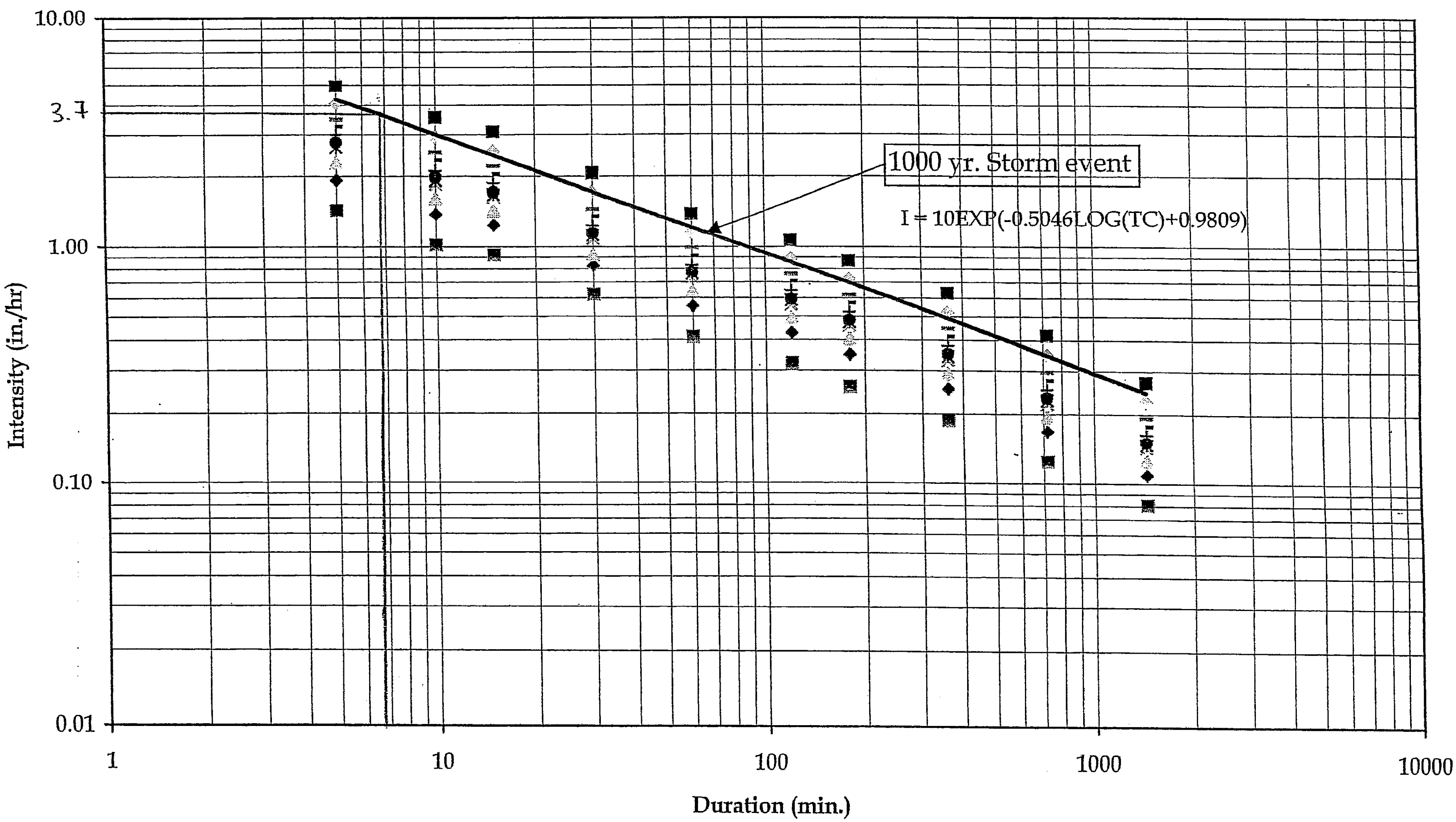
SURFACE WATER RUNOFF ANALYSIS
FINAL GRADING PLAN

NORCAL/NWSHRL JTD UPDATE/CA

Golder Associates

DWG ID: jraub | N:\Projects\053-7433 (Norcal-NWSHRL JTD Update)\Surface Runoff\Fig 1 - Surface Water Runoff.dwg | 1-20-5 13:43 | xrf: NONE

053-7433 NC AL/NWSHRL
2005 JTD UPDATE
FIGURE 2.
RAINFALL INTENSITY



TABLES

053-7433 N[illegible]AL/NWSHRL
2005 J[illegible] DATE
TABLE 1.
PEAK DISCHARGE SUMMARY

Sub-basin [1]	Area [2]	Slope Corrected Area	Area	$C^{(4)}$	Overland flow		Collector (V-Ditch)			Overland flow + Collector	Cumlative	Intensity	Cumlative Intensity	Peak Discharge	Cumlative Peak Discharge
North	(ft^2)	(ft^2)	(acres)		L(ft)	S (ft/ft)	L(ft)	S (ft/ft)	V (fps) [3]	tc(min)	tc (min)	(in/hr)	I (in/hr)	Q (cfs)	Q (cfs)
1-B	475073	489325	11.233	0.5	197	0.25	694	0.02000	7.89	6.66		3.68		20.65	
1-C	200699	206720	4.7	0.5	177	0.25	1700	0.00087	3.05	14.19	14	2.51	2.51	5.95	20.05
2-A	251830		5.8	0.4	451	0.05	0			15.66		2.39		5.52	
2-B	633238	652235	15.0	0.5	240	0.25	626	0.02000	7.89	7.05		3.57		26.74	
2-C	239556	246743	5.7	0.5	206	0.25	1500	0.00120	3.59	12.28	21	2.70	2.05	7.65	42.30
3-A	299005		6.9	0.4	230	0.10	324, 474, 359	0.02, 0.06, 0.04	11.27	10.74		2.89		7.93	
3-B	232860	239846	5.5	0.5	217	0.25	412	0.02000	7.89	6.32		3.78		10.39	
3-C	278620	286979	6.6	0.5	151	0.25	921	0.00015	1.27	16.65	33	2.32	1.63	7.63	48.02
4-B	222985	229675	5.3	0.5	225	0.25	201	0.02000	7.89	5.97		3.88		10.24	
4-C	80854	83280	1.9	0.5	766	0.06	814	0.00042	2.12	22.85	40	1.97	1.49	1.89	49.31
5-A	329556		7.6	0.4	322	0.05	1076	0.02000	7.89	15.50		2.40		7.26	
5-B	141064	145296	3.3	0.5	206	0.25	572	0.02000	7.89	6.52		3.72		6.20	
5-C	262580	270457	6.2	0.5	197	0.25	511	0.00042	2.12	9.20	44	3.12	1.42	9.69	58.07
6-A	347555		8.0	0.4	472	0.05	0			16.02		2.36		7.53	
6-B	342794	353078	8.1	0.5	206	0.25	572	0.02000	7.89	6.52		3.72		15.06	
6-C	218056	224598	5.2	0.5	173	0.25	1314	0.00120	3.59	10.97	50	2.86	1.33	7.37	67.45
7-B	475606	489874	11.2	0.5	206	0.25	517	0.02000	7.89	6.40		3.75		21.09	
7-C	192453	198227	4.6	0.5	230	0.25	1160	0.00075	2.84	12.42	57	2.68	1.25	6.11	73.08
8-B	262768	270651	6.2	0.5	205	0.25	500	0.02000	7.89	6.35		3.77		11.70	
8-C	164287	169216	3.9	0.5	200	0.25	1213	0.00070	2.74	12.61	64	2.66	1.17	5.17	74.62

Note (1): Sub-basins are delineated in Figure 1.
Note (2): The area for each sub-basin was calculated using the updated Final Cover grades.
Note (3): Collector ditch and perimeter conveyance channel flow velocities used to calculate Time to Concentration were estimated using Manning's equation for open channel flow, refer to **Attachment 3.**
Note (4): The runoff coefficient, C, (used as part of the Rational Method was used to calculated Time to Concentration for each sub-basin. The calculation of C is presented in **Attachment 2.**

Time to Concentration

$$t_c = \frac{1.8(1.1 - C)L^{1/2}}{(S * 100)^{0.333}}$$

Rainfall Intensity - I

$$I = 10^{-0.5046 \log(tc) + 0.9809}$$

I based on 1000 yr. storm
24 hr. duration

Rational Equation

$$Q = CIA$$

053-7433 NC[illegible]L/NWSHRL
2005 JT[illegible] DATE
TABLE 1.
PEAK DISCHARGE SUMMARY

Sub-basin (1)	Area (2)	Slope Corrected Area	Area		Overland flow		Collector (V-Ditch)			Overland flow + Collector	Cumlative	Intensity	Cumlative Intensity	Peak Discharge	Cumlative Peak Discharge
South	(ft^2)	(ft^2)	(ac)	C (4)	L(ft)	S (ft/ft)	L(ft)	S (ft/ft)	V (fps) (3)	tc(min)	tc (min)	(in/hr)	(in/hr)	Q (cfs)	Q (cfs)
1-A	218274	218274	5	0.4	490	0.05	0			16.32		2.34		4.69	-
1-B	470919	485047	11	0.5	206	0.25	533	0.02000	7.89	6.43		3.74		20.83	
1-C	149494	153979	4	0.5	130	0.06	526	0.00100	3.27	9.46	16	3.08	2.34	5.44	21.84
2-B	362094	372957	9	0.5	206	0.25	585	0.02000	7.89	6.54		3.71		15.88	
2-C	120660	124280	3	0.5	173	0.25	407	0.00100	3.27	6.93	18	3.60	2.20	5.14	33.13
3-A	234532	234532	5	0.4	517	0.05	0			16.76		2.31		4.97	
3-B	521419	537062	12	0.5	244	0.25	475	0.02000	7.89	6.78		3.64		22.46	
3-C	193083	198875	5	0.5	219	0.25	1166	0.00200	4.63	9.67	23	3.05	1.98	6.95	50.91
4-B	424809	437553	10	0.5	200	0.25	628	0.02000	7.89	6.56		3.71		18.61	
4-C	211873	218229	5	0.5	162	0.25	1272	0.00400	6.55	7.94	26	3.36	1.86	8.42	61.55
5-A	224935	224935	5	0.4	662	0.05	0			18.97		2.17		4.48	
5-B	574308	591537	14	0.5	209	0.25	323	0.02000	7.89	6.03		3.87		26.25	
5-C	175007	180257	4	0.5	219	0.25	1041	0.00200	4.63	9.22	30	3.12	1.73	6.46	76.41
6-A	115153	115153	3	0.4	301	0.10	310	0.01600	7.06	11.06		2.85		3.01	
6-B	596475	614369	14	0.5	209	0.25	663	0.02000	7.89	6.75		3.65		25.76	
6-C	143322	147622	3	0.5	175	0.25	623	0.00100	3.27	8.06	33	3.34	1.65	5.66	88.72
7-A	206838	206838	5	0.4	360	0.05	221	0.01000	5.58	14.65		2.47		4.69	
7-B	437545	450671	10	0.5	205	0.25	366	0.02000	7.89	6.07		3.85		19.93	
7-C	182886	188373	4	0.5	150	0.25	1131	0.00100	3.27	10.28	38	2.95	1.52	6.38	95.76
8-C	202302	208371	5	0.5	200	0.25	455	0.00150	4.01	7.12	40	3.55	1.48	8.50	97.01

Note (1): Sub-basins are delineated in Figure 1.
Note (2): The area for each sub-basin was calculated using the updated Final Cover grades.
Note (3): Collector ditch and perimeter conveyance channel flow velocities used to calculate Time to Concentration were estimated using Manning's equation for open channel flow, refer to Attachment 3.
Note (4): The runoff coefficient, C, (used as part of the Rational Method was used to calculated Time to Concentration for each sub-basin. The calculation of C is presented in Attachment 2.

Time to Concentrat ion

$$t_c = \frac{1.8(1.1 - C)L^{1/2}}{(S * 100)^{0.333}}$$

Rainfall Intensity - I

$$I = 10^{-0.5046\log(tc) + 0.9809}$$

I based on 1000 yr. storm
24 hr. duration

Rational Equation

$$Q = CIA$$

053-7433 NORCAL/NWSHRL
2005 JTD UPDATE
TABLE 2.
DOWNDRAIN SUMMARY

North Side of Cover

Downdrain	Peak Inflow (cfs) (1)	Length (ft)	Inlet Head (ft) (2)	Downdrain I.D. (ft) (2)
1-B	20.7	238	3.51	2.0
2-A	5.5	87	1.39	1.5
2-B	26.7	174	3.88	2.5
3-A	7.9	57	1.91	1.5
3-B	10.4	175	2.73	1.5
4-B	10.2	252	2.14	2.0
5-A	7.3	284	1.68	1.5
5-B	6.2	194	1.50	1.5
6-A	7.5	247	1.71	1.5
6-B	15.1	265	2.25	2.0
7-B	21.1	200	2.42	2.5
8-B	11.7	266	1.90	2.0

South Side of Cover

Downdrain	Peak Inflow (cfs) (1)	Length (ft)	Inlet Head (ft) (2)	Downdrain I.D. (ft) (2)
1-A	4.69	80	2.40	1.0
1-B	25.52	190	2.75	2.5
2-B	15.88	383	2.42	2.0
3-A	4.97	74	2.60	1.0
3-B	27.43	204	2.95	2.5
4-B	18.61	255	2.23	2.5
5-A	4.48	88	2.25	1.0
5-B	30.73	176	3.67	2.5
6-A	3.01	223	1.40	1.0
6-B	28.76	173	3.28	2.5
7-A	4.69	63	2.40	1.0
7-B	24.62	158	2.68	2.5

Note (1): Peak inflows were estimated using the Rational Method, refer to **Table 1.**

Note (2): Downdrains were sized using Inlet Head Control. Inlet head was required to be less than 4-feet, Refer to **Attachment 4.**

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TABLE 3.
PERIMETER CONVEYANCE DITCH SUMMARY

North Side of Final Cover

Downdrain Outlet (1)	Bottom Width (ft)	Gradient (%) (2)	Side-Slope (XH:1V) (3)	Peak Discharge (cfs) (4)	Depth (ft) (5&6)
1	0.00	0.22	2	20.05	1.95
2	6.00	0.04	2	42.30	2.38
3	8.00	0.04	2	48.02	2.28
4	10.00	0.03	2	49.31	2.27
5	4.00	0.15	2	58.07	2.28
6	4.00	0.25	2	67.45	2.17
7	5.00	0.20	2	73.08	2.22
8	4.00	0.26	2	74.62	2.26

South Side of Final Cover

Downdrain Outlet (1)	Bottom Width (ft)	Gradient (%) (2)	Side-Slope (XH:1V) (3)	Peak Discharge (cfs) (4)	Depth (ft) (5&6)
1	0.00	0.09	2	21.84	2.38
2	5.00	0.03	2	33.13	2.41
3	2.00	0.31	2	50.91	2.13
4	3.00	0.20	2	61.55	2.36
5	4.00	0.20	2	76.41	2.43
6	9.00	0.09	2	88.72	2.43
7	10.00	0.08	2	95.76	2.50
8	11.00	0.08	2	97.01	2.41

Note (1): Downdrain locations are shown on Figure 1.

Note (2): Represent existing on-site grades in perimeter ditch system.

Note (3): Existing ditch side slopes vary, but are all less steep than 2H:1V. Assume that ditches will be shaped at time of closure to 2H:1V or gentler. Capacity increases as slope decreases.

Note (4): Peak discharge was estiamted using the Rational Method, refer to **Table 1.**

Note (5): Actual depth calculated using Manning's equation, FlowMaster Outputs presented in **Attachment 5.**

Note (6): Assume max ditch depth of 2.5 feet.

ATTACHMENT 1.

SELECTION OF RUNOFF COEFFICIENT, C

Objective: Calculate the runoff coefficient, C, for the final cover grades at NWSHRL using method presented in Gupta, 1995.

Method: Use values presented in Table 12.5 of Gupta, 1995 to calculate C.

1) Top Deck of Final Cover System and Interim Slopes
   Given: Rural Catchments
   - Basic Factor (Grassland): 0.35
   - Recurrence Interval > 50 yr. (100 yr): +0.05
   - **Total 0.40**

2) Side Slopes of Final Cover System and Interim Slopes
   Given: Rural Catchments
   - Basic Factor (Bare Surface): 0.40
   - Slope > 10%: +0.05
   - Recurrence Interval > 50 yr. (100 yr): +0.05
   - **Total 0.50**

Conclusions: The components of the final cover system were classified as rural catchments based on the assumption that the top of cover system would consist of tracked soil. The surface of the top deck will probably consist of the prescriptive vegetative cover and was characterized as grassland. The side slopes will consist of the same type material, but due to the slope inclination the side slopes were characterized as a bare surface.

ATTACHMENT 2.

PEAK DISCHARGE SAMPLE CALCULATIONS

Golder Associates	SUBJECT NWSHRL / JTD Update		
	Job No. 053-7433	Made by WRC	Date 2/9/05
	Ref.	Checked SHY	Sheet 1 of 4
		Reviewed [illegible]	

Objective: Provide sample calculation of peak discharge computations performed in Table 1.

Method: The Rational Method was used to estimate the storm water runoff peak discharges produced by the design storm event for the Hay Road LF site. The design storm is the 1000-year, 24-hour event.

1) Rational Method:

$$Q_{peak} = \Sigma\, C i A$$

where C = Runoff coefficient, refer to Attachment 1).

$C_{Top\ Deck} = 0.4$

$C_{sideslope} = 0.5$

i = Rainfall Intensity (in/hr)

i is a function of precipitation and Time to Concentration (t_c).

A = Area of each Basin (Acres)

2) Precipitation:

Intensity, Duration, Frequency (IDF) curves were obtained for the site (Golder, 2000). The curves are presented in Figure 1.

Golder Associates	SUBJECT NWS HRL / JTD Update		
	Job No. 053-7433	Made by WRC	Date 2/9/05
	Ref.	Checked SHY	Sheet 2 of 4
		Reviewed	

2) Precipitation (Cont'd)

The following equation was developed for the 1000-yr IDF curve and used to calculate i in Table 1.

$$i = 10^{(-0.5046 \, LOG(t_c) + 0.98109)}$$

A value for i will be selected from Figure 2 to verify the equation as part of the sample calculation.

3) Time to Concentration (t_c)

$$t_c = \frac{1.8\,(1.1 - C)\,L^{1/2}}{(S \times 100)^{0.333}} + \frac{L_{col}}{V_{col} * 60 \text{ s/min}}$$

Where:

L = Length of overland flow (ft)

S = Slope of overland flow (ft/ft)

L_{col} = Length of flow in Collector drainage (ft)

V_{col} = Velocity of Collector flow (fps)

refer to Attachment 3 for Velocity calculations.

* This Equation for t_c (overland portion) was developed by the Federal Aviation Administration for large uniformly graded watersheds and is presented in Gupta, 1995.

Solution:

Calculate Peak discharge for North Sub-basin Number 1-B, refer to Figure 1.

1) $t_c = \frac{1.8(1.1 - C)L^{1/2}}{(S \times 100)^{0.333}} + \frac{L_{col}}{V_{col} \times 60 \frac{sec}{min}}$

where:

$C = 0.5$

$L = 197$ ft

$S = 0.25$ ft/ft

$L_{col} = 694$

$V_{col} = 55.78\sqrt{S_{col}}$ (Refer to Attachment 3)

$S_{col} = 0.02$ ft/ft

$t_c = \frac{1.8(1.1 - 0.5)\, 197 ft^{1/2}}{(0.25 \times 100)^{0.333}} + \frac{694 ft}{55.78\sqrt{0.02}\ fps \times 60\ s/min}$

$= 6.66$ min

Check with Table 1 $t_c = 6.66$ min OK.

Golder Associates	SUBJECT NWSHRL / JTD Update		
	Job No. 053-7344	Made by WRC	Date 2/9/05
	Ref.	Checked SHY	Sheet 4 of 4
		Reviewed KJA	

Solution:

2) Calculate Rainfall Intensity, i

Using $t_c = 6.66$ min read i from Figure 2,

$i \approx 3.7$

Table 1 Value $i = 3.68$ OK.

3) Calculate Peak Discharge, Q

$$Q = C\,i\,A$$

$$= 0.5 * 3.7\ (in/hr) \times 11.23\ (ac)$$

$$= 20.78\ cfs$$

Table 1 Value $Q = 20.65$ cfs

Difference due to i read from Figure 2.

$$Q = 0.5 \times 3.68 \times 11.23 = 20.66 \quad OK$$

ATTACHMENT 3.

COLLECTOR AND CHANNEL FLOW VELOCITY CALCULATIONS

Golder Associates

SUBJECT Norcal / Hay Road JTD Update Surface Water	
Job No. 053-7433	Made by WRC
Ref.	Checked
	Reviewed
Date 1/12/05	Sheet 1 of 4

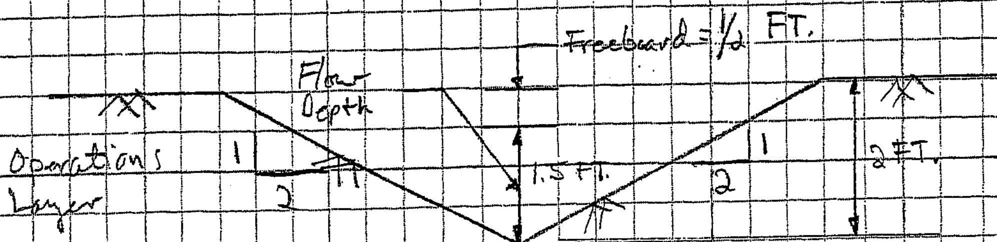
Objective: Analyze flow regime for conveyance ditches along Final Cover benches and the Perimeter conveyance channel.

Method: Use Manning's Equation for Open Channel Flow, existing site data & Final Cover Grading Plan details.

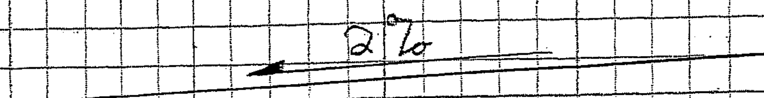
Calculations:

① V-Ditches along Final Cover Benches

Typical Section:



Elevation Profile of Bench Parallel to Flow:



① V-Ditches along Final Cover Benches

Manning's Equation:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2} \quad \text{where } R = A/P$$

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

where:

V = Velocity (fps)

Q = Flow Rate (cfs)

n = Mannings Coefficient

R = Hydraulic Radius → R = A/P

A = Channel Crosssectional Area (sf)

P = Wetted Perimeter (ft)

S = Slope (ft/ft)

ⓐ Manning's Number, n:

From Provided Table

Canals and Ditches, Smooth Earth 0.017 - 0.025

Use Average Value n = 0.021

Golder Associates	SUBJECT Norcal / NWSHRL JTD Update		
	Job No. 053-7433 Ref.	Made by LVRC Checked [initials] Reviewed [initials]	Date 1/12/05 Sheet 4 of 4

(a) Manning's n:

Use 0.021

(b) R, A, P

$A = 2.5' \times 10' + 2.5' \times 5' = 37.5\ ft^2$

$P = 10 + 2 \times \sqrt{5^2 + 2.5^2} = 21.18\ ft$

$R = \dfrac{37.5\ ft^2}{21.18\ ft} = 1.77$

(c) $V = \dfrac{1.486}{0.021}(1.77)^{2/3}(0.001)^{1/2}$

$= 3.27\ fps$

Note the Perimeter channel grade varies around the landfill. The grade will be accounted for and noted in the spread sheet calculation using this formula

$V = 103.56\sqrt{S}$

(d) $Q = \dfrac{1.486}{0.021}(37.5)(1.77)^{2/3}\sqrt{S}$

$= 3883.6\sqrt{S}$

ATTACHMENT 4.

DOWNDRAIN CAPACITY CALCULATIONS

N1B

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 2

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 238

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
20.70	0.50	3.51	-6.44	0.97	1.63	0.97	13.74

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

N2B

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 2.5

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 174

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
32.30	0.50	3.88	-4.05	1.11	1.93	1.11	15.36

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

N3B

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet)	1.5
FHWA Chart Number (1,2 or 3)	2
Scale Number on Chart (Type of Culvert Entrance)	2
Manning`s Roughness Coefficient (n-value)	0.015
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (feet)	175
Culvert Slope (feet per foot)	0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
10.40	0.50	2.73	-4.30	0.76	1.24	0.76	11.58

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

N5A

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 1.5

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 284

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
7.30	0.50	1.68	-10.71	0.62	1.05	0.62	10.70

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

N6A

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 1.5

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 247

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
7.50	0.50	1.71	-8.98	0.63	1.06	0.63	10.62

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

N7B

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 2.5

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 200

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
21.10	0.50	2.42	-6.84	0.88	1.56	0.88	13.69

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

S1A

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 1.0

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 80

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
4.69	0.50	2.40	-0.38	0.60	0.90	0.60	9.46

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

S2B

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 2.0

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 383

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
15.88	0.50	2.42	-14.34	0.83	1.44	0.83	12.80

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

S3B

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet)	2.5
FHWA Chart Number (1,2 or 3)	2
Scale Number on Chart (Type of Culvert Entrance)	2
Manning`s Roughness Coefficient (n-value)	0.015
Entrance Loss Coefficient of Culvert Opening	0.5
Culvert Length (feet)	204
Culvert Slope (feet per foot)	0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
27.43	0.50	2.95	-6.12	1.01	1.79	1.01	14.72

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

S5A

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 1.0

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) .015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 88

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
4.48	0.50	2.25	-0.86	0.59	0.89	0.59	9.36

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

S6A

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 1.0

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 223

Culvert Slope (feet per foot) 0.050

*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
3.01	0.50	1.40	-7.83	0.46	0.74	0.46	8.50

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

S7A

PIPE CULVERT ANALYSIS

COMPUTATION OF CULVERT PERFORMANCE CURVE

Culvert Diameter (feet) 1.0

FHWA Chart Number (1,2 or 3) 2

Scale Number on Chart (Type of Culvert Entrance) 2

Manning`s Roughness Coefficient (n-value) 0.015

Entrance Loss Coefficient of Culvert Opening 0.5

Culvert Length (feet) 63

Culvert Slope (feet per foot) 0.050

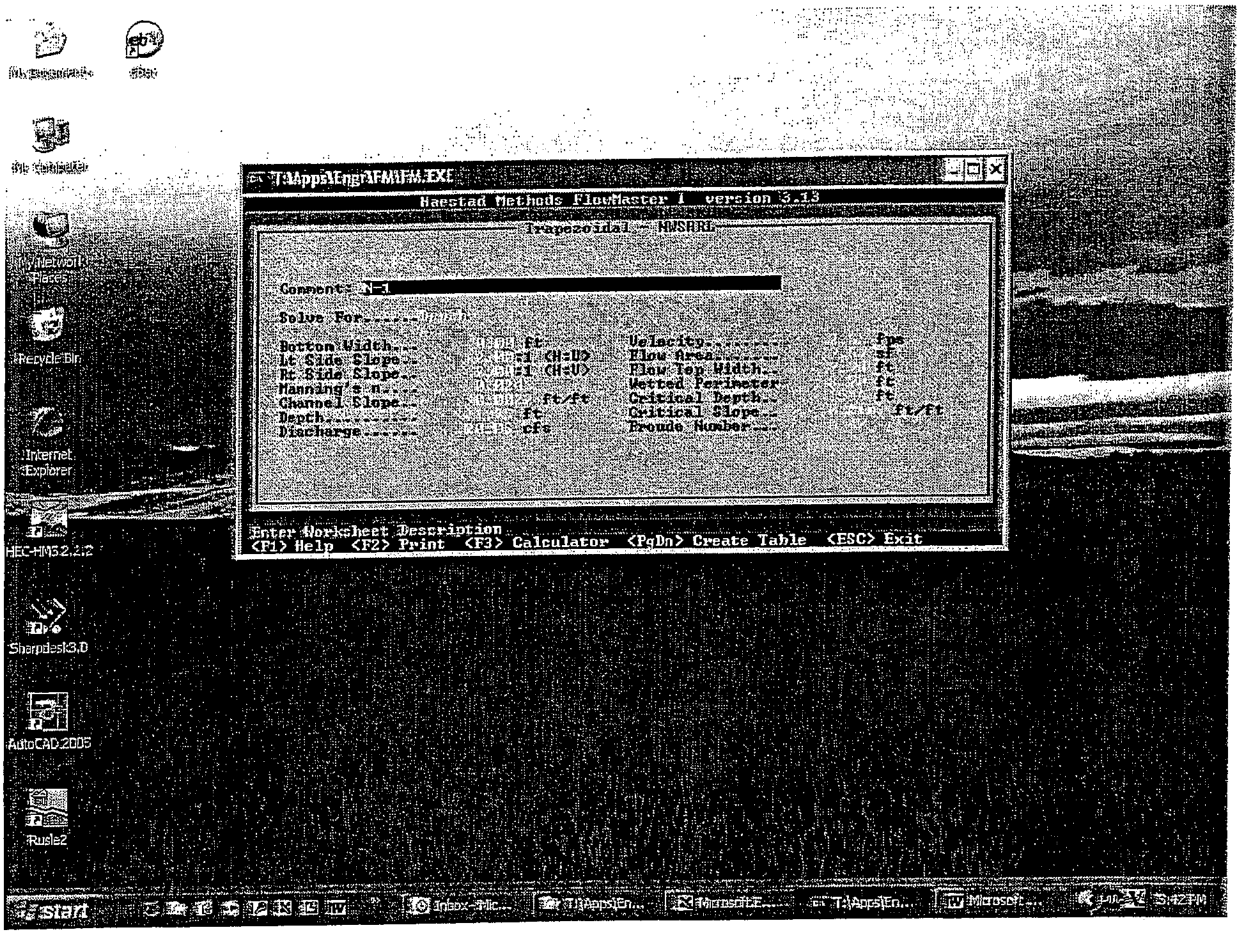
*** RESULTS ***

Flow Rate (cfs)	Tailwater Depth(ft)	..Headwater (ft).. In.Ctrl.	Out.Ctrl.	Normal Depth(ft)	Critical Depth(ft)	Depth at Outlet(ft)	Outlet Vel.(fps)
4.69	0.50	2.40	0.08	0.60	0.90	0.60	9.46

Enter Flow Rate and Tailwater, or Press the <Esc> Key to End

ATTACHMENT 5.

PERIMETER CONVEYANCE CHANNEL CAPACITY CALCULATIONS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Manning's n
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Depth ft
Discharge cfs
Velocity fps
Flow Area sf
Flow Top Width ft
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Critical Slope ft/ft
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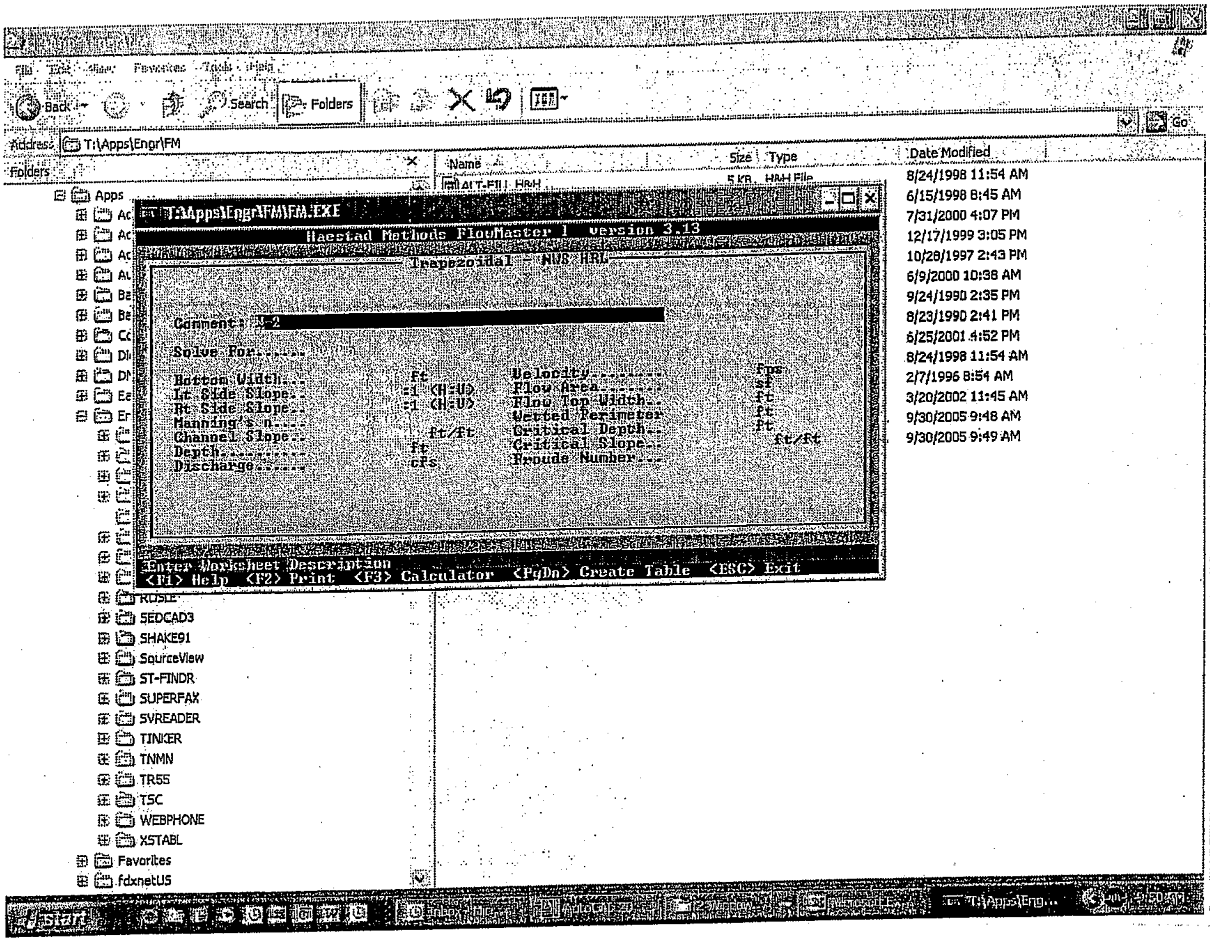

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Channel Slope.. ft/ft
Depth......... ft
Discharge...... cfs
Velocity........ fps
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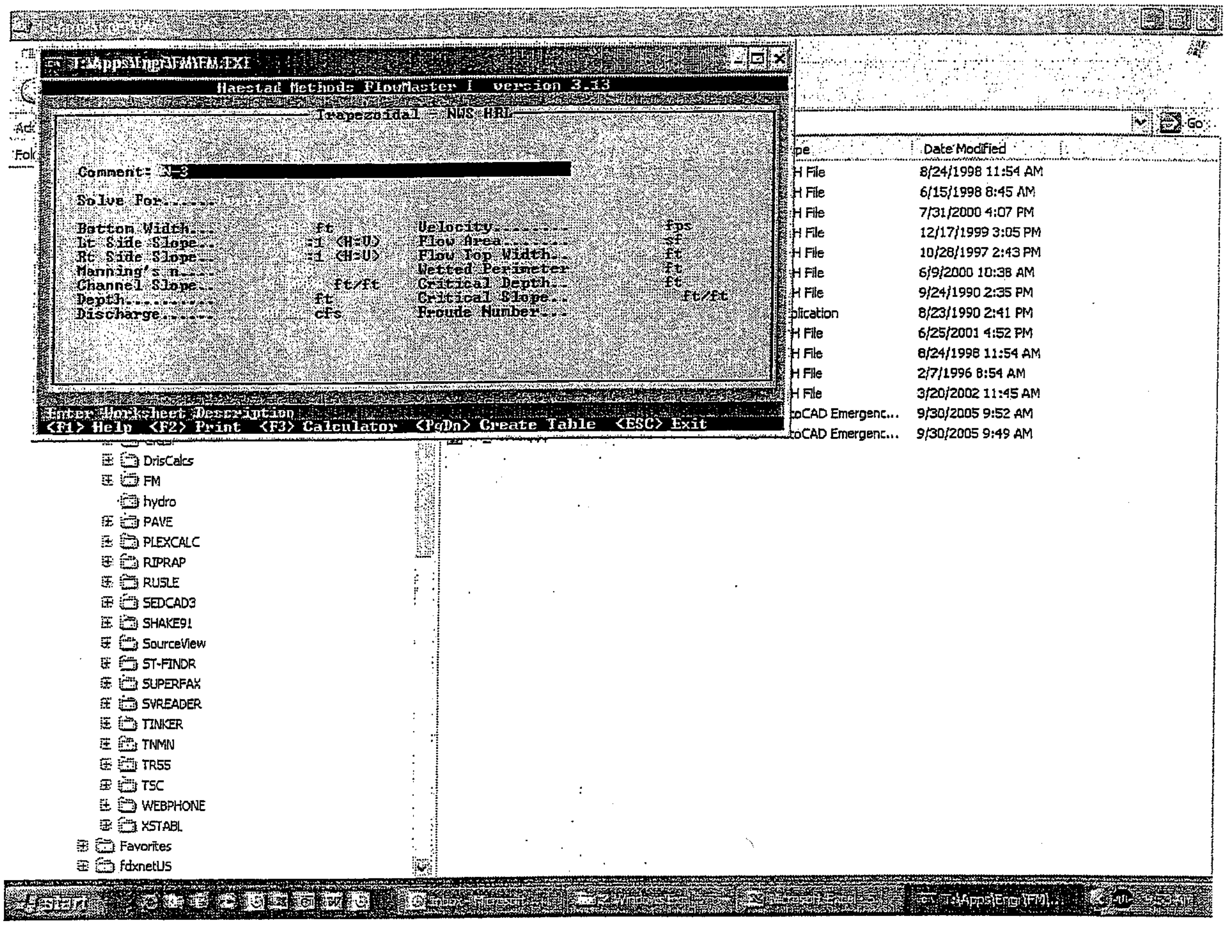

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Channel Slope..
Depth..........
Discharge......
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ft/ft
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cfs
Velocity........
Flow Area.......
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Wetted Perimeter
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Critical Slope..
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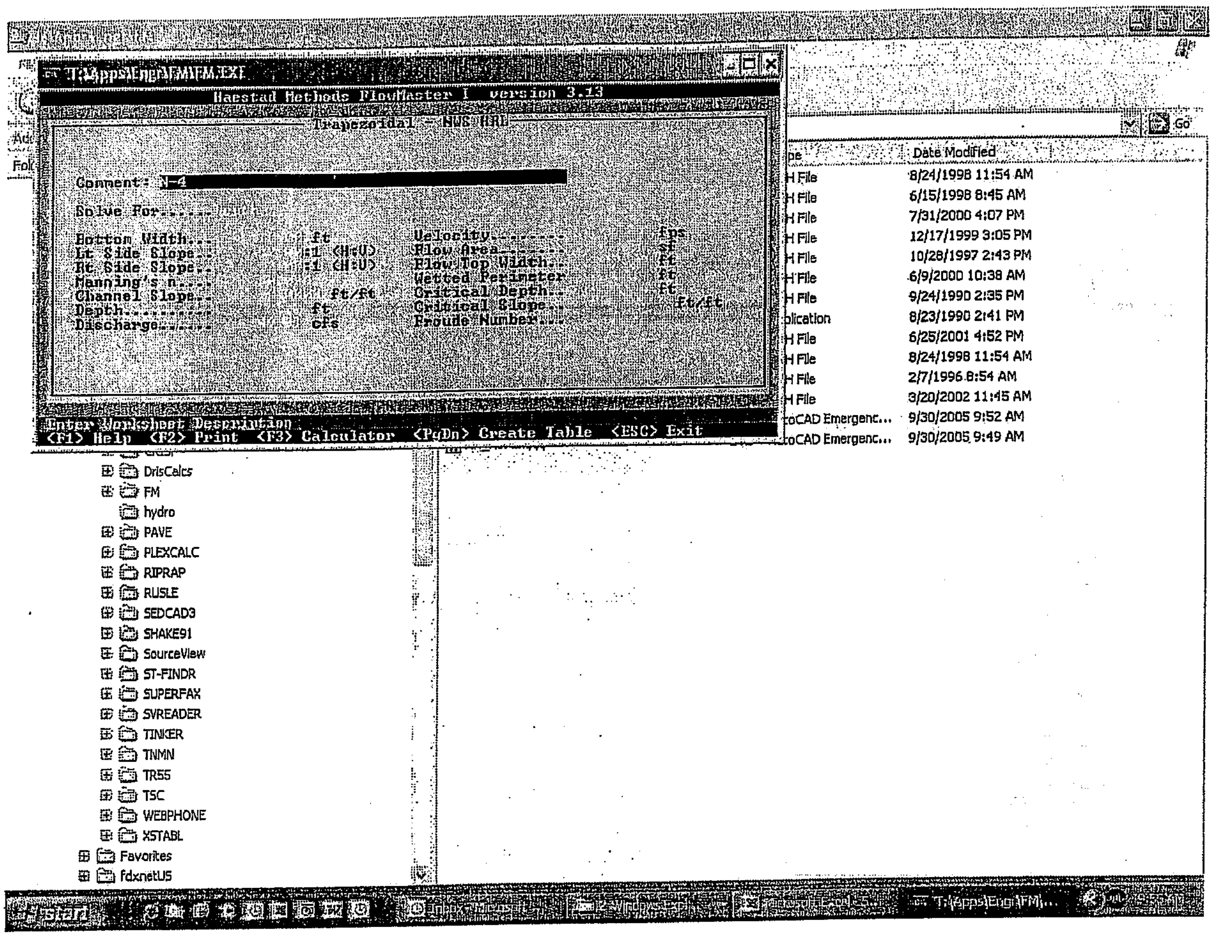
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Manning's n....
Channel Slope..
Depth..........
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:1 (H:V)
ft/ft
ft
cfs
Velocity........
Flow Area.......
Flow Top Width..
Wetted Perimeter
Critical Depth..
Critical Slope..
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ft/ft
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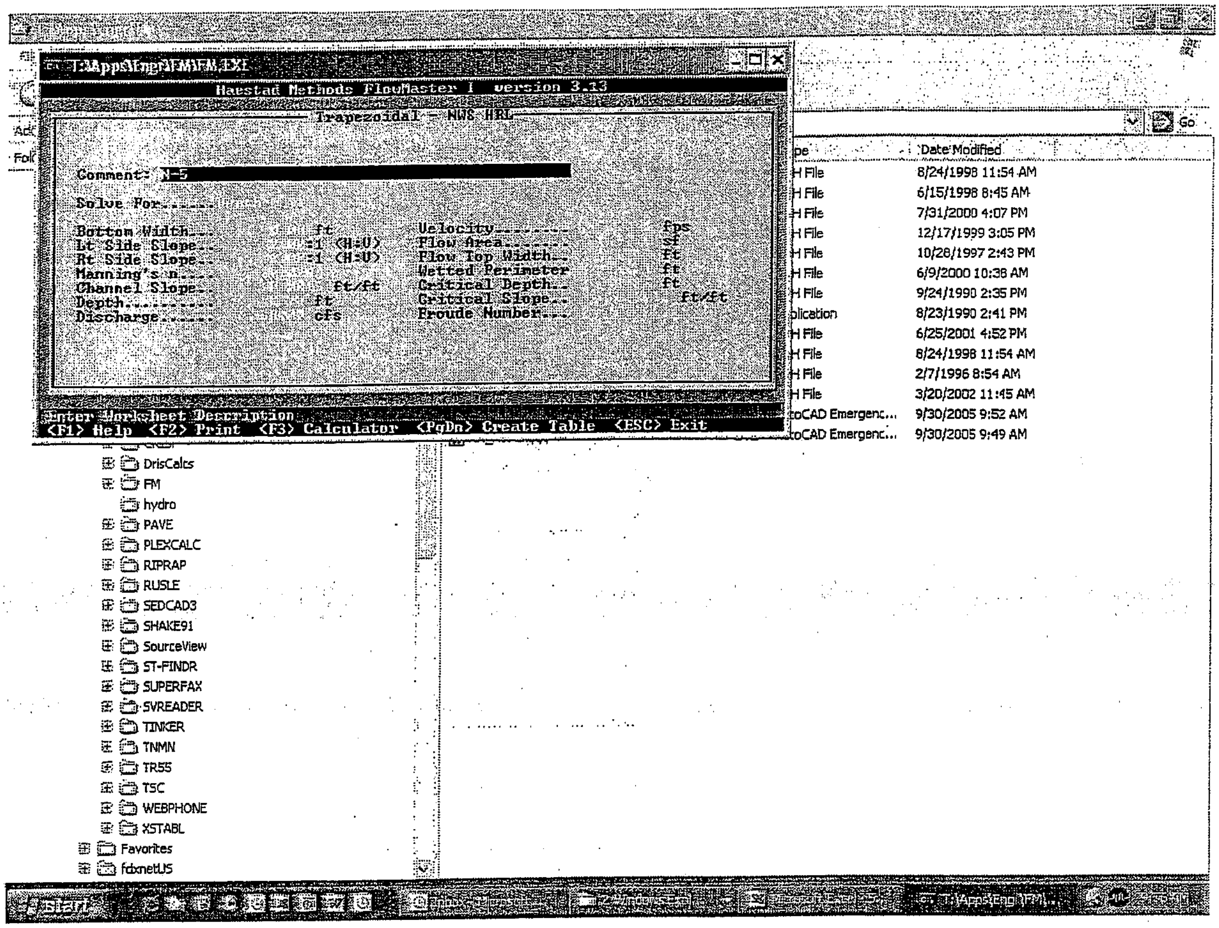

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Channel Slope.. ft/ft
Depth......... ft
Discharge...... cfs
Velocity........ fps
Flow Area....... sf
Flow Top Width.. ft
Wetted Perimeter ft
Critical Depth.. ft
Critical Slope.. ft/ft
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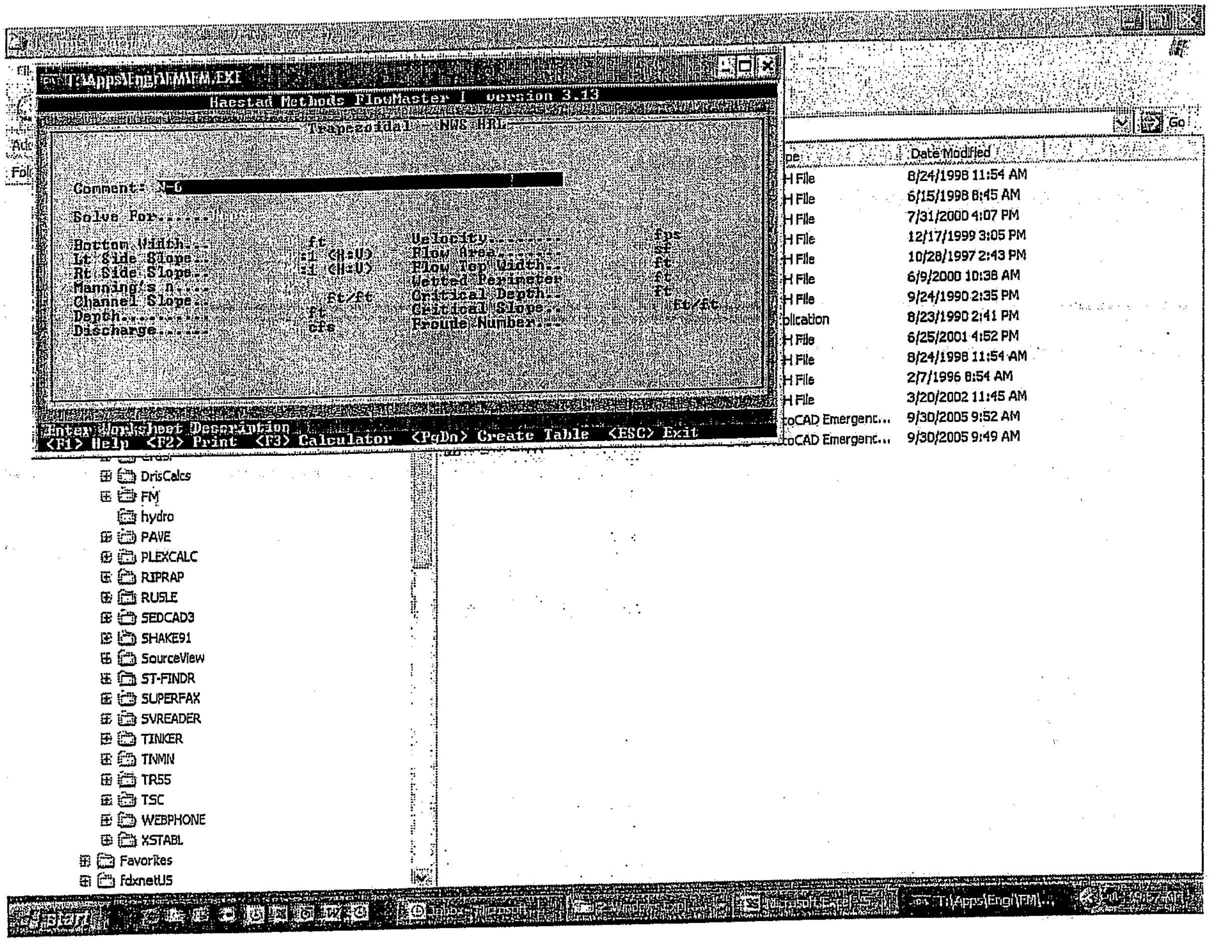
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Trapezoidal NWS HRL
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Manning's n....
Channel Slope..
Depth..........
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ft
:1 (H:V)
:1 (H:V)
ft/ft
ft
cfs
Velocity........
Flow Area.......
Flow Top Width..
Wetted Perimeter
Critical Depth..
Critical Slope..
Froude Number...
fps
sf
ft
ft
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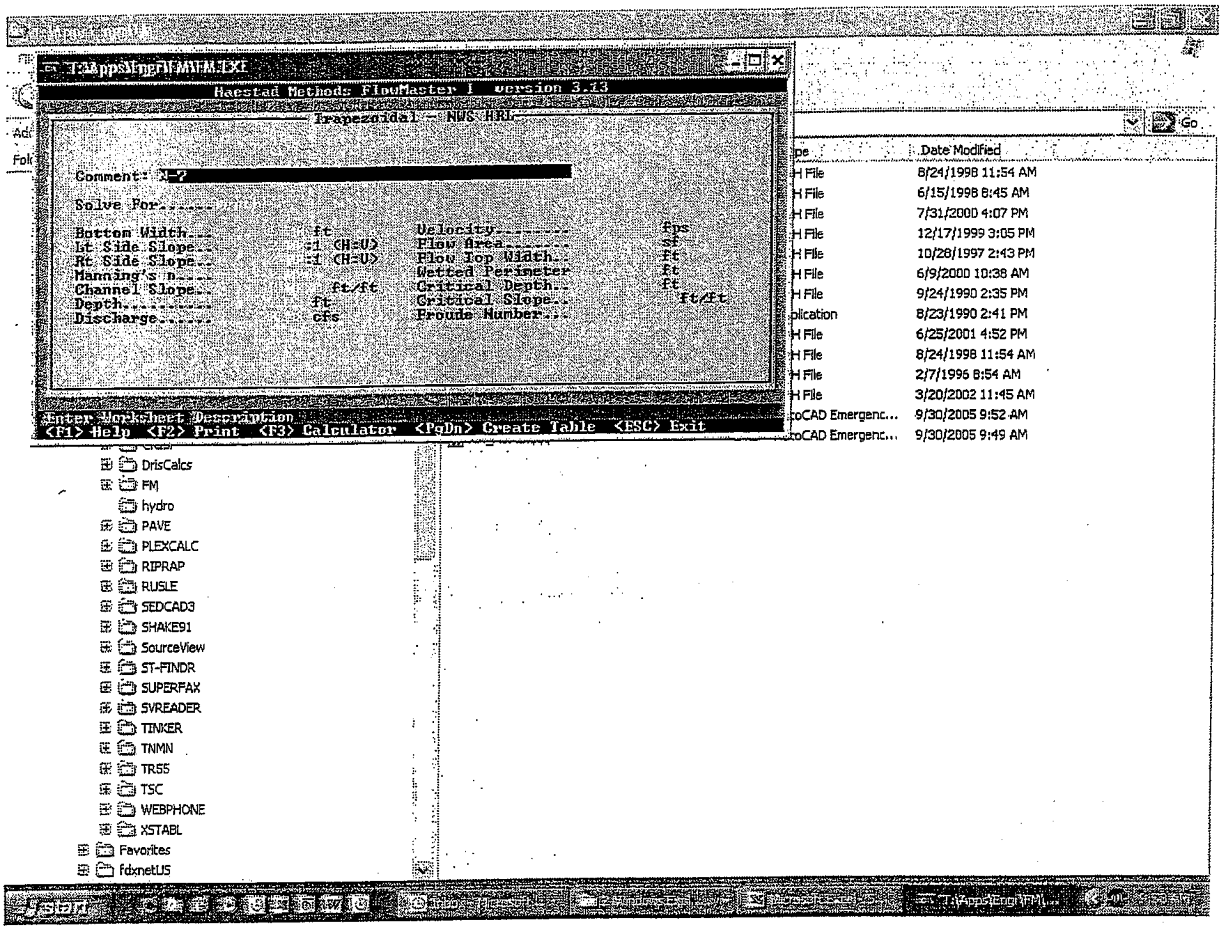
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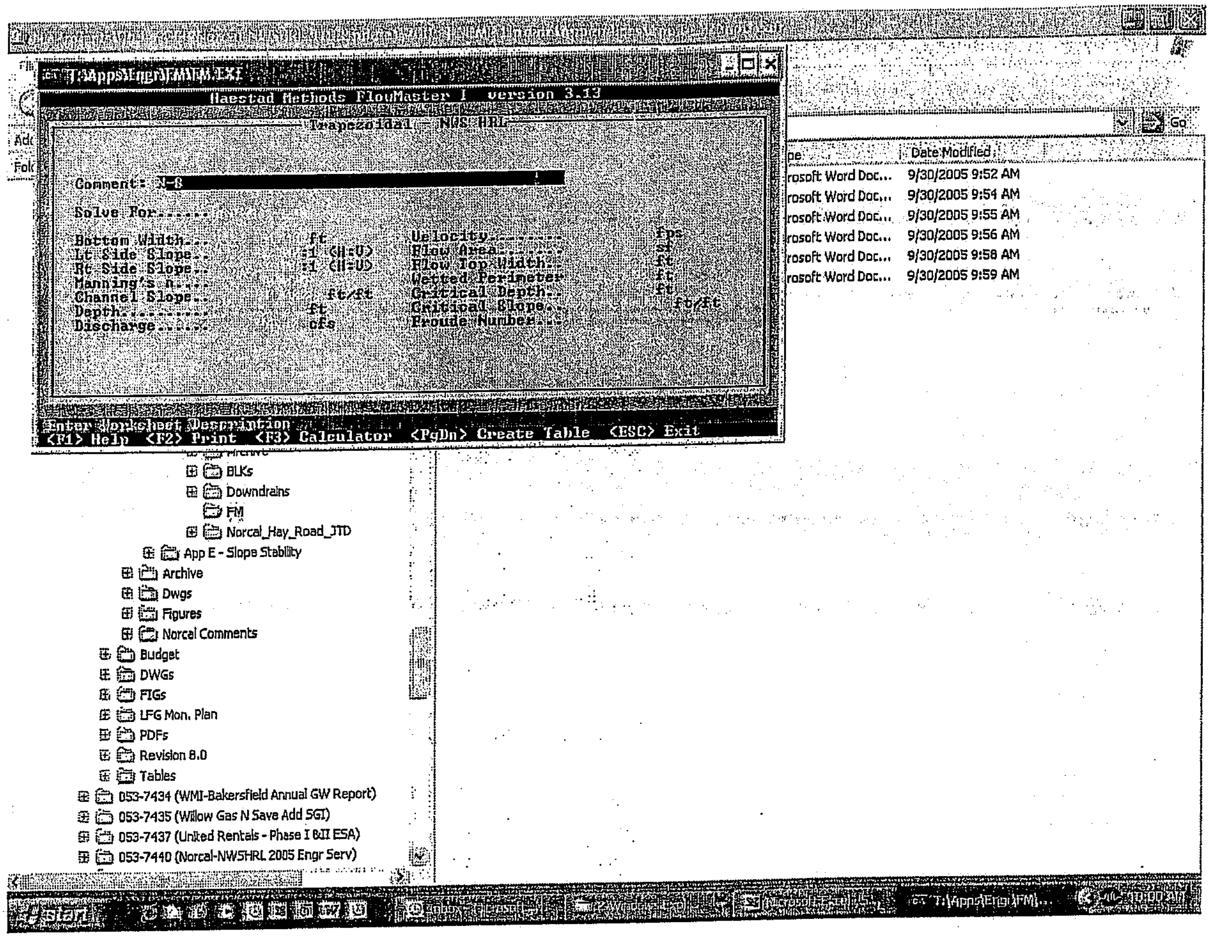
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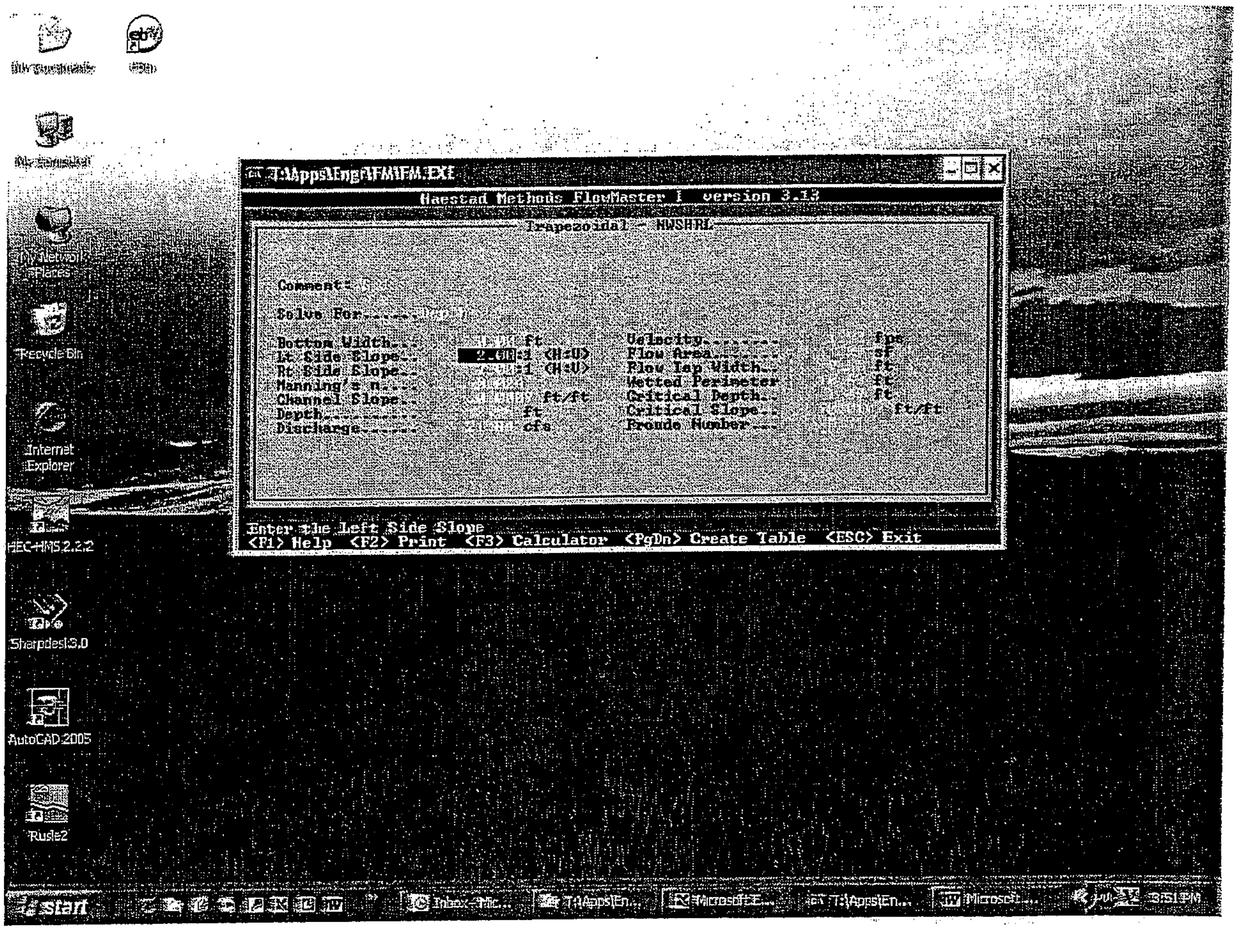
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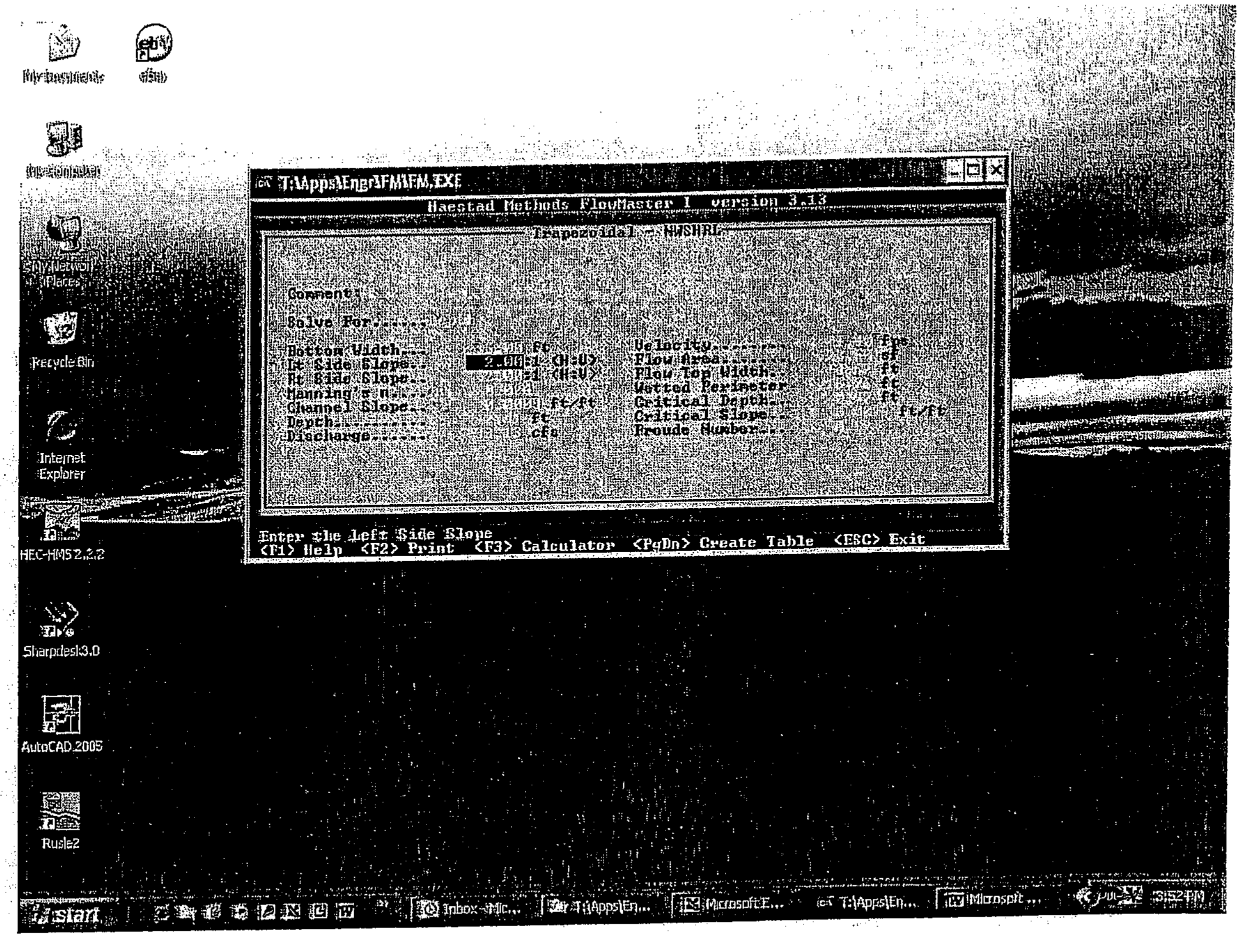
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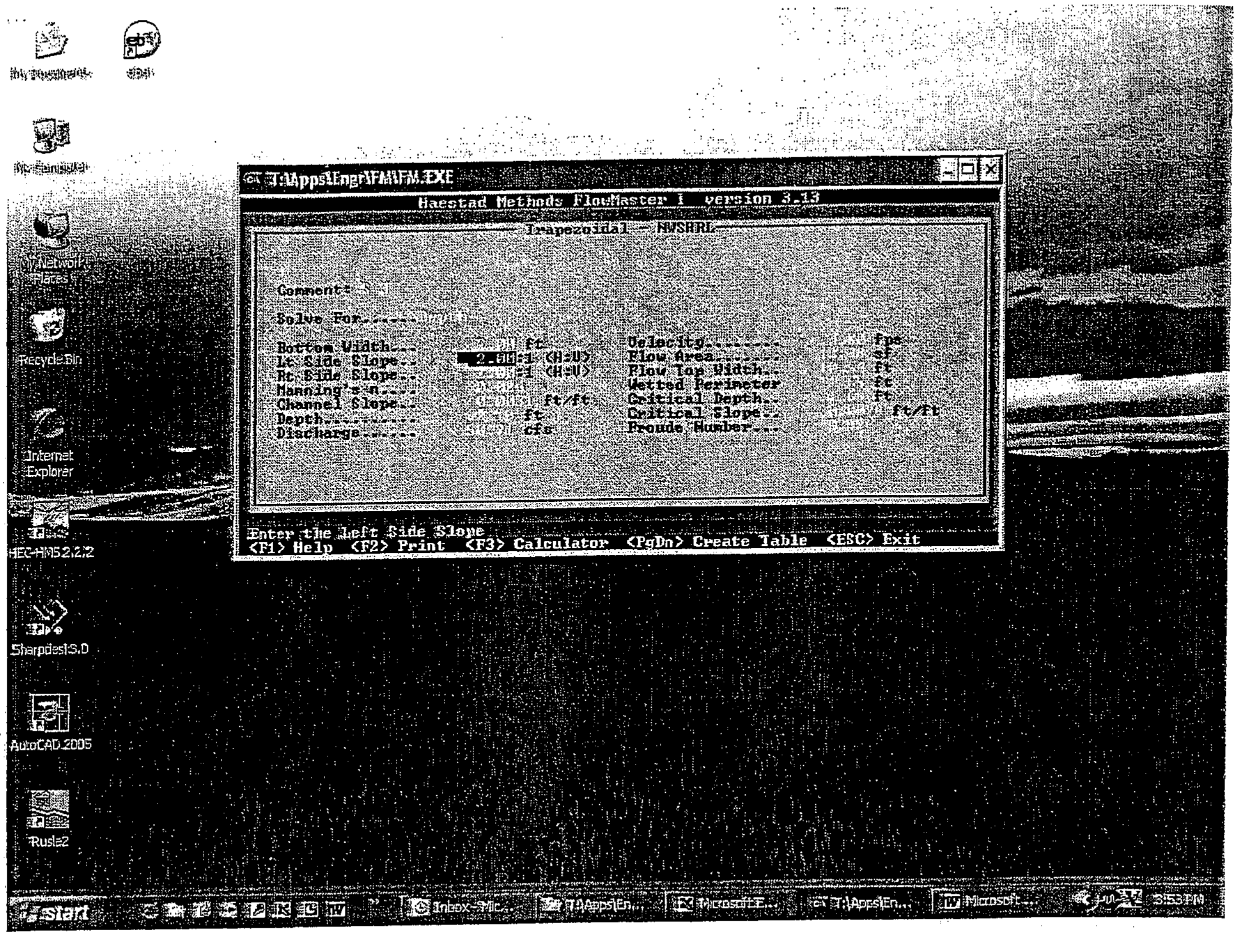

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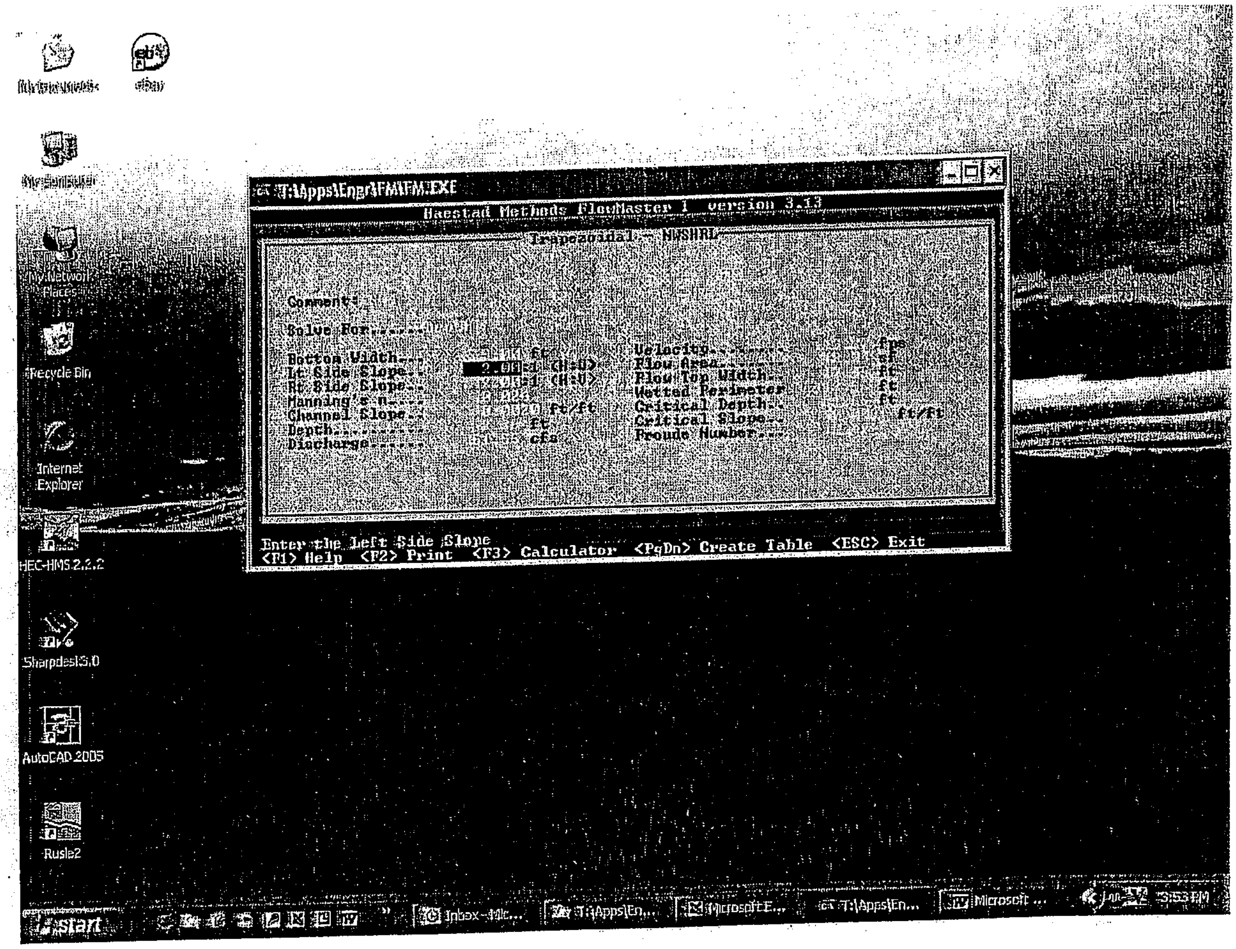

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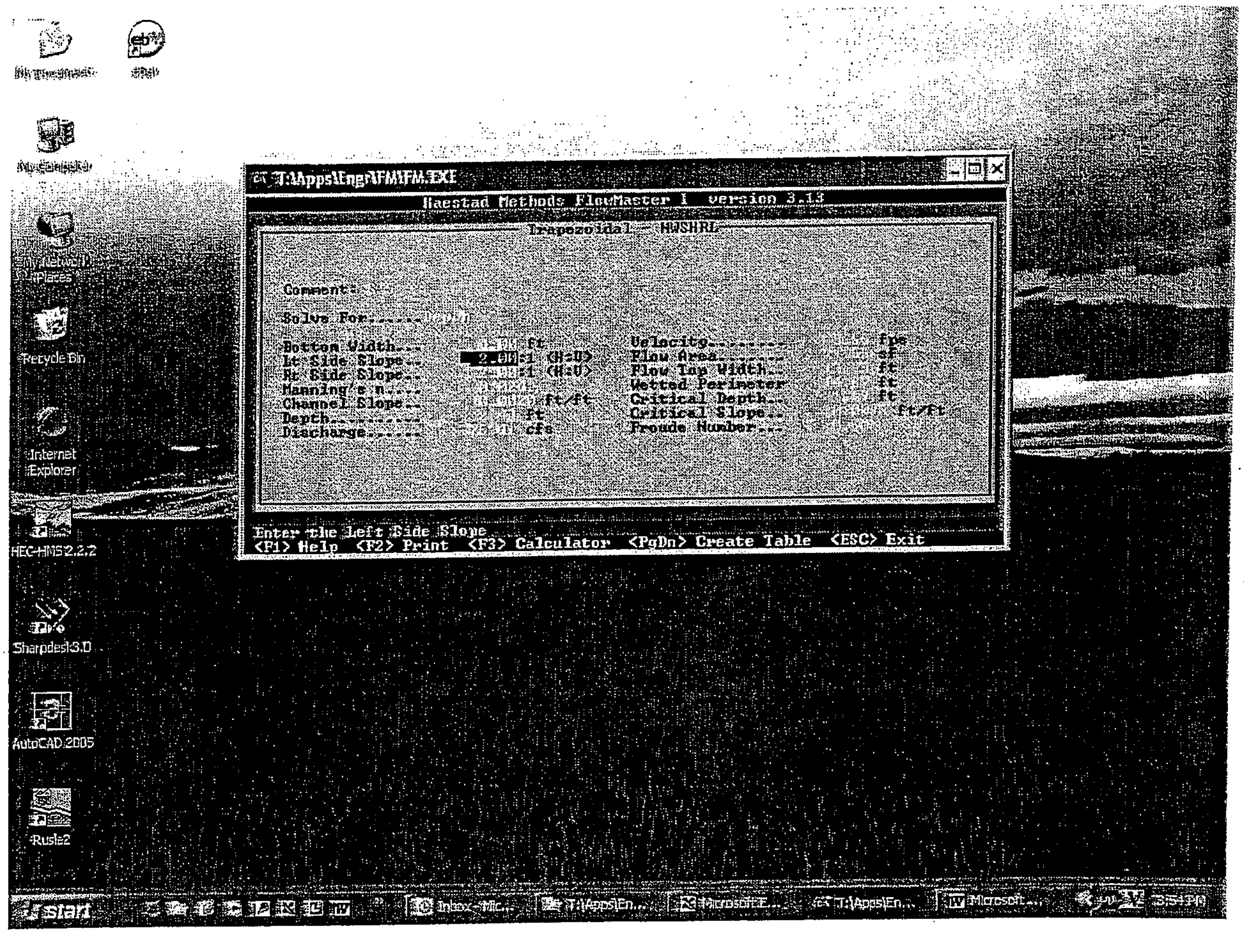

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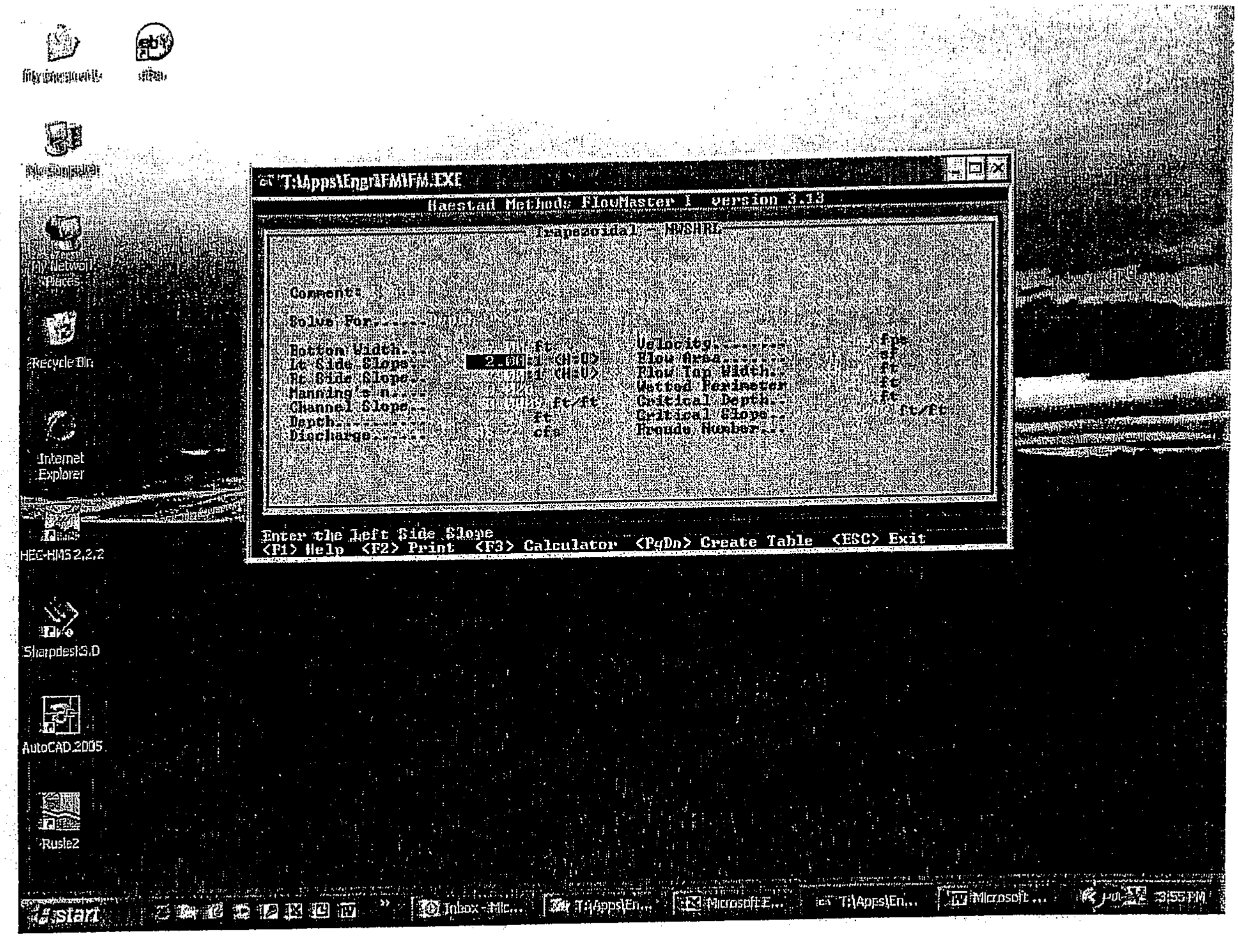
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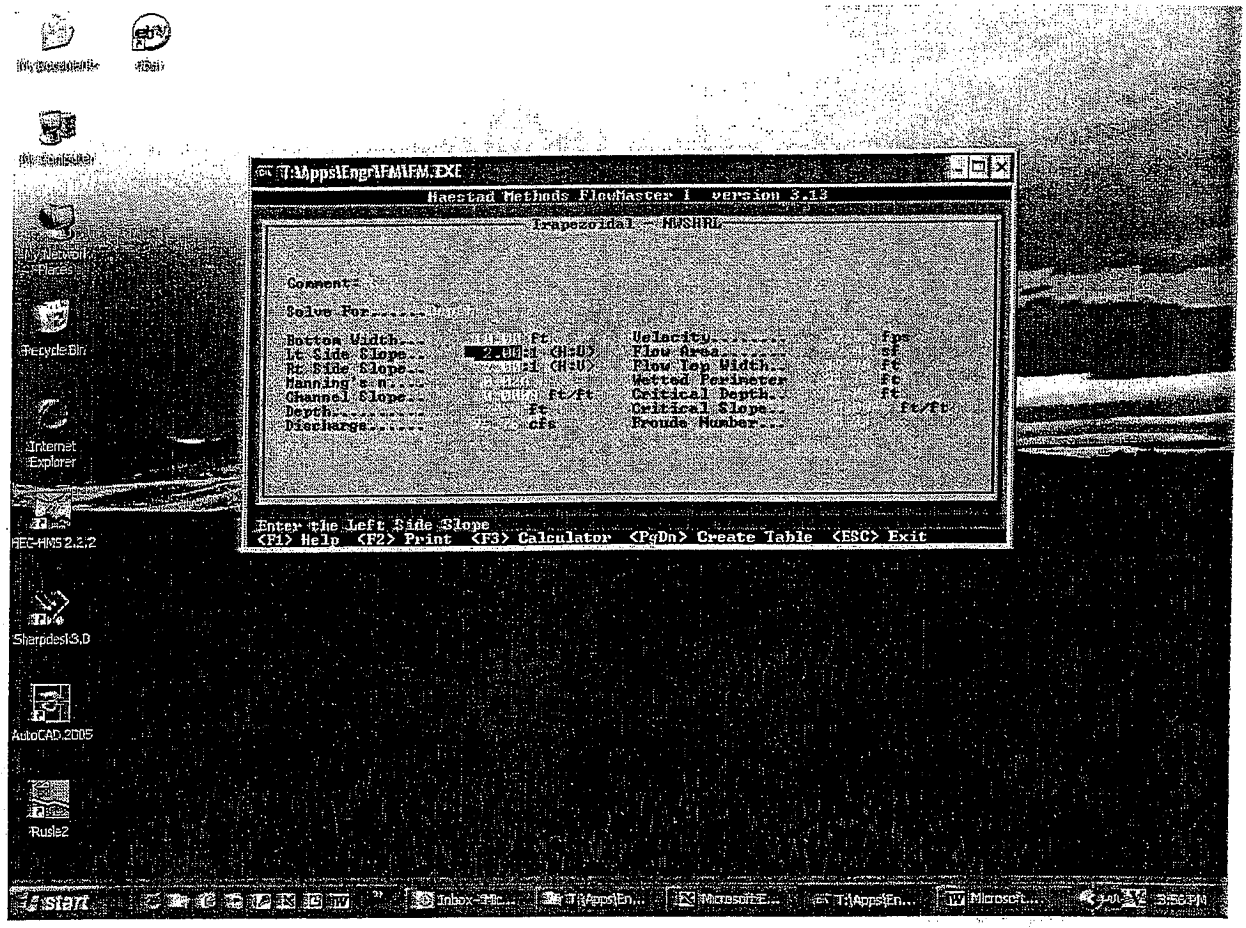

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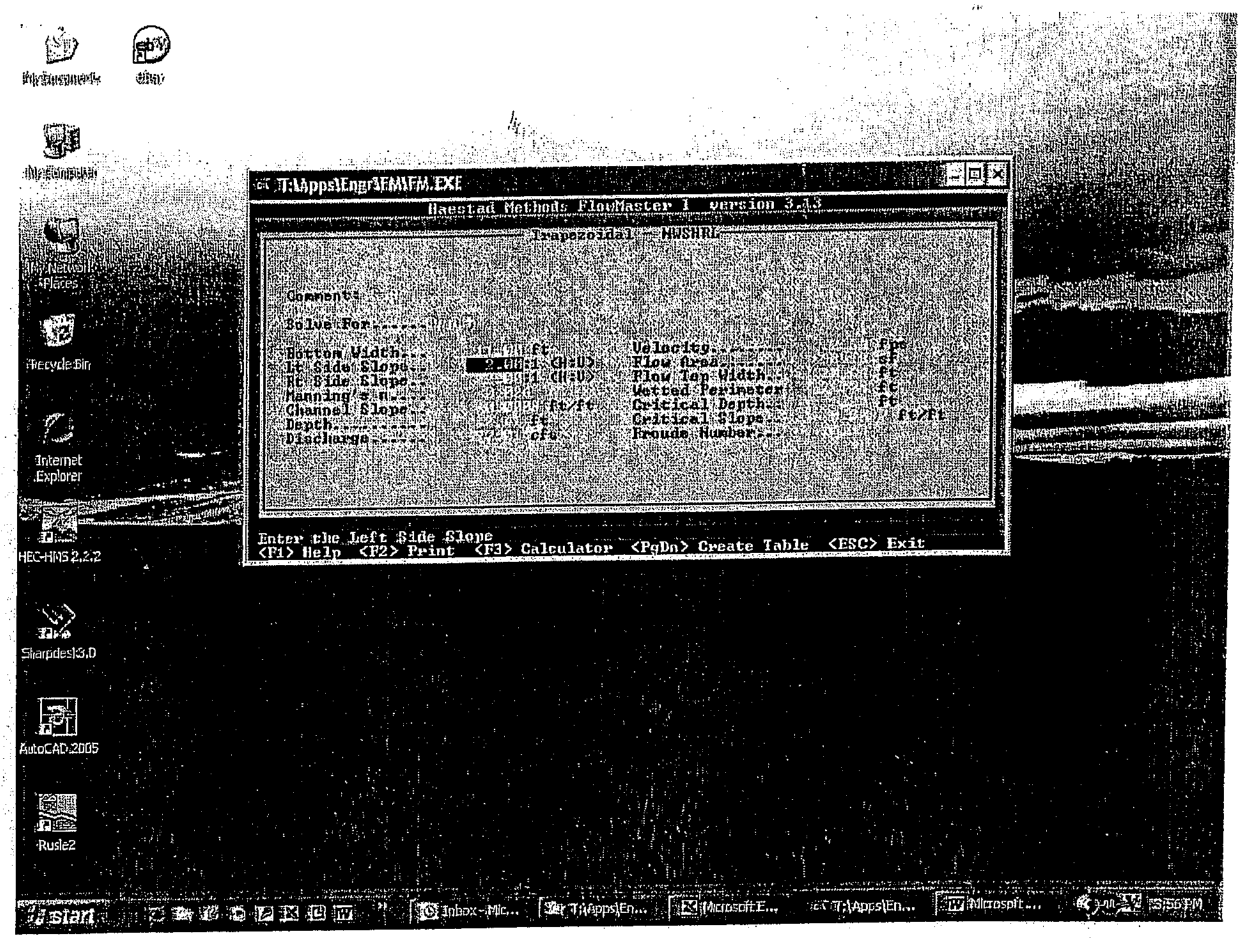

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Appendix G

Closure/Postclosure Cost Detail

ATTACHMENT A
INITIAL COST ESTIMATE WORK SHEET

Site Description

The following questions will provide general information regarding the site description, the type of waste accepted at the site and basic geological information. This information will aid in assessing factors that may affect the initial cost estimates.

Prepared By: Golder Associates Inc.
Revised: April 24, 2007

General Site Information:

Name of Solid Waste Landfill:	NWSHRL
Solid Waste Facilities Permit Number:	48-AA-0002
Facility Operator:	Norcal
Site Owner:	NWS
Site Location:	Township 14 North, Range 5 East, Mt. Diablo Base and Meridian
Assessors Parcel Number:	15-080-17
Site Address:	6426 Hay Road, Vacaville, CA 95687

hat is the existing State Water Resources Control Board classification of the solid waste landfill.

New (If WDR revised since 11-84)

______ Class I

Note: The solid waste landfill is excluded from these requirements, if the facility is a hazardous waste facility or co-disposal facility of both hazardous and nonhazardous waste as a RCRA Subtitle C facility subject to specified closure plan requirements

X Class II

______ Class III

Old

______ Class I

______ Class II-1

______ Class II-2

______ Class II-2

2. What is the anticipated closing date for the existing permitted landfill? Proposed expansions which have not been approved by the Board and LEA are not to be included in these calculations. Include calculations supporting the estimated date. (Attach additional sheets as necessary).

Month: ______ Year: 2077

Type of Fill

3. **Type of Fill (Check appropriate type)**

______	Trench	______	Canyon
X	Area	______	Other (describe)
______	Pit		

Volume of Waste

4. **What is the estimated in-place volume of landfilled wastes at the site in cubic yards? (as of April 1, 2007 and not including DM-1)**	3,910,000
5. **What is the design capacity of the site in cubic yards? (Table 4, Item 5 - Net Total Refuse Airspace)**	34,811,000
6. **Minimum thickness of waste (ft)?**	1
7. **Average thickness of waste (ft)?**	83
8. **Maximum thickness of waste (ft)?**	185
9. **Average height above surrounding terrain (ft)?**	103
10. **Typical inclination of side slopes, in ratio (horizontal:vertical)? (e.g., 5:1, 2:1)**	4:1

Note:

11. **Quantity of waste typically received (tons/day)?**	425
12. **Total permitted site acreage?**	
13. **Waste disposal area acreage?**	260

Waste Description

14. Estimate of solid waste received (total entries for residential, commercial, inductrial, demolition, and other should add up to 100%)

% Residential 40% % Commercial 55%

% Industrial ______ % Demolition ______

% other (special waste streams, such as ash, auto shredder waste, infectious waste, sludge, asbestos) 5%

Describe material under "other" and give its percentage

Material	**Percentage**
Sludge	5%

15. Briefly describe the underlying geology of the site. (Mark as many boxes that apply)

______ Shallow alluvium <50' X Deep alluvium > 50'

______ Sedimentary ______ Igneous

______ Metamorphic

a. What is the name of the nearest major fault Sierran Foothill Fault System

b. Distance from site 20 miles

c. On-site fault(s), if known None known

16. What are the groundwater characteristics

a. What is the depth to groundwater (ft) 5 to 30 ft

This will be the range of water levels, from well data, in a groundwater will network. Note: Consider seasonal variation from rainy to dry period, wet and dry years, well locations and variations in the subsurface geology.

Highest recorded level (depth in ft) Data Not Avail.

Well Number ______ Date Recorded ______

Highest recorded level (depth in ft) ______

Well Number ______ Date Recorded ______

Typical: ______

b. What direction does the groundwater flow? West

c. What is the groundwater gradient? 0.5 to 2 %

CLOSURE COSTS

17. Area of Final Cover		
a. Surface area of top deck (sf)		1,578,954 sf
b. Surface area of side slopes to be capped (sf)		10,105,109 sf
1) Plan area of side slopes to be capped (sf)		9,803,396 sf
2) Slope Correction Factor		1.031
18. Final Cover Soil		
a. Thickness		
1) Top deck thickness (ft)		1 ft
2) Side slope thickness normal to the slope (ft)		1 ft
b. Volume (cy) = (Line 17a * Line18a) + (Line 17b * Line 18b) / 27 cf/cy Note: 1 foot of veg. soil; assume foundation already in place		432,743 cy
c. Percent native soil used (decimal)		1
d. Native soil acquisition cost (excavation, hauling) ($/cy)	$	- /cy
e. Native soil cost ($) = (Line 18b * Line 18c * Line 18d)	$	-
f. Percent imported soil (decimal)		0
g. Imported material acquisition cost (purchase, delivery, etc.) ($/cy)	$	- /cy
h. Imported soil cost ($) = (Line 18b * Line 18f * Line 18g)	$	-
i. Placement, grading and compaction unit cost ($/cy)	$	8.00 /cy
j. Placement, grading and compaction cost ($) = (Line 18b * Line 18i)	$	3,461,945
k. Subtotal final cover layer ($) = (Line 18e + Line 18h + Line 18j)	$	**3,461,945**
19. Clay Layer		
a. Area to be capped (sf) = (Line 17a + Line 17b)		0 sf
b. Thickness, minimum 1 foot (ft)		0 ft
c. Volume of barrier layer soil (cy) = (Line 19a * Line 19b) / 27 cf/cy		0 cy
d. Percent on-site hydraulic barrier material (decimal)		1
e. On-site hydraulic barrier material unit cost (excavation, hauling, etc.) ($/cy)	$	- /cy
f. On-site hydraulic barrier material cost ($) = (Line 19c * Line 19d * Line 19e)	$	-
g. Percent imported hydraulic barrier material (decimal)		0
h. Imported hydraulic barrier material unit cost (purchase, delivery, etc.) ($/cy)	$	- /cy
i. Imported hydraulic barrier material cost ($) = (Line 19c * Line 19g * Line 19h)	$	-
j. Placement, grading and compaction unit cost ($/cy)	$	- /cy

k. Placement, grading and compaction cost ($) = (Line 19c * Line 19j)	$	-
l. Subtotal hydraulic barrier material cost ($) = (Line 19f + Line 19i + Line 19k)	$	-

20. Geosynthetic Materials (if applicable)

Note: This item must be esitmated in addition to the hydraulic barrier layer unless/until an alternative final cover design has been approved in the closure plan.

a. Type of geosynthetic materials used in cover		60-mil HDPE Geomembrane, Geocomposite, GCL, Geotextile
b. Quantity (sf)		Varies (see summary table) sf
c. Purchase, delivery and installation unit cost ($/sf)		Varies (see summary table) sf
d. Geosynthetic layer testing (percent of total geosynthetic membrane unit cost) (decimal)		0.02
e. Geosynthetic materials cost ($) = (Line 20b * Line 20c * (1+Line 20d))	$	14,220,777

21. What other types of materials/layers are included in the design (e.g., asphalt-tar, gravel for gas venting)?

___X___ None

22. Design/Construction Quality Assurance

Note: The following cost estimates apply to the quality assurance activities necessary to ensure that the final cover is installed properly, as specified in the design parameters, and fulfill the conditions mandated by regulations.

a. Monitoring costs incurred while evaluating the final cover system components:

1) Laboratory testing fees (e.g., soil permeability, soil moisture/density relationship) ($)	$	180,000
2) Field test expenditures (e.g., test pad, field permeability tests, and relative compaction tests) ($)	$	120,000
b. Inspection labor (e.g., initial inspection of native and imported soil, visual check of completed cover) ($)	$	300,000
c. Reporting costs (e.g., reporting procedures, corrective measure reports) ($) (Post-Closure Maintenance Plan)	$	30,000
d. Engineering design costs ($)	$	95,000
e. Subtotal of quality assurance costs ($) = (Line 22a1 + Line 22a2 + Line 22b + Line 22c + Line 22d)	$	**725,000**
23. Final Cover Subtotal ($) (Line 18k + Line 19l + Line 20e +Line 22e)	$	**18,407,722**

Revegetation

24. Soil Preparation

Note: Soil preparation for the vegetated layer is not required because planting, fertilizing and mulching will proceed immediately following the vegetative layer placement.

a. Area to be vegetated, included closed areas that need replanting (acres) (Line 17a + Line 17b) / 43560 sf/acre		260 acres
b. Preparation unit cost ($/acre)	$	- /ac
c. Subtotal soil preparation ($) = (Line 24a * Line 24b)	$	-

25. Planting

a. Type of vegetation		Native grasses that require no irrigation
b. Planting unit cost (e.g. seeding, sprigging, plugs) (include cost of seeds, sprigs, plugs)($/acre)	$	1,000 /ac
c. Planting costs ($) = (Line 24a * Line 25b)	$	**260,000**

26. Fertilizing

a. Type of Fertilizer - included in 25b		
b. Fertilizer unit cost ($/acre)	$	- /ac
c. Subtotal fertilizing costs ($) = (Line 24a * Line 26b)	$	-

27. Mulching

a. Mulching unit cost ($/acre) - Mulch is included in 25b	$	- /ac
b. Subtotal mulching costs ($) = (Line 24a * Line 27a)	$	-

28. Irrigation installation cost Irrigation is not required

a. Irrigation installation unit cost ($/acre)	$	- /ac
b. Subtotal irrigation installation costs ($) = (Line 9a * Line 13a)	$	-

29. Revegetation Subtotal

a. Subtotal revegation costs ($) = (Line 24c + Line 25c + Line 26b + Line 27b + Line 28b)	$	**260,000**

LANDFILL GAS MONITORING AND CONTROL

Does the landfill have a gas monitoring network?

YES [X] NO [ ]

If NO, (Partial network in-place, additional gas monitoring and control will be installed at closure)

a. What will be the spacing between monitoring wells (<= 1000 ft)		1000	ft max.
b. What criteria was used to select this spacing?		N/A	
c. Total number of gas monitoring wells		19	wells
d. Number of probes per wellbore		1	

Suggested minimum:
1) Surface (5 - 10 ft.)
2) Intermediate (half the depth of boring)
3) Deep (to depth of boring)

e. Cost of design ($)	$	2,000	
f. Cost of drilling and materials ($)	$	1,400	/well
g. Cost of installation and permitting ($)	$	500	/well
h. Unit cost for gas monitoring network ($) = (Line 30e / Line 30c + Line 30f + Line 30g)	$	2,005	/well

YES, (Considered "yes" prior to closure)

i. How many gas monitoring wells are in place?		11	
j. What is the lateral spacing between gas monitoring wells?		1000	ft max.
k. Number of probes per wellbore		1	
l. Are additional wells required at closure?		8	wells
m. Additional number of probes per boring		1	
n. Cost to expand gas monitoring network (design, drilling and installation) ($)	$	**16,042**	

31. Is there a gas control system operating at the landfill?

YES [ ] NO [X] Will be installed prior to closure => Yes

If YES,

a. What type(s) are in place (e.g., recovery, perimeter extraction, air injection, etc.) N/A

If NO, (To be installed prior to closure)

b. What type of system will be installed during closure? N/A

c. Cost of design ($)	$	-
d. Cost of materials ($)	$	-
e. Cost of installation ($) - relocating collection lines	$	36,000
f. Subtotal for gas control system ($) = (Line 31c + Line 31d + Line 31e)	$	**36,000**

32. Landfill Gas Subtotal

a. Subtotal for landfill gas monitoring and control ($) = (Line 32n + Line 32f) **$ 52,042**

GROUNDWATER MONITORING INSTALLATIONS

33. Does the landfill have a groundwater monitoring network?

YES [X] NO [ ]

If YES,

a. Number of up-gradient wells, minimum 1 — 3

b. Number of down-gradient wells, minimum 3 — 8

If NO,

c. Number of wells to be installed (min. 1 up-gradient and 3 down-gradient) — 0

d. Total drilling depth (ft) — ft

e. Cost of design ($)	$	-
f. Cost of well materials, installation and development ($)	$	-

34. Groundwater monitoring subtotal

a. Subtotal for groundwater monitoring installation ($) = (Line 33e + Line 33f) $ -

DRAINAGE

35. Is there surface water run-on and run-off control system existing at the site?

YES [X] NO [ ]

If NO, (Surface water conveyance system will be installed prior to closure)

a. What will be the estimated cost of installation and construction of the drainage conveyance system to accommodate anticipated run-off (e.g., diversion ditches, downdrains, energy dissipators, etc.) and protection from run-on (e.g., dikes, levees, protective berms, etc.)? ($)	$	665,400
b. Cost of design ($)	$	-
c. Subtotal of drainage costs ($) = (Line 35a + Line 35b)	**$**	**665,400**

SECURITY

36. Is there a security system established at the landfill?

YES [ ] NO [X]

If NO, Security fencing and gates to be installed prior to closure

a. What is presently in-place at the site:

Fencing	X	Locks	X
Gates	X	Other	
Signs			

b. Estimated cost of installing a security fence, access gates with locks, and/or informational signs (e.g., either around the site perimeter or around enclosures) to protect equipment and the public and is compatible with post-closure use ($)	$	-
c. Estimated cost of dismantling and removing security equipment not necessary after closure and incompatible with post-closure use ($)	$	-
d. Subtotal security system installation costs ($) = (Line 36b + Line 36c)	$	-

SUPPLEMENTAL DATA

37. Supplemental Costs

a. Site access road and service road costs ($)	$	-
b. Survey and settlement monuments costs ($)	$	5,000
c. Aerial topographic survey cost at the end of closure activities ($)	$	5,000
d. Well abandonment costs ($)	$	-
e. Erosion control measures to be used		
f. Erosion control measures cost ($)	$	-
g. Subtotal supplemental costs ($) = (Line 37a+Line 37b+Line 37c+Line 37d+Line 37e+Line 37f)	**$**	**10,000**

POST-CLOSURE MONITORING AND MAINTENANCE COSTS

REVEGETATION

38. Fertilizing (annually)

a. Area to be fertilized (acres)	Assume site will be fertilized once during construction		0 acres
b. Type of fertilizer			
c. Fertilizer unit cost ($/acre/year)		$	-
d. Fertilizing costs ($/year) = (Line 38a * Line 38c)		$	-

39. Irrigation

a. Type of irrigation system	None		
b. Quantity (gallon/day)			0 gal/day
c. Irrigation unit cost ($/gallon)		$	- /gallon
d. Number of irrigation days per week			0
e. Annual irrigation costs ($/year) = (Line 39b * Line 39c * Line 39d) * 52 wk/year		$	- /year
f. Annual maintenance costs ($/year)		$	- /year
Subtotal irrigation costs ($/year) = (Line 39e + Line 39f)		$	- /year

40. Revegetation Subtotal

a. Revegetation subtotal ($/year) = (Line 38d + Line 39g) - add 13 acre reseed @250/acre	$	**3,250**

LEACHATE MANAGEMENT

41. Does the solid waste disposal site have a liner?

YES [X] NO [ ]

42. Does the landfill have a leachate collection/removal system?

YES [X] NO [ ]

If YES,

a. What type of system? — Drainage gravel over floor with collection pipes and 17 sumps

b. Annual operating and maintenance costs of system ($/year) — $ 8,500 /year

43. Type(s) of on-site leachate treatment		
a. Type of treatment (on-site)		N/A
b. Volume/unit frequency (gal/day)		N/A gal/day
c. Leachate treatment unit cost ($/gallon)	$	/gallon
d. Annual on-site treatment costs ($/year)	$	/year
44. Type(s) of off-site treatment		
a. Volume/unit frequency (gal/day)		256 gal/day
b. Leachate treatment unit cost ($/gallon)	$	- /gal
c. Annual off-site treatment costs ($/year) (included in the maintenance cost)	$	- /year
d. Other (explain) (Trucking cost)	$	7,200
45. Leachate Sampling and Testing		
a. Number of samples per round		22
b. Sampling unit cost ($/round)	$	2,555 /round
c. Number of sampling rounds per year		2 /year
d. Annual sampling costs ($/year) = (Line 45b * Line 45c)	$	5,110 /year
e. Sample testing unit cost ($/sample)	$	1,090 /sample
f. Annual sample testing costs ($/year) = (Line 45a * Line 45c * Line 45e)	$	47,960 /year
g. Subtotal leachate sampling and testing costs ($/year) = (Line 45d + Line 45f)	$	53,070 /year
46. Subtotal leachate management costs		
a. Subtotal annual leachate management costs ($/year) (Line 42b + Line 43d + Line 44c + Line 44d + Line 45g)	**$**	**68,770** /year

MONITORING

4. Gas Monitoring Systems

a. Monitoring devices of principal gases:		GEM 500 (or equivalent) for LFG; PID calibrated to benzene for VOC's
b. Frequency of monitoring (e.g., daily, weekly, monthly)		4 /year
c. On-site annual monitoring costs for principal gases ($/year)	$	2,400 /year
d. Annual sampling costs for trace gases ($/year)	$	- /year
e. Annual testing costs for trace gases ($/year) = (Line 32a * Line 32d)	$	- /year
f. Assumed replacement frequency of probes, in years		10 years
g. Installation unit costs of probes ($)	$	1,000 /probe
h. Annual replacement costs ($/year) = (Line 39i * Line 47g)/(Line 47f)	$	1,100 /year
i. Annual maintenance costs ($/year) - includes $6,521/2 net O&M costs	$	3,361 /year
j. Subtotal of gas monitoring costs ($/year) (Line 32c + Line 32d + Line 32e + Line 32h + Line 32i)	$	**6,861** /year

48. Vadose Zone Monitoring

Is the vadose zone monitored at this landfill?

YES [X] NO [ ]

If YES,

a. What type of monitoring procedures and equipment are utilized?		Pan Lysimeters
b. Frequency of sampling per year		2 /year
c. Number of monitoring devices utilized		22
d. Sampling unit cost ($/sample)	$	1,955 /sample
e. Annual sampling costs ($/year)	$	3,910 /year
f. Testing unit cost ($/sample)	$	524 /sample
g. Annual testing costs ($/year)	$	23,056 /year
h. Assumed annual replacment frequency of devices		0
i. Installation unit cost of devices ($/device)	$	- /device
j. Annual replacement cost of devices ($/year) = (Line 33b * Line 33f)/(Line 33e)	$	- /year
k. Annual maintenance cost of devices ($/year)	$	- /year
l. Subtotal of vadose zone monitoring ($/year) = (Line 48c + Line 48d + Line 48g + Line 48h)	$	26,966 /year

49. Groundwater monitoring

a. Number of wells		25
b. Annual monitoring frequency		2 /year
c. Analytical methods (e.g., EPA 601 and 602 or 624, and 625)		per WDRs
d. Number of samples/round - includes 1 QC samples/round		26
e. Sample testing unit cost ($/sample)	$	623.80 /sample
f. Annual testing cost ($/sample) ((Line 49d * Line 49e * Line 49b))	$	32,438 /year
g. Annual sampling costs ($/year)	$	**13,560** /year
h. Assumed replacement frequency of wells, in years		10 years
i. Installation unit cost of wells ($/well)	$	5,000 /well
j. Annual replacement cost of wells ($/year) = (Line 49a * Line 49i)/Line 49h	$	12,500 /year
k. Annual well maintenance costs ($/year)	$	500 /year
l. Subtotal of groundwater monitoring ($/year) = (Line 49f + Line 49g + Line 49j + Line 49k)	$	**58,998** /year

<u>49(b). Surface Water Monitoring:</u> ****_**Note: Added line item by Golder (6/98)**_****

a. Number of monitoring points		7
b. Analytical methods (e.g., EPA 601 and 602 or 624, and 625)		per WDR's
c. Annual monitoring frequency		2 /year
d. Sample testing unit cost ($/sample)		592.9 /sample
e. Number of samples/round - include 1 QC sample		8
f. Annual sampling costs ($/year)	$	17,760 /year
g. Annual testing costs ($/year)	$	9,486 /year
h. Annual surface water sampling and testing costs ($/year) (Line 49(b)f + Line 49(b)g)	$	**27,246** /year

Monitoring subtotal ($/year)

a. Subtotal for monitoring groundwater, surface water, vadose zone, etc. ($/year) ((Line 47j + Line 481 + Line 491 + Line 49(b)h)	$	**120,071** /year

DRAINAGE

51. How often do you anticipate the need to perform maintenance activities (e.g., clear material from run-off surface water conveyances, erosion repair, minor grading, repair of articulated drains, problems with articulated drains, problems with run-on maintenance and repairs of levees, dikes, protective berms, etc. ?

		Annually
a. Annual maintenance costs ($/year)	$	18,000 /year

SECURITY

52. What are the estimated annual maintenance costs to repair/replace fencing, gates, locks, signs, and/or other security equipment at the landfill site ($/year)?	$	1,000 /year

INSPECTION

53. What will be the routine maintenance inspection frequency of the landfill during post-closure (minimum, semi-annually)?		semi-annually
a. Inspection unit cost ($)	$	1,000
b. Annual inspection costs during post-closure care period ($/year)	$	2,000 /year

Components that should be inspected include, but are not limited to:
Final cover - erosion damage
Final grading - ponding caused by settlement
Drainage control systems - continuity of articulated drains, sediment choked conduits
Gas collection/control systems
Leachate collection and treatment system effectiveness and continuity
Security - fences, gates and signs
Vector and control
Monitoring equipment
Litter control

54. Itemize annual costs for monitoring and post-closure maintenance procedures specific to this solid waste disposal site.

- Aerial topographic survey and settlement report, every 5 years (average over 5 years)	$	2,000
- DM-1 Groundwater maintenance	$	11,000
- Subtotal	$	13,000

55. Post-closure annual permitting fees:	$	11,000 /year

SUMMARY OF CLOSURE AND POST-CLOSURE MAINTENANCE COST ESTIMATES

Closure		
Final Cover (Line 23)	$	18,407,722
Revegetation (Line 29)	$	260,000
Landfill Gas Monitoring and Control (Line 32)	$	52,042
Groundwater Monitoring Installation (Line 34)	$	-
Drainage Installation (Line 35c)	$	665,400
Security Installation (Line 36d)	$	-
Others (Line 37)	$	10,000
I. Subtotal	$	19,395,164
II. Subtotal I * 20% Contigency Costs	$	3,879,033
III. Subtotal	$	23,274,196
Monitoring and post-closure maintenance		
Revegetation (Line 40)	$	3,250
Leachate management (Line 46)	$	68,770
Monitoring (Line 50)	$	120,071
Drainage (Line 51a)	$	18,000
Security (Line 52)	$	1,000
Inspection (Line 53b)	$	2,000
Others (Line 54)	$	13,000
Permitting (Line 55)	$	11,000
IV. Subtotal	$	237,091 /year
V. Subtotal III * 30 years	$	7,112,715
TOTAL COST	$	30,386,911

Appendix H

SCS Landfill Gas System O&M Cost Esimate

Environmental Consultants

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SCS ENGINEERS

February 1, 2006
File No. 01198193.04

Ms. Stephanie Young
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235 North First Street
Dixon, CA 95620
(707) 678-1492
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SUBJECT: **POST-CLOSURE COST INFORMATION, OPERATIONS AND MAINTENANCE OF LANDFILL GAS COLLECTION AND CONTROL SYSTEM, HAY ROAD LANDFILL, VACAVILLE, CALIFORNIA**

Dear Stephanie:

At your request, SCS Engineers (SCS) developed an updated cost estimate for long-term operations and maintenance (O&M) of a landfill gas (LFG) collection and control system (GCCS) for the Norcal Waste Systems Hay Road Landfill (NWSHRL) located in Vacaville, California. The purpose of this evaluation was to determine the likely costs that will be incurred by the landfill for O&M, monitoring, and maintenance of a GCCS during the 30-year post-closure period required under Resource Conservation and Recovery Act (RCRA) Subtitle D and Title 27 of the California Code of Regulations (CCR).

TIMELINE FOR GCCS OPERATION

The NWSHRL is considered a "new" landfill under the federal New Source Performance Standards (NSPS; 40 CFR Part 60, Subpart WWW) because it received an increase in landfill capacity after May 31, 1991 and has a design capacity over 2.5 million Megagrams (Mg). To comply with NSPS requirements, the NWSHRL is obligated to submit annual emission rate estimates for non-methane organic compounds (NMOCs). Within 2 years after NMOC emissions are reported to be greater than 50 Mg per year, a GCCS must be installed at the NWSHRL.

To evaluate when a GCCS would be required at the NWSHRL, SCS completed LFG modeling for the site in accordance with the NSPS requirements starting at the present time and continuing out until 30 years beyond site closure. NMOC emissions were estimated for each year within that time period. The annual NMOC emission rates were then used to predict the year in which the GCCS would initially be required to be installed and to estimate costs for LFG monitoring and control during the 30 year post closure maintenance period.

The LFG modeling information described above are summarized in Attachment 1. Based on the Tier 2 analysis, NMOC emissions are projected to first exceed 50 Mg in 2010. As such, under the NSPS, a GCCS would have to be installed and operated beginning in 2012 to comply with the NSPS. Therefore, the capital cost for installation of the GCCS will be incurred during the operational life of the landfill and was not included in this post-closure budgetary estimate.

In accordance with NSPS requirements, the GCCS will be required to be operated until the site's NMOC emission rate drops back below 50 Mg after closure (plus 3 years) or for a minimum of 15 years, whichever is longer. Based on the Tier 2 analysis, NMOC emissions from the NWSHRL will decrease below 50 Mg in 2112, approximately 24 years after projected closure in 2088. As such, the GCCS could be turned off in accordance with NSPS regulations at the end of 2115. However, California Code of Regulations (CCR) Title 27 requires a cost estimate for a 30-year post-closure maintenance period, including LFG monitoring and control. Accordingly, the cost estimate is based on operating the LFG system throughout the entire 30 years into the post-closure period.

PROJECTED O&M COSTS

Based on the above, it is clear that the NWSHRL is likely to incur a substantial annual cost during the post-closure maintenance period for O&M of the GCCS. These O&M activities will include periodic LFG system O&M; to include power, replacement costs, system upgrades and upkeep, and required regulatory compliance monitoring for all applicable regulatory requirements.

For the purposes of post-closure funding, SCS completed a budgetary cost estimate of the LFG system O&M during the 30 years of the post-closure period when a GCCS will be required to be operated under the NSPS and/or CCR Title 27. These costs were based on the extent and magnitude of the LFG system that will likely be in place at site closure (based on final refuse tonnages and landfill acreage). The cost estimate was developed by SCS Field Services, which operates over 50 LFG systems in California, and was based on the following assumptions:

- Site Area: 256 acres.
- Number of LFG extraction wells: 150 vertical.
- LFG Header/Wellheads: above grade (no vaults).
- Flares: 2 @ 1,500 standard cubic feet per minute (scfm), each.

- Blowers: 2 @ 1,500 scfm, each.

- Condensate Management: 6 underground sumps, pneumatic pumps, holding tank, injected into flare(s).

The cost estimate includes annual O&M costs in 2005 dollars for the 30 year post-closure period. These costs include routine O&M, monitoring, and testing; projected non-routine maintenance and repair services; and expected emergency repair services. Because the landfill will be equipped with a synthetic cap as part of the closure plan, we did not include any costs for re-monitoring due to emissions exceedances.

Based on the information provided by SCS Field Services using data from similarly sized landfills in California, the annual O&M costs for operation of the GCCS at closure would be $112,000/year (2005 dollars) during the 30 years of required operation. In addition, the electrical costs for the LFG system are expected to be approximately $27,000/year (225,000 kW-hr per year @ $0.12/kW-hr). This brings the total projected O&M costs to $139,000/year. To this, we have added a contingency of 10 percent to account for other unexpected costs. Therefore, the projected annual cost for O&M, monitoring, testing, and maintenance of the GCCS at the NWSHRL for the base year of the post-closure period (2088) is $152,900/year (2005 dollars).

REVENUE FROM LFG-TO-ENERGY

These O&M costs could be offset by net revenue generated from an LFG-to-energy (LFGTE) facility that could be operated on-site to produce electricity for on-site use and/or sale. To assist in this effort, SCS completed a LFG recovery model run to calculate the likely amount of LFG that would be available during the 30 year post-closure period for LFGTE. Based on the LFG modeling, the landfill will produce sufficient quantities of LFG (approximately 3,000 scfm at closure) to make energy recovery economically feasible.

The LFG recovery model is provided in Attachment 2. In summary, the NWSHRL should produce approximately 3,000 scfm (at 50% methane) of recoverable LFG at closure (2089); with production of recoverable LFG declining to approximately 850 scfm at the end of the 30-year post-closure period (2118). To accommodate the condensate injection system for condensate management, we reserved 500 scfm of LFG (from the numbers above) for use in one of the two LFG flares. Assuming a LFGTE facility size of 2.0 megawatts (MW), the needed gross heat input rate for the LFGTE facility would be 21 million British Thermal Units (MM Btu) per hour. This equates to 700 scfm of LFG (assuming 500 BTU/scf). Therefore a minimum of 1,200 scfm of LFG is needed to run both the LFGTE facility and the flare for condensate treatment. Based on the model the site will produce less than 1,200 scfm of recoverable LFG beginning in 2110, which is 22 years into the 30-year post-closure period.

In order to evaluate the potential revenue that could be generated by an LFGTE project, SCS completed a financial proforma for an LFGTE project that could be reasonably expected to occur in the future, (coinciding with the first 22 years of the 30 year post-closure period). It was assumed that the capital costs for the LFGTE system installation were incurred prior to closure; therefore, those costs were not included in our cost estimate. However, we have accounted for the costs to service the debt incurred through a major overhaul of the system that would occur during the 22-year period the LFGTE plant would be expected to operate (50% of the total capital costs assumed to be required for major overhaul). Separate O&M costs for the LFGTE system are included in the proforma. The cost estimate includes annual net revenue from the LFGTE project in 2005 dollars during the 30-year post-closure period. The following assumptions were used in completion of the proforma:

- Plant capacity 2.0 MW; assumed to be reciprocating engine.
- Gross plant heat rate = 10,500 BTU/kW-hr.
- Parasitic load = 10%.
- Plant capacity factor = 90%.
- Electricity sold into the grid at $0.060/kW-hr (typical 2005 price for LFGTE projects).
- Electricity used to offset retail power purchased for on-site use; expected load 225,000 kw-hr per year for blower/flare station.
- Retail power rate assumed to be $0.12/kW-hr (typical 2005 retail price in California).
- Avoided cost for offsetting of retail power purchases (typical 2005 cost for avoiding the purchase of retail power at $0.12/kW-hr in California).
- Capital costs = $3,000,000 (major overhaul = $1,500,000).
- No subsidies or tax credits assumed.
- O&M costs for LFGTE system assumed to be $0.017/kW-hr.
- Debt service included; assumed that 50% of the $3,000,000 capital cost was financed for major overhaul at an interest rate of 6.5%.

The proforma is included in Attachment 3.

NET COSTS FOR LFG SYSTEM O&M

The net revenue from the LFGTE project during the post-closure period (based on a conservative minimum landfill gas utilization rate of 700 scfm) could be used to offset the post-closure maintenance costs for the GCCS. Attachment 3 shows that during the first 22 years of the post-closure period that the LFGTE plant would operate, that the energy project actually generates enough net revenue ($342,487/year) to completely cover LFG system O&M costs ($152,900/year), with $188,587/year left over.

During the last 8 years of the 30-year post-closure period there would be no revenue to offset the LFG system O&M costs. However over the 30-year period the LFGTE project's net revenues would still cover all of the LFG system O&M costs over the period, with a total of approximately $3,100,000 left over. A summary of the year-by-year net costs is provided in Attachment 3. Please note that all of the above costs are in 2005 dollars without indexing for inflation.

CLOSING

SCS is hopeful that this information is helpful in your development of cost estimates for post-closure maintenance of the NWSHRL. If you have any questions regarding this submittal or desire any additional information, please contact the undersigned.

Sincerely,

Steven M. Hamilton, R.E.P.
Project Director
SCS ENGINEERS

Attachments

ATTACHMENT 1

NSPS LFG MODEL SUMMARY

ATTACHMENT 1. PROJECTED LFG AND NMOC GENERATION RATES
Hay Road Landfill, Vacaville, California

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	Disposal Rate (Mg/yr)	Refuse In-Place (Mg)	Methane Generation Rates (m^3/yr)	LFG Generation Rates (cfm)	LFG Generation Rates (Million ft^3/yr)	NMOC Generation Rates (tons/yr)	NMOC Generation Rates (Mg/yr)
1965	20,000	0	18,144	0	0.000E+00	0	0	0	0
1966	20,600	20,000	18,688	18,144	1.542E+05	21	11	1	1
1967	21,218	40,600	19,249	36,832	3.055E+05	41	22	1	1
1968	21,855	61,818	19,826	56,080	4.543E+05	61	32	2	2
1969	22,510	83,673	20,421	75,906	6.006E+05	81	42	2	2
1970	23,185	106,183	21,034	96,327	7.449E+05	100	53	3	3
1971	23,881	129,368	21,665	117,361	8.874E+05	119	63	4	3
1972	24,597	153,249	22,314	139,025	1.028E+06	138	73	4	4
1973	25,335	177,847	22,984	161,340	1.168E+06	157	82	5	4
1974	26,095	203,182	23,673	184,324	1.306E+06	176	92	5	5
1975	26,878	229,278	24,384	207,997	1.444E+06	194	102	6	5
1976	27,685	256,156	25,115	232,381	1.581E+06	212	112	6	6
1977	28,515	283,841	25,869	257,496	1.717E+06	231	121	7	6
1978	29,371	312,356	26,645	283,364	1.853E+06	249	131	7	7
1979	30,252	341,726	27,444	310,009	1.989E+06	267	140	8	7
1980	31,159	371,978	28,267	337,453	2.125E+06	286	150	8	8
1981	32,094	403,138	29,115	365,720	2.262E+06	304	160	9	8
1982	33,057	435,232	29,989	394,836	2.399E+06	322	169	9	9
1983	34,049	468,289	30,888	424,824	2.537E+06	341	179	10	9
1984	35,070	502,337	31,815	455,713	2.676E+06	360	189	11	10
1985	36,122	537,407	32,770	487,528	2.816E+06	378	199	11	10
1986	37,206	573,530	33,753	520,297	2.957E+06	397	209	12	11
1987	38,322	610,736	34,765	554,050	3.100E+06	417	219	12	11
1988	39,472	649,058	35,808	588,815	3.244E+06	436	229	13	12
1989	40,656	688,529	36,882	624,623	3.390E+06	456	239	13	12
1990	41,876	729,185	37,989	661,506	3.538E+06	475	250	14	13
1991	43,132	771,061	39,129	699,495	3.689E+06	496	261	15	13
1992	99,928	814,193	90,653	738,623	3.841E+06	516	271	15	14
1993	98,958	914,121	89,773	829,276	4.425E+06	595	313	17	16
1994	115,583	1,013,079	104,855	919,050	4.972E+06	668	351	20	18
1995	111,813	1,128,662	101,435	1,023,905	5.621E+06	755	397	22	20
1996	120,201	1,240,475	109,045	1,125,340	6.209E+06	834	439	25	22
1997	110,133	1,360,676	99,911	1,234,384	6.833E+06	918	483	27	24
1998	110,723	1,470,809	100,446	1,334,295	7.349E+06	988	519	29	26
1999	131,789	1,581,532	119,557	1,434,741	7.844E+06	1,054	554	31	28
2000	124,299	1,713,321	112,762	1,554,298	8.478E+06	1,139	599	33	30
2001	131,586	1,837,620	119,373	1,667,061	9.023E+06	1,212	637	36	32
2002	133,850	1,969,206	121,427	1,786,433	9.598E+06	1,290	678	38	34
2003	151,890	2,103,056	137,792	1,907,860	1.016E+07	1,365	718	40	36
2004	146,708	2,254,946	133,091	2,045,652	1.084E+07	1,456	765	43	39
2005	148,175	2,401,654	134,422	2,178,744	1.144E+07	1,537	808	45	41
2006	149,657	2,549,829	135,767	2,313,166	1.202E+07	1,616	849	48	43
2007	151,154	2,699,486	137,125	2,448,932	1.259E+07	1,692	889	50	45
2008	152,665	2,850,640	138,495	2,586,057	1.314E+07	1,766	928	52	47
2009	154,192	3,003,305	139,881	2,724,552	1.368E+07	1,838	966	54	49
2010	155,734	3,157,497	141,280	2,864,433	1.420E+07	1,908	1,003	56	51
2011	157,291	3,313,231	142,692	3,005,712	1.471E+07	1,977	1,039	58	53
2012	158,864	3,470,522	144,119	3,148,404	1.521E+07	2,043	1,074	60	54
2013	160,453	3,629,386	145,560	3,292,523	1.569E+07	2,108	1,108	62	56
2014	162,057	3,789,838	147,016	3,438,083	1.616E+07	2,172	1,141	64	58
2015	163,678	3,951,895	148,486	3,585,099	1.662E+07	2,234	1,174	66	60
2016	165,314	4,115,573	149,971	3,733,585	1.707E+07	2,294	1,206	67	61
2017	166,968	4,280,887	151,470	3,883,556	1.752E+07	2,354	1,237	69	63
2018	168,637	4,447,855	152,985	4,035,026	1.795E+07	2,412	1,268	71	64
2019	170,324	4,616,492	154,515	4,188,011	1.837E+07	2,469	1,298	73	66
2020	172,027	4,786,816	156,060	4,342,526	1.879E+07	2,525	1,327	74	67
2021	173,747	4,958,843	157,621	4,498,586	1.920E+07	2,580	1,356	76	69
2022	175,485	5,132,590	159,197	4,656,207	1.960E+07	2,634	1,385	77	70
2023	177,239	5,308,074	160,789	4,815,404	2.000E+07	2,688	1,413	79	72
2024	179,012	5,485,314	162,397	4,976,193	2.039E+07	2,740	1,440	81	73
2025	180,802	5,664,326	164,021	5,138,590	2.078E+07	2,792	1,468	82	74
2026	182,610	5,845,128	165,661	5,302,611	2.116E+07	2,843	1,494	84	76
2027	184,436	6,027,738	167,318	5,468,272	2.154E+07	2,894	1,521	85	77
2028	186,280	6,212,174	168,991	5,635,589	2.191E+07	2,944	1,547	87	79
2029	188,143	6,398,454	170,681	5,804,580	2.228E+07	2,993	1,573	88	80
2030	190,025	6,586,597	172,387	5,975,261	2.264E+07	3,042	1,599	89	81
2031	191,925	6,776,622	174,111	6,147,648	2.300E+07	3,091	1,625	91	82
2032	193,844	6,968,547	175,852	6,321,759	2.336E+07	3,139	1,650	92	84
2033	195,783	7,162,391	177,611	6,497,612	2.371E+07	3,187	1,675	94	85
2034	197,740	7,358,174	179,387	6,675,223	2.407E+07	3,234	1,700	95	86
2035	199,718	7,555,914	181,181	6,854,610	2.442E+07	3,281	1,725	96	88
2036	201,715	7,755,632	182,993	7,035,791	2.477E+07	3,328	1,749	98	89
2037	203,732	7,957,347	184,823	7,218,784	2.512E+07	3,375	1,774	99	90
2038	205,769	8,161,079	186,671	7,403,606	2.546E+07	3,421	1,798	101	91
2039	207,827	8,366,848	188,538	7,590,277	2.581E+07	3,468	1,823	102	92
2040	209,905	8,574,676	190,423	7,778,815	2.615E+07	3,514	1,847	103	94
2041	212,005	8,784,581	192,327	7,969,238	2.649E+07	3,560	1,871	105	95
2042	214,125	8,996,586	194,251	8,161,565	2.684E+07	3,606	1,895	106	96
2043	216,266	9,210,710	196,193	8,355,816	2.718E+07	3,652	1,920	107	97
2044	218,428	9,426,976	198,155	8,552,009	2.752E+07	3,698	1,944	109	99

2045	220,613	9,645,404	200,137	8,750,164	2.786E+07	3,744	1,968	110	100
2046	222,819	9,866,017	202,138	8,950,300	2.821E+07	3,790	1,992	111	101
2047	225,047	10,088,836	204,159	9,152,438	2.855E+07	3,836	2,016	113	102
2048	227,298	10,313,883	206,201	9,356,597	2.889E+07	3,882	2,041	114	104
2049	229,570	10,541,181	208,263	9,562,798	2.923E+07	3,928	2,065	115	105
2050	231,866	10,770,751	210,345	9,771,061	2.958E+07	3,975	2,089	117	106
2051	234,185	11,002,617	212,449	9,981,407	2.992E+07	4,021	2,114	118	107
2052	236,527	11,236,802	214,573	10,193,856	3.027E+07	4,068	2,138	120	108
2053	238,892	11,473,329	216,719	10,408,429	3.062E+07	4,114	2,163	121	110
2054	241,281	11,712,221	218,886	10,625,148	3.097E+07	4,161	2,187	122	111
2055	243,694	11,953,502	221,075	10,844,034	3.132E+07	4,208	2,212	124	112
2056	246,131	12,197,195	223,286	11,065,110	3.167E+07	4,256	2,237	125	113
2057	248,592	12,443,326	225,519	11,288,396	3.202E+07	4,303	2,262	127	115
2058	251,078	12,691,918	227,774	11,513,915	3.238E+07	4,351	2,287	128	116
2059	253,589	12,942,996	230,052	11,741,689	3.273E+07	4,399	2,312	129	117
2060	256,125	13,196,585	232,352	11,971,740	3.309E+07	4,447	2,337	131	119
2061	258,686	13,452,709	234,676	12,204,093	3.345E+07	4,496	2,363	132	120
2062	261,273	13,711,395	237,023	12,438,768	3.382E+07	4,544	2,389	134	121
2063	263,885	13,972,668	239,393	12,675,791	3.418E+07	4,593	2,414	135	123
2064	266,524	14,236,553	241,787	12,915,184	3.455E+07	4,643	2,440	136	124
2065	269,189	14,503,077	244,205	13,156,970	3.492E+07	4,693	2,466	138	125
2066	271,881	14,772,267	246,647	13,401,175	3.529E+07	4,743	2,493	139	126
2067	274,600	15,044,148	249,113	13,647,822	3.567E+07	4,793	2,519	141	128
2068	277,346	15,318,748	251,604	13,896,935	3.605E+07	4,844	2,546	142	129
2069	280,120	15,596,094	254,120	14,148,539	3.643E+07	4,895	2,573	144	131
2070	282,921	15,876,214	256,661	14,402,659	3.681E+07	4,947	2,600	145	132
2071	285,750	16,159,135	259,228	14,659,321	3.720E+07	4,998	2,627	147	133
2072	288,608	16,444,885	261,820	14,918,549	3.759E+07	5,051	2,655	148	135
2073	291,494	16,733,492	264,439	15,180,369	3.798E+07	5,104	2,682	150	136
2074	294,409	17,024,986	267,083	15,444,808	3.837E+07	5,157	2,710	152	138
2075	297,353	17,319,395	269,754	15,711,891	3.877E+07	5,210	2,739	153	139
2076	300,326	17,616,747	272,451	15,981,644	3.917E+07	5,264	2,767	155	140
2077	303,329	17,917,073	275,176	16,254,096	3.958E+07	5,319	2,796	156	142
2078	306,363	18,220,403	277,928	16,529,272	3.999E+07	5,374	2,824	158	143
2079	309,426	18,526,765	280,707	16,807,199	4.040E+07	5,429	2,853	160	145
2080	312,521	18,836,192	283,514	17,087,906	4.082E+07	5,485	2,883	161	146
2081	315,646	19,148,712	286,349	17,371,420	4.124E+07	5,541	2,912	163	148
2082	318,802	19,464,358	289,213	17,657,769	4.166E+07	5,598	2,942	165	149
2083	321,990	19,783,161	292,105	17,946,982	4.209E+07	5,655	2,972	166	151
2084	325,210	20,105,151	295,026	18,239,086	4.252E+07	5,713	3,003	168	152
2085	328,462	20,430,361	297,976	18,534,112	4.295E+07	5,772	3,034	170	154
2086	331,747	20,758,823	300,956	18,832,088	4.339E+07	5,830	3,064	171	155
2087	335,064	21,090,570	303,965	19,133,044	4.383E+07	5,890	3,096	173	157
2088	120,000	21,425,635	108,862	19,437,009	4.428E+07	5,950	3,127	175	159
2089	0	21,545,635	0	19,545,871	4.304E+07	5,784	3,040	170	154
2090	0	21,545,635	0	19,545,871	4.094E+07	5,502	2,892	162	147
2091	0	21,545,635	0	19,545,871	3.895E+07	5,234	2,751	154	140
2092	0	21,545,635	0	19,545,871	3.705E+07	4,978	2,617	146	133
2093	0	21,545,635	0	19,545,871	3.524E+07	4,735	2,489	139	126
2094	0	21,545,635	0	19,545,871	3.352E+07	4,505	2,368	132	120
2095	0	21,545,635	0	19,545,871	3.189E+07	4,285	2,252	126	114
2096	0	21,545,635	0	19,545,871	3.033E+07	4,076	2,142	120	109
2097	0	21,545,635	0	19,545,871	2.885E+07	3,877	2,038	114	103
2098	0	21,545,635	0	19,545,871	2.744E+07	3,688	1,938	108	98
2099	0	21,545,635	0	19,545,871	2.611E+07	3,508	1,844	103	94
2100	0	21,545,635	0	19,545,871	2.483E+07	3,337	1,754	98	89
2101	0	21,545,635	0	19,545,871	2.362E+07	3,174	1,668	93	85
2102	0	21,545,635	0	19,545,871	2.247E+07	3,019	1,587	89	81
2103	0	21,545,635	0	19,545,871	2.137E+07	2,872	1,510	84	77
2104	0	21,545,635	0	19,545,871	2.033E+07	2,732	1,436	80	73
2105	0	21,545,635	0	19,545,871	1.934E+07	2,599	1,366	76	69
2106	0	21,545,635	0	19,545,871	1.840E+07	2,472	1,299	73	66
2107	0	21,545,635	0	19,545,871	1.750E+07	2,352	1,236	69	63
2108	0	21,545,635	0	19,545,871	1.665E+07	2,237	1,176	66	60
2109	0	21,545,635	0	19,545,871	1.583E+07	2,128	1,118	63	57
2110	0	21,545,635	0	19,545,871	1.506E+07	2,024	1,064	60	54
2111	0	21,545,635	0	19,545,871	1.433E+07	1,925	1,012	57	51
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2113	0	21,545,635	0	19,545,871	1.296E+07	1,742	916	51	46
2114	0	21,545,635	0	19,545,871	1.233E+07	1,657	871	49	44
2115	0	21,545,635	0	19,545,871	1.173E+07	1,576	829	46	42
2116	0	21,545,635	0	19,545,871	1.116E+07	1,499	788	44	40
2117	0	21,545,635	0	19,545,871	1.061E+07	1,426	750	42	38
2118	0	21,545,635	0	19,545,871	1.010E+07	1,357	713	40	36

ESTIMATED NMOC CONCENTRATION IN LFG	508.4 ppmv	(Tier 2 Test Result)
ASSUMED METHANE CONTENT OF LFG	50%	(USEPA NSPS default value)
SELECTED DECAY RATE CONSTANT.	0.05	(USEPA NSPS default value)
SELECTED ULTIMATE METHANE RECOVERY RATE:	5,446 ft3/ton	(USEPA NSPS default value)
METRIC EQUIVALENT	170 cu m/Mg	(USEPA NSPS default value)

Conversions:

35.314667 cu ft per cu m
1.1023113 ton per Mg
32.037 cu ft/ton per cu m/Mg

ATTACHMENT 2

SCS LANDFILL GAS RECOVERY PROJECTIONS
HAY ROAD LANDFILL

ATTACHMENT 2. LFG RECOVERY PROJECTION
Hay Road Landfill, Vacaville, California

Year	Disposal Rate (tons/yr)	Refuse In-Place (tons)	LFG Recovery Potential (scfm)	LFG Recovery Potential (mmcf/day)	LFG Recovery Potential (mmBtu/yr)	LFG System Coverage (%)	LFG Recovery from Existing and Planned System (scfm)	LFG Recovery from Existing and Planned System (mmcf/day)	LFG Recovery from Existing and Planned System (mmBtu/yr)
1965	20,000	20,000	0	0.00	0	0%	0	0.00	0
1966	20,600	40,600	9	0.01	2,380	0%	0	0.00	0
1967	21,218	61,818	18	0.03	4,734	0%	0	0.00	0
1968	21,855	83,673	27	0.04	7,064	0%	0	0.00	0
1969	22,510	106,183	35	0.05	9,375	0%	0	0.00	0
1970	23,185	129,368	44	0.06	11,668	0%	0	0.00	0
1971	23,881	153,249	52	0.08	13,948	0%	0	0.00	0
1972	24,597	177,847	61	0.09	16,216	0%	0	0.00	0
1973	25,335	203,182	69	0.10	18,476	0%	0	0.00	0
1974	26,095	229,278	78	0.11	20,732	0%	0	0.00	0
1975	26,878	256,156	86	0.12	22,985	0%	0	0.00	0
1976	27,685	283,841	95	0.14	25,238	0%	0	0.00	0
1977	28,515	312,356	103	0.15	27,495	0%	0	0.00	0
1978	29,371	341,726	112	0.16	29,758	0%	0	0.00	0
1979	30,252	371,978	120	0.17	32,029	0%	0	0.00	0
1980	31,159	403,138	129	0.19	34,312	0%	0	0.00	0
1981	32,094	435,232	138	0.20	36,609	0%	0	0.00	0
1982	33,057	468,289	146	0.21	38,923	0%	0	0.00	0
1983	34,049	502,337	155	0.22	41,256	0%	0	0.00	0
1984	35,070	537,407	164	0.24	43,611	0%	0	0.00	0
1985	36,122	573,530	173	0.25	45,991	0%	0	0.00	0
1986	37,206	610,736	182	0.26	48,399	0%	0	0.00	0
1987	38,322	649,058	191	0.28	50,836	0%	0	0.00	0
1988	39,472	688,529	200	0.29	53,306	0%	0	0.00	0
1989	40,656	729,185	210	0.30	55,811	0%	0	0.00	0
1990	41,876	771,061	219	0.32	58,354	0%	0	0.00	0
1991	43,132	814,193	229	0.33	60,938	0%	0	0.00	0
1992	99,928	914,121	239	0.34	63,564	0%	0	0.00	0
1993	98,958	1,013,079	274	0.39	72,842	0%	0	0.00	0
1994	115,583	1,128,662	307	0.44	81,624	0%	0	0.00	0
1995	111,813	1,240,475	346	0.50	92,022	0%	0	0.00	0
1996	120,201	1,360,676	382	0.55	101,544	0%	0	0.00	0
1997	110,133	1,470,809	420	0.60	111,673	0%	0	0.00	0
1998	110,723	1,581,532	452	0.65	120,187	0%	0	0.00	0
1999	131,789	1,713,321	483	0.70	128,421	0%	0	0.00	0
2000	124,299	1,837,620	522	0.75	138,823	0%	0	0.00	0
2001	131,586	1,969,206	556	0.80	147,906	0%	0	0.00	0
2002	133,850	2,103,056	592	0.85	157,483	0%	0	0.00	0
2003	151,890	2,254,946	628	0.90	166,935	0%	0	0.00	0
2004	146,708	2,401,654	670	0.96	178,146	0%	0	0.00	0
2005	148,175	2,549,829	708	1.02	188,279	0%	0	0.00	0
2006	149,657	2,699,486	745	1.07	198,169	0%	0	0.00	0
2007	151,154	2,850,640	781	1.13	207,829	0%	0	0.00	0
2008	152,665	3,003,305	817	1.18	217,270	0%	0	0.00	0
2009	154,192	3,157,497	852	1.23	226,503	0%	0	0.00	0
2010	155,734	3,313,231	886	1.28	235,537	0%	0	0.00	0
2011	157,291	3,470,522	919	1.32	244,384	0%	0	0.00	0
2012	158,864	3,629,386	951	1.37	253,051	85%	809	1.16	215,094
2013	160,453	3,789,838	983	1.42	261,550	85%	836	1.20	222,317
2014	162,057	3,951,895	1,015	1.46	269,888	85%	863	1.24	229,405
2015	163,678	4,115,573	1,046	1.51	278,074	85%	889	1.28	236,363
2016	165,314	4,280,887	1,076	1.55	286,116	85%	914	1.32	243,199
2017	166,968	4,447,855	1,106	1.59	294,023	85%	940	1.35	249,919
2018	168,637	4,616,492	1,135	1.63	301,800	85%	965	1.39	256,530
2019	170,324	4,786,816	1,164	1.68	309,457	85%	989	1.42	263,038
2020	172,027	4,958,843	1,192	1.72	316,999	85%	1,013	1.46	269,449
2021	173,747	5,132,590	1,220	1.76	324,434	85%	1,037	1.49	275,769
2022	175,485	5,308,074	1,247	1.80	331,768	85%	1,060	1.53	282,003

2023	177.239	5.485.314	1.275	1.84	339.007	85%	1.083	1.56	288.156
2024	179.012	5.664.326	1.302	1.87	346.157	85%	1.106	1.59	294.233
2025	180.802	5.845.128	1.328	1.91	353.224	85%	1.129	1.63	300.240
2026	182.610	6.027.738	1.354	1.95	360.213	85%	1.151	1.66	306.181
2027	184.436	6.212.174	1.380	1.99	367.130	85%	1.173	1.69	312.061
2028	186.280	6.398.454	1.406	2.02	373.980	85%	1.195	1.72	317.883
2029	188.143	6.586.597	1.432	2.06	380.768	85%	1.217	1.75	323.652
2030	190.025	6.776.622	1.457	2.10	387.498	85%	1.238	1.78	329.373
2031	191.925	6.968.547	1.482	2.13	394.175	85%	1.260	1.81	335.049
2032	193.844	7.162.391	1.507	2.17	400.804	85%	1.281	1.84	340.683
2033	195.783	7.358.174	1.532	2.21	407.388	85%	1.302	1.87	346.280
2034	197.740	7.555.914	1.556	2.24	413.932	85%	1.323	1.91	351.843
2035	199.718	7.755.632	1.581	2.28	420.441	85%	1.344	1.93	357.375
2036	201.715	7.957.347	1.605	2.31	426.916	85%	1.364	1.96	362.879
2037	203.732	8.161.079	1.629	2.35	433.364	85%	1.385	1.99	368.359
2038	205.769	8.366.848	1.654	2.38	439.786	85%	1.406	2.02	373.818
2039	207.827	8.574.676	1.678	2.42	446.186	85%	1.426	2.05	379.258
2040	209.905	8.784.581	1.702	2.45	452.568	85%	1.446	2.08	384.683
2041	212.005	8.996.586	1.726	2.48	458.935	85%	1.467	2.11	390.095
2042	214.125	9.210.710	1.750	2.52	465.290	85%	1.487	2.14	395.496
2043	216.266	9.426.976	1.773	2.55	471.636	85%	1.507	2.17	400.890
2044	218.428	9.645.404	1.797	2.59	477.975	85%	1.528	2.20	406.279
2045	220.613	9.866.017	1.821	2.62	484.311	85%	1.548	2.23	411.665
2046	222.819	10.088.836	1.845	2.66	490.647	85%	1.568	2.26	417.050
2047	225.047	10.313.883	1.869	2.69	496.984	85%	1.588	2.29	422.437
2048	227.298	10.541.181	1.893	2.73	503.326	85%	1.609	2.32	427.827
2049	229.570	10.770.751	1.916	2.76	509.675	85%	1.629	2.35	433.224
2050	231.866	11.002.617	1.940	2.79	516.034	85%	1.649	2.37	438.629
2051	234.185	11.236.802	1.964	2.83	522.404	85%	1.670	2.40	444.043
2052	236.527	11.473.329	1.988	2.86	528.788	85%	1.690	2.43	449.470
2053	238.892	11.712.221	2.012	2.90	535.188	85%	1.710	2.46	454.910
2054	241.281	11.953.502	2.036	2.93	541.607	85%	1.731	2.49	460.366
2055	243.694	12.197.195	2.061	2.97	548.045	85%	1.752	2.52	465.839
2056	246.131	12.443.326	2.085	3.00	554.506	85%	1.772	2.55	471.330
2057	248.592	12.691.918	2.109	3.04	560.992	85%	1.793	2.58	476.843
2058	251.078	12.942.996	2.134	3.07	567.503	85%	1.814	2.61	482.378
2059	253.589	13.196.585	2.158	3.11	574.043	85%	1.835	2.64	487.936
2060	256.125	13.452.709	2.183	3.14	580.612	85%	1.856	2.67	493.520
2061	258.686	13.711.395	2.208	3.18	587.213	85%	1.877	2.70	499.131
2062	261.273	13.972.668	2.233	3.22	593.847	85%	1.898	2.73	504.770
2063	263.885	14.236.553	2.258	3.25	600.517	85%	1.919	2.76	510.439
2064	266.524	14.503.077	2.283	3.29	607.223	85%	1.941	2.79	516.139
2065	269.189	14.772.267	2.309	3.32	613.967	85%	1.962	2.83	521.872
2066	271.881	15.044.148	2.334	3.36	620.751	85%	1.984	2.86	527.638
2067	274.600	15.318.748	2.360	3.40	627.576	85%	2.006	2.89	533.440
2068	277.346	15.596.094	2.386	3.44	634.444	85%	2.028	2.92	539.278
2069	280.120	15.876.214	2.412	3.47	641.357	85%	2.050	2.95	545.153
2070	282.921	16.159.135	2.438	3.51	648.315	85%	2.072	2.98	551.068
2071	285.750	16.444.885	2.464	3.55	655.320	85%	2.094	3.02	557.022
2072	288.608	16.733.492	2.491	3.59	662.374	85%	2.117	3.05	563.018
2073	291.494	17.024.986	2.517	3.62	669.478	85%	2.140	3.08	569.057
2074	294.409	17.319.395	2.544	3.66	676.633	85%	2.163	3.11	575.138
2075	297.353	17.616.747	2.571	3.70	683.841	85%	2.186	3.15	581.265
2076	300.326	17.917.073	2.599	3.74	691.103	85%	2.209	3.18	587.438
2077	303.329	18.220.403	2.626	3.78	698.420	85%	2.232	3.21	593.657
2078	306.363	18.526.765	2.654	3.82	705.793	85%	2.256	3.25	599.924
2079	309.426	18.836.192	2.682	3.86	713.225	85%	2.279	3.28	606.241
2080	312.521	19.148.712	2.710	3.90	720.715	85%	2.303	3.32	612.608
2081	315.646	19.464.358	2.738	3.94	728.265	85%	2.328	3.35	619.025
2082	318.802	19.783.161	2.767	3.98	735.877	85%	2.352	3.39	625.495
2083	321.990	20.105.151	2.796	4.03	743.551	85%	2.376	3.42	632.018
2084	325.210	20.430.361	2.825	4.07	751.289	85%	2.401	3.46	638.596
2085	328.462	20.758.823	2.854	4.11	759.092	85%	2.426	3.49	645.228
2086	331.747	21.090.570	2.884	4.15	766.961	85%	2.451	3.53	651.917
2087	335.064	21.425.635	2.914	4.20	774.897	85%	2.477	3.57	658.663

2088	120,000	21,545,635	2,944	4.24	782,902	100%	2,944	4.24	782,902
2089	0	21,545,635	2,876	4.14	764,983	100%	2,876	4.14	764,983
2090	0	21,545,635	2,758	3.97	733,519	100%	2,758	3.97	733,519
2091	0	21,545,635	2,645	3.81	703,349	100%	2,645	3.81	703,349
2092	0	21,545,635	2,536	3.65	674,420	100%	2,536	3.65	674,420
2093	0	21,545,635	2,432	3.50	646,681	100%	2,432	3.50	646,681
2094	0	21,545,635	2,332	3.36	620,083	100%	2,332	3.36	620,083
2095	0	21,545,635	2,236	3.22	594,579	100%	2,236	3.22	594,579
2096	0	21,545,635	2,144	3.09	570,123	100%	2,144	3.09	570,123
2097	0	21,545,635	2,056	2.96	546,674	100%	2,056	2.96	546,674
2098	0	21,545,635	1,971	2.84	524,189	100%	1,971	2.84	524,189
2099	0	21,545,635	1,890	2.72	502,629	100%	1,890	2.72	502,629
2100	0	21,545,635	1,812	2.61	481,956	100%	1,812	2.61	481,956
2101	0	21,545,635	1,738	2.50	462,133	100%	1,738	2.50	462,133
2102	0	21,545,635	1,666	2.40	443,125	100%	1,666	2.40	443,125
2103	0	21,545,635	1,598	2.30	424,900	100%	1,598	2.30	424,900
2104	0	21,545,635	1,532	2.21	407,423	100%	1,532	2.21	407,423
2105	0	21,545,635	1,469	2.12	390,666	100%	1,469	2.12	390,666
2106	0	21,545,635	1,409	2.03	374,598	100%	1,409	2.03	374,598
2107	0	21,545,635	1,351	1.94	359,191	100%	1,351	1.94	359,191
2108	0	21,545,635	1,295	1.86	344,417	100%	1,295	1.86	344,417
2109	0	21,545,635	1,242	1.79	330,251	100%	1,242	1.79	330,251
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2111	0	21,545,635	1,142	1.64	303,643	100%	1,142	1.64	303,643
2112	0	21,545,635	1,095	1.58	291,154	100%	1,095	1.58	291,154
2113	0	21,545,635	1,050	1.51	279,179	100%	1,050	1.51	279,179
2114	0	21,545,635	1,007	1.45	267,696	100%	1,007	1.45	267,696
2115	0	21,545,635	965	1.39	256,686	100%	965	1.39	256,686
2116	0	21,545,635	925	1.33	246,128	100%	925	1.33	246,128
2117	0	21,545,635	887	1.28	236,005	100%	887	1.28	236,005
2118	0	21,545,635	851	1.23	226,298	100%	851	1.23	226,298

Methane Content of LFG Adjusted to: 50% (Typical Default Value)
Selected Decay Rate Constant (k): 0.0420
Selected Ultimate Methane Recovery Rate (Lo): 2,800 cu ft/ton

Note: This is a **LFG RECOVERY** not a LFG Generation model. As such, SCS selects K & Lo values from an SCS-Proprietary database that we believe best represent site conditions. If the landfill's LFG collection system covers 100 percent of the landfill, then it should collect 100 percent of the Recoverable gas.

ATTACHMENT 3

LANDFILL GAS-TO-ENERGY PROFORMA
HAY ROAD LANDFILL

ATTACHMENT 3. ROAD LFGTE PROJECT PROFORMA

	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099
POWER PURCHASE RATE ($/kWh)	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200
ON SITE POWER SALES (MWh/yr)	225	225	225	225	225	225	225	225	225	225	225	225
ON SITE POWER REVENUE	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000
OFF SITE POWER SALES RATE($/kWh)	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060
OFF SITE POWER SALES (MWh/yr)	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389
OFF SITE POWER REVENUE	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364
RENEWABLE ENERGY CREDIT	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364
PLANT LFG CONSUMED (MMBtu/yr)	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564
LFG RATE ($/MMBtu)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANNUAL LFG COST	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ANNUAL NON-FUEL O&M COST	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840
ANNUAL DEBT SERVICE	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529
TOTAL ANNUAL OPERATING COST	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369
NET CASH FLOW	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995
LFG SYSTEM O&M COSTS	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900
NET LFG SYSTEM O&M COSTS	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)

	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111
POWER PURCHASE RATE ($/kWh)	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200	$0.1200
ON SITE POWER SALES (MWh/yr)	225	225	225	225	225	225	225	225	225	225	225	225
ON SITE POWER REVENUE	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000	$27,000
OFF SITE POWER SALES RATE($/kWh)	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060	$0.060
OFF SITE POWER SALES (MWh/yr)	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389	12,389
OFF SITE POWER REVENUE	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364	$743,364
RENEWABLE ENERGY CREDIT	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
GRAND TOTAL REVENUE	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364	$778,364
PLANT LFG CONSUMED (MMBtu/yr)	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564	165,564
LFG RATE ($/MMBtu)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ANNUAL LFG COST	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
ANNUAL NON-FUEL O&M COST	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840	$297,840
ANNUAL DEBT SERVICE	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529	$159,529
TOTAL ANNUAL OPERATING COST	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369	$457,369
NET CASH FLOW	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995	$312,995
LFG SYSTEM O&M COSTS	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900	$152,900
NET LFG SYSTEM O&M COSTS	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)	($160,095)

GROSS PLANT CAPACITY (kW)	2,000	RETAIL POWER RATE	$0.120
NET PLANT CAPACITY (kW)	1,600	AVOIDED PURCHASE PRICE ($/kWh)	$0.120
PLANT CAPACITY FACTOR	90%	OFF SITE SALES RATE	$0.060
ANNUAL POWER PRODUCTION (MWh/yr)	12,614	POWER PRICE ESCALATION	0.0%
ON SITE POWER CONSUMPTION (MWh/yr)	225	RENEWABLE ENERGY CREDIT (REPI)	$0.0000
OFF SITE POWER SALE (MWh/yr)	12,389	RENEWABLE ENERGY CREDIT (CEC)	$0.0000
GROSS PLANT HEAT RATE (Btu/kWh)(HHV)	10,500	BASE YEAR NON-FUEL O&M	$297,840
LFG CONSUMPTION (MMBtu/hr)	21.0	NON-FUEL COST ESCALATION	0.0%
LFG CONSUMPTION (scfm)	700	LFG PURCHASE RATE	$0.00
ANNUAL LFG CONSUMPTION(MMBtu/yr)	165,564	FUEL ESCALATION RATE	0.0%
PLANT CAPITAL COST	$3,000,000	INTERNAL RATE OF RETURN	NA
STATE GRANT PERCENTAGE	0%		
EQUITY PERCENTAGE	50%		
EQUITY CONTRIBUTION	$1,500,000		
INTEREST RATE ON DEBT	6.5%		
FINANCING LIFE (yrs)	15		
CAPITAL RECOVERY FACTOR	0.1064		