ENVIRONMENTAL RESTORATION PROJECT

A Department of Energy
Environmental Cleanup Program

LA-UR-02-4433
October 2002
ER2002-0359

Voluntary Corrective Measure Plan for Potential Release Sites 73-001(a)-99 and 73-001(b)-99

Los Alamos
NATIONAL LABORATORY

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Produced by the Remedial Actions Focus Area

EXECUTIVE SUMMARY

This voluntary corrective measure (VCM) plan addresses the conceptual design options for the construction of landfill covers at potential release sites (PRSs) 73-001(a)-99, an inactive municipal landfill, and 73-001(b)-99, an inactive debris disposal area (DDA), collectively identified as the airport landfills. The airport landfills ceased operation and were closed in 1973, prior to the development and promulgation of New Mexico solid waste regulation. As such, the existing cover is not adequate, in today's regulatory context, for future site developments and transfer. Both PRS 73-001(a)-99 and PRS 73-001(b)-99 are located at the Los Alamos Airport.

The recommendations presented in the relevant Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) report (LANL 1998, 63070.1) stated that the final remedy for the airport landfills should be consistent with RCRA Subtitle D regulations, and that a final corrective action plan and site engineering design would be developed according to the New Mexico Environment Department (NMED) Solid Waste Bureau (SWB) guidelines for municipal landfills. Upon review of the RFI report, NMED requested that the final remedy for the airport landfills achieve performance equivalency with, RCRA Subtitle C regulations, as applicable.

This VCM plan covers the first phase of a phased approach to the corrective measure that was agreed to by Los Alamos National Laboratory (LANL) and NMED in March 2000 at a high performing team (HPT) meeting. The objectives of this VCM plan are to (1) present conceptual design options for a landfill cover and long-term monitoring system that will achieve performance equivalency with applicable RCRA Subtitle C requirements, (2) describe methodologies to guide soil excavation or recontouring of the existing landfill surfaces, and (3) identify additional sampling required for preparing a final landfill cover design. The conceptual design options in this plan present the basic performance standards pursuant to which the final design will be prepared. This document will be followed by a detailed engineering design of the final remedy and implementation and final reporting of the completed remedy. Three overall objectives must be met in the engineering plan: (1) a minimum of 3% slope will be used on the landfill, (2) FAA requirements for airport facilities must be met, and (3) no waste will be moved offsite.

Airport Landfill PRS [73-001(a)-99]

Site investigations of soil gas, vegetation growth, rooting depth, and subsidence suggest that landfill gas reduces plant and root growth, which will probably reduce plant transpiration and increase percolation of water through a landfill cover. Water-balance modeling showed the need for a venting layer below the soil cover to aerate the rooting zone. The proposed minimum cover thickness needed at the landfill is 1 ft of soil over a 6-in. venting layer. Venting may be needed over most of the landfill. Because some waste will need to be reconfigured within the current footprint, the extent of the final venting layout will be determined after a final regrading decision is made.

Regrading at the landfill will be constrained by Federal Aviation Administration (FAA) requirements and by the project requirement that no waste be moved offsite. FAA regulations (see Federal Aviation Regulation [FAR] 77.25) specify a horizontal 125-ft setback from the center of the runway and a 7-ft horizontal:1-ft vertical (7:1) slope beyond the setback. Regrading will also be consistent with the relevant standards within the RCRA Subtitle C requirements.

This VCM plan provides recommendations and the information needed to selects and complete the final design. Selection of the final cover design will require technical and economic tradeoffs. It is recommended that the evaluation of options be done with the following constraints:

1. A grading plan and cost analysis with a 125-ft setback and a 7:1 slope cresting and breaking to a 4:1 slope on the north face of the landfill. This option is probably the least expensive because the maximum amount of waste could be moved from the steep eastern face and stored on the existing landfill footprint. This configuration would result in a mound that is approximately 10 ft high above runway elevation (height includes the proposed cover) from the west end through the middle portion of the landfill.

2. A grading plan in which a maximum plausible area on the western edge of the landfill is covered with Matcon asphalt. This grading plan would reduce the volume available for relocated waste storage and would require some combination of higher waste elevation on the rest of the landfill and/or more slope stabilization, such as retaining walls and the attendant increased expense, on the eastern face of the landfill. This configuration would result in a mound that is approximately 22 ft high above runway elevation (height includes the proposed cover) near the east end of the landfill.

3. Scenarios with intermediate reconfiguration of waste, such as a 3:1 slope on the east face, which would provide some possibility for maximum expansion of airport activities at the cost of additional stabilization measures at the east end of the landfill. In these scenarios, the cover would be approximately 2 ft above runway elevation. The level of effort required, as well as that required for options 1 and 2, would be highly dependent upon actual waste volumes. If existing contour information overestimates waste volume, then the smaller actual waste volumes would require less waste relocation and provide a less expensive solution.

DDA PRS [73-001(b)-99]

Most of the existing DDA surface is in satisfactory condition and already has adequate soil cover material to control percolation. There are isolated areas in which ponding occurs and/or where debris is visible at the surface. By placing additional cover material in these areas and performing minor regrading, the existing cover can be enhanced to provide positive drainage as well as cover the debris adequately. The final grades will not vary significantly from existing grades. During the site inspection it was estimated that less than one acre of regrading and/or filling with associated revegetation efforts would be involved in constructing a cover over the DDA. Most of the DDA contours will remain unchanged with the exception of some isolated areas, which may require between one and two ft of cover material. No earthwork quantities are provided for the DDA because existing contour data do not provide adequate detail to determine the extent of regrading required. However, total fill material required to provide 12 in. of soil cover over the areas where it is lacking, or where low areas are present, is not anticipated to exceed 5000 yd^3.

Data Gaps

Several data gaps remain that need to be filled before the final cover design can be developed. Refined topographical contours are needed to accurately evaluate cut-and-fill options, slope-stabilization scenarios, and associated costs. The horizontal and vertical extents of waste also need to be refined to better evaluate both volumes and cover options on the east face of the landfill. Slope stabilization for the east face will also require additional geotechnical evaluation. However, topographical data should be gathered before further geotechnical investigations are conducted, and the investigations should focus on the scale of waste stabilization indicated by the refined waste volume data. Geotechnical investigations will probably require additional data on the properties and the strength characteristics of waste and soil fill and on potential borrow soil properties and strength characteristics of native soils and rock. In addition, the costs of moving waste at the site should also be refined to better evaluate project tradeoffs between slope stabilization and slope reduction on the east face of the landfill.

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1.0 INTRODUCTION

Los Alamos National Laboratory (LANL or the Laboratory) is a multidisciplinary research facility owned by the Department of Energy (DOE) and managed by the University of California. The Laboratory is located in north-central New Mexico, approximately 60 miles northeast of Albuquerque and 20 miles northwest of Santa Fe. The Laboratory site covers 43 square miles of the Pajarito Plateau, which consists of a series of fingerlike mesas separated by deep canyons containing ephemeral and intermittent streams that flow from west to east. Mesa tops range in elevation from approximately 6200 ft to 7800 ft. The eastern portion of the plateau stands 300 to 900 ft above the Rio Grande.

The Laboratory's Environmental Restoration (ER) Project is involved in a national effort by the DOE to clean up facilities that were formerly involved in weapons production. The goal of the ER Project is to ensure that DOE's past operations do not threaten human or environmental health and safety in and around Los Alamos County, New Mexico. To achieve that goal, the project is currently investigating sites potentially contaminated by past laboratory operations. The sites under investigation are divided into one of two categories: solid waste management units (SWMUs) or areas of concern (AOCs). In the ER Project, SWMUs and AOCs are collectively referred to as potential release sites, or PRSs.

This voluntary corrective measure (VCM) plan addresses consolidated PRSs 73-001(a)-99 and 73-001(b)-99, both of which are located at the Los Alamos Airport. Consolidated PRS 73-001(a)-99 consists of PRS 73-001(a), an inactive municipal landfill (main landfill), and PRS 73-004(d), a septic tank that served the landfill office. The septic tank lies within the boundary of the main landfill but is no longer identifiable as a discrete entity and is indistinguishable from the landfill (LANL 1998, 63070.1). Consolidated PRS 73-001(b)-99 consists of PRSs 73-001(b), a waste oil pit; 73-001(c), bunker debris pits; and 73-001(d), an inactive debris disposal area (DDA). However, PRSs 73-001(b) and 73-001(c) were destroyed by the trenching for PRS 73-001(d) and are indistinguishable from that PRS (LANL 1998, 63070.1). For these reasons, data collected for PRSs 73-001(a) and 73-001(d) will be applicable to their entire respective consolidated units. In general, data collected for PRS 73-001(a) will also be applicable to PRS 73-001(d) and vice versa. Within this VCM plan, PRSs 73-001(a)-99 and 73-001(b)-99 are discussed either individually or collectively as the airport landfills, whichever use is most appropriate.

This VCM, including sampling and analysis, is conducted under RCRA/Hazardous and Solid Waste Amendments of 1984 (HSWA) corrective action requirements. The approved Installation Work Plan (LANL 1998, 62060.4) describes the methodologies used in the investigation and analysis. The investigation was performed in accordance with HSWA and follows the requirements in Module VIII of the Laboratory's Hazardous Waste Facility Permit (EPA 1990, 01585). Module VIII was issued to the Laboratory by the EPA on May 23, 1990, and modified on May 19, 1994. Radionuclides are regulated under DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (proposed rule 10 CFR 843.5 in 58 FR 16268). Although the investigatory results regarding the PRSs in this VCM plan have never documented a radionuclide component, anecdotal evidence presented in the RCRA facility investigation (RFI) report (LANL 1998, 63070.1) suggests it is possible that the main landfill contains minute amounts of radioactive material.

This document follows a VCM plan outline developed by the ER Project; if a section is not applicable to this plan, a statement to that effect is provided under the section heading. The purpose and scope, regulatory history, and rationale for the proposed VCM are presented in the remainder of this section. Section 2 contains the site descriptions, operational histories, and descriptions of previous field investigations at PRSs 73-001(a)-99 and 73-001(b)-99. The basis for cleanup levels is presented in section 3. Section 4 includes the conceptual model, the conceptual design, the supplemental sampling, the cleanup activities, and the site restoration activities. The confirmatory sampling is discussed in section 5. Section 6 presents the estimated types and volumes of waste and the method of management and disposal. Section 7 discusses the proposed schedule and uncertainties. References can be found in section 8.

The appendixes include a list of acronyms and abbreviations; a completed VCM checklist; the results of performing standard operating procedure 2.01 (SOP-2.01), Surface Water Assessment; a completed ecological scoping checklist; estimated costs; an input file for soil gas generation calculations; results of modeling runs; waste calculations and details of landfill partitioning, methane generation potential and gas generation rate results, and active and dual active air injection venting system diagrams; and regrading calculations.

1.1 Purpose and Scope

The purposes of this plan are to

- present conceptual design options for a landfill cover and long-term monitoring system,
- prepare methodologies to guide soil excavation or recontouring of the existing landfill surfaces, and
- identify additional sampling needed for the preparation of a final landfill cover design.

1.2 Regulatory History

After the submittal and approval of the airport landfill RFI report (LANL 1998, 63070.1) a multiagency HPT was formed that included representatives from the DOE Oversight Bureau, LANL, and the NMED SWB, Hazardous Waste Bureau, and Surface Water Quality Bureau. The members of this HPT were charged with developing a remedial path toward a final remedy for the landfill and with implementing that approach once all HPT members were satisfied that the proposed remedy would adequately protect human health and the environment.

As the remedial approach developed over time, the mechanisms for documenting and implementing the final remedy were modified from the initial concept discussed in the RFI report (LANL 1998, 63070.1), as was the regulatory framework under which the remedy would take place. Chief among these changes to the remedial approach was the decision to proceed with a "phased VCM" that allowed for development of a final remedy with full regulator involvement, one that is functionally comparable to the more traditional approach recommended in the RFI report (LANL 1998, 63070.1).

This document, the first phase in the process, is to be followed by a detailed engineering design of the final remedy and the implementation of, and final reporting on, the completed remedy. The documents listed below represent the path taken to this phase of the final remedy.

- May 1992, "RFI Work Plan for Operable Unit 1071" (LANL 1992, 07667) (includes airport landfill PRSs)
- September 1997, "No Further Action (NFA) Report for PRSs 0-034(a), 0-034(b), 73-001(b), 73-004(c), and 73-004(d)" (LANL 1997, 59367)
- November 1998, "RFI Report for PRSs 73-001(a,b,c,d) and 73-004(d) (Airport Landfill Areas)" (LANL 1998, 63070.1)

- December 1999, approval to proceed, 73-001(a,b,c,d) and 73-004(d) RFI report (airport landfill areas), Los Alamos National Laboratory, NM0890010515 (NMED 1999, 65133)
- October 2001, "Supplemental Sampling and Analysis Plan for Potential Release Sites 73-001(a) and 73-001(d)" (LANL 2001, 71258)
- November 2001, letter of approval for the "Supplemental Sampling and Analysis Plan for Potential Release Sites 73-001(a) and 73-001(d)" (NMED 2001, 72812)

1.3 Rationale for Proposed Corrective Action

The ultimate objective of the VCM is to achieve a final remedy for the airport landfills which is consistent with current regulatory requirements. The recommendations presented in the RFI report (LANL 1998, 63070.1) stated that the final remedy for the airport landfills should be consistent with state and federal regulations set forth for covering other municipal waste landfills [RCRA Subtitle D regulations (40 CFR Parts 257 and 258)], and that a final corrective action plan and site engineering design would be developed according to NMED Solid Waste Bureau guidelines for municipal landfills. However, NMED subsequently required that the landfill covers demonstrate performance equivalency with Subtitle C requirements (40 CFR Part 124).

2.0 PREVIOUS SITE CHARACTERIZATION

2.1 Site Description and Operational History

2.1.1 Site Description

PRSs 73-001(a)-99 (main landfill) and 73-001(b)-99 (DDA) are inactive PRSs and are listed in Table A within Module VIII of the Laboratory's Hazardous Waste Facility Permit (LANL 1996, 57486.1). Both landfill areas are located within Technical Area 73 (TA-73) on DOE property (Figure 2.1-1), immediately north of the Los Alamos Airport runway, between the runway and the edge of the mesa (Figure 2.1-2).

The main landfill area consists of a natural hanging valley into which municipal and Laboratory sanitary waste was disposed of for approximately 30 years. The west and south sides of the main landfill coincide approximately with the edges of the asphalt tie-down area and the asphalt taxiway to the hot pad, respectively. The north side extends approximately to the chainlink security fence along the north side of the airport. To the east, the landfill extends to the end of the hanging valley and pinches out toward the hot pad. To the north and east lie four drainages littered with debris consistent with items disposed of within the landfill proper. An interim measure has been prepared to address these drainages.

The DDA lies east of the main landfill and consist of two roughly parallel trenches excavated to a maximum depth of approximately 35 ft. To the west, the trenches extend to within approximately 150 ft of the windsock. To the east, the trenches extend approximately 800 ft beyond the end of the runway.

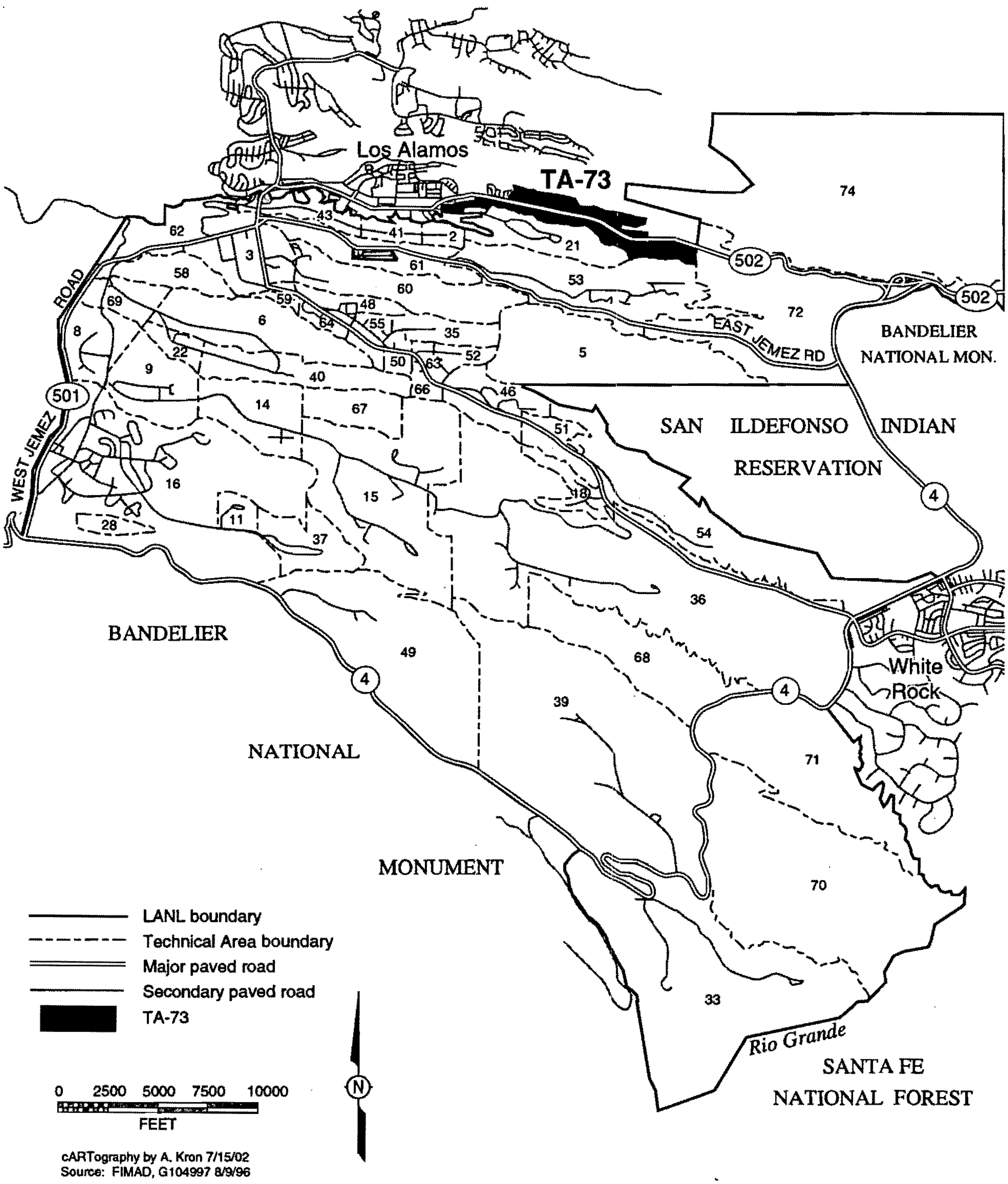


Figure 2.1-1. Location of TA-73 with respect to laboratory technical areas and surrounding landholdings

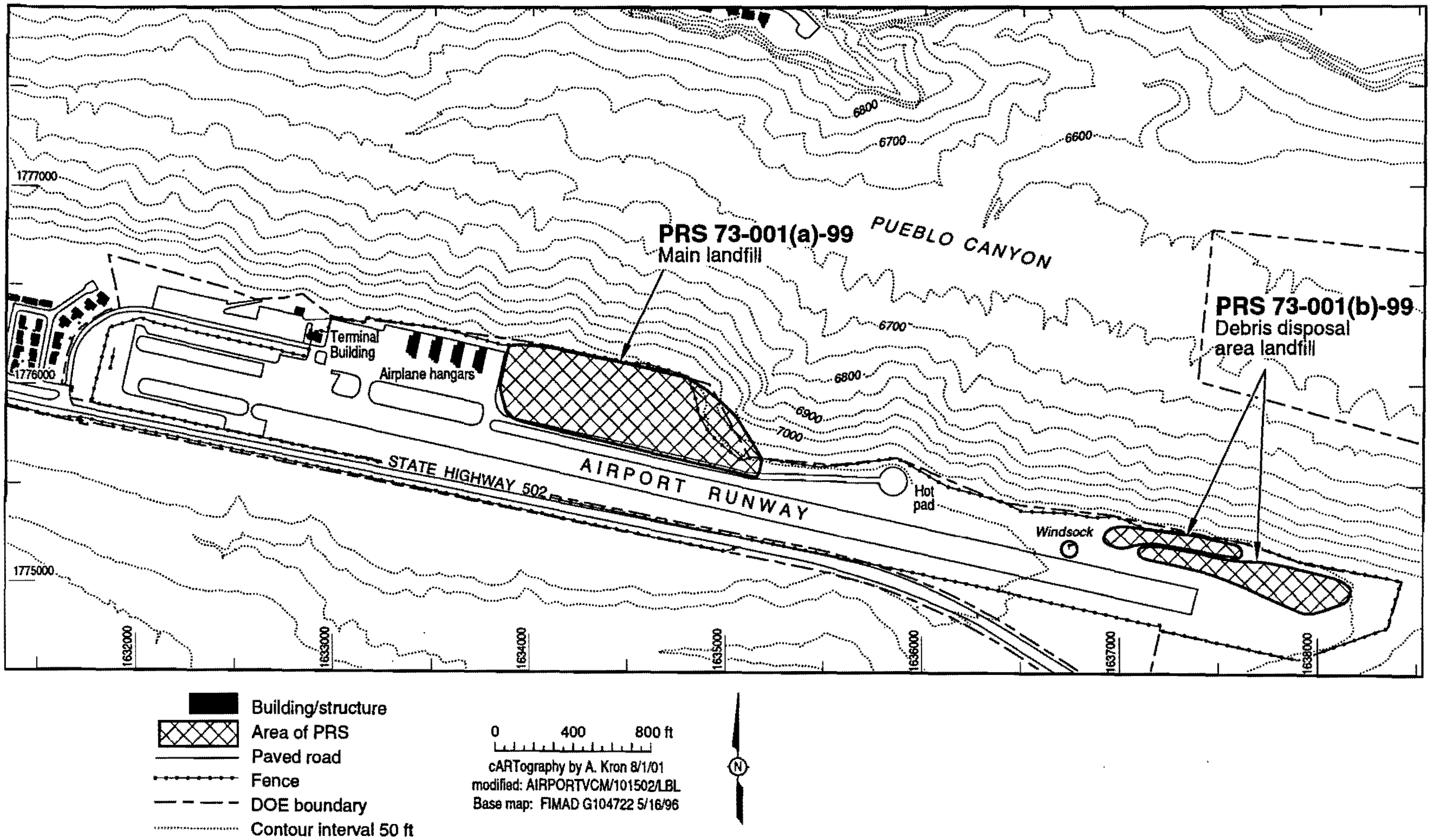


Figure 2.1-2. Locations of landfill areas

The main landfill covers a surface area of approximately 11.5 acres. The DDA covers a surface area of approximately 5 acres. The approximate depths obtained from geophysical survey and drilling activities (LANL 1998, 63070.1) and existing topographic contours put the main landfill and DDA volume estimates at 536,800 and 126,000 yd^3, respectively.

The areas encompassing PRSs 73-001(a)-99 and 73-001(b)-99 are currently part of the Los Alamos Airport but are not being used for any specific purpose. Future land use projections indicate that these areas will continue to be included as part of the airport (i.e., an industrial use). The current airport operations manager has stated that Los Alamos County has expressed interest in using a portion of the main landfill area for additional aircraft hangars and an aircraft tiedown area, assuming that no restrictions are placed on these activities following capping of the landfill. FAA regulations preclude future use of the DDA for these activities.

For many years, access to PRSs 73-001(a)-99 and 73-001(b)-99 was, and still is, controlled by a perimeter fence around the entire airport. Access to the tarmac is limited to private airplane owners, operators, passengers, and other individuals with legitimate reasons to be there.

2.1.2 Operational History

In 1943, the DOE began using the hanging valley north of the airport runway as a landfill [PRS 73-001(a)-99]. Garbage was collected twice a week from the Laboratory and town site and burned at the edge of the hanging valley (Miller 1963, 00684.1). Heavy equipment was then used to push the burned residues and ash into whichever landfill disposal area was being used at the time. This intentional burning ceased in 1965 when Los Alamos County assumed operation of the landfill (Miller and Shaykin 1966, 36692). The county continued to operate the landfill until June 30, 1973 (Drennon 1990, 00650.1).

The DDA [PRS 73-001(b)-99] was used from 1984 to 1986 to bury debris excavated from the western portion of the main landfill (LANL 1990, 07514.1). This material was excavated and replaced with clean fill to prepare the western portion of the landfill for constructing airplane hangars and tiedown areas. Since the wastes placed in the DDA came from the main landfill, both areas contain similar types of debris. In 1986, the DDA was covered with soil and hydroseeded (LANL 1990, 07514.1).

2.2 Previous Field Investigations

2.2.1 RFI-Related Activities

As part of the field activities conducted over a period of several years, a number of nonsampling activities were completed, including site surveys, radiological surveys, infrared photography surveys, geophysical surveys, geomorphologic mapping, and geodetic surveys. Detailed information about the results of these activities is provided in the RFI report, section 2.3.4 (LANL 1998, 63070.1). The geophysical survey results are the most relevant to this VCM plan.

The survey methods involved several basic principles, including wave propagation at different wavelengths (seismic refraction and ground-penetrating radar), potential fields (magnetic total field and gravity field profiling and mapping), and Schlumberger vertical electric sounding resistivity measurement. The surveys were based on a measured grid and were performed using conventional methods. The surveys successfully provided data on landfill thicknesses and depths to the native tuff, and on the location of landfill boundaries and buried objects.

Numerous sampling activities were also carried out over a period of several years. These activities consisted of soil gas sampling, surface soil and sediment sampling, interior and perimeter borehole drilling, subsurface soil and tuff sampling, cone penetrometer testing, monitoring well installation, pore water and leachate sampling, and related activities. Detailed information about the results of these activities is also provided in the RFI report, section 2.3.4, along with an in-depth data review, screening assessment, and human health risk assessment (sections 2.3.4.3, 2.4.2, and 2.4.3.1, respectively) (LANL 1998, 63070.1).

2.2.2 Supplemental Investigations

Prior to preparing this VCM plan, the existing RFI data were reviewed and data gaps were identified, particularly those gaps affecting the preparation of a conceptual cover design. A supplemental sampling and analysis plan (SAP) (LANL 2001, 71258) was prepared, the execution of which would provide the necessary data to fill the gaps and complete a conceptual design of suitable landfill covers for the airport landfills. The supplemental investigation was completed over approximately 2 weeks at the end of October and the beginning of November 2001. Pursuant to the provisions of the SAP, the investigation consisted of three major activities: (1) sampling the existing monitoring well network, (2) soil gas sampling, and (3) backhoe trenching and soil sampling for hydraulic and geotechnical properties.

2.2.2.1 Monitoring Well Sampling

To determine current subsurface conditions and thus provide evidence of any effect that the stormwater runon controls installed in late 1998 may have had on main landfill gas concentrations or moisture content, samples were collected from the existing monitoring well network. Functional soil gas ports, lysimeters, heat dissipation sensors, and thermocouples were sampled. Relative changes in soil/tuff moisture content were logged using a neutron probe.

2.2.2.2 Soil Gas Sampling

As proposed in the SAP, a soil gas sampling grid of 100 by 200 ft was established over both the main landfill and DDA. This resulted in 37 sampling locations: 23 within the landfill and 14 within the DDA (Figures 2.2-1, 2.2-2, and 2.2-3). Within the main landfill, seven additional biased locations were selected to represent areas of subsidence or stressed or healthy vegetation. At each location, in 4- to 6-in. intervals, the procedure was to drive a soil gas sampling probe vertically into the ground using a Bosch rotary hammer. At the bottom of each interval, a sample of the soil vapor was analyzed for oxygen (O_2), carbon dioxide (CO_2), and methane (CH_4) using a Landtech gas analyzer. Where possible, the sampling probe was driven to a maximum depth of 5 to 6 ft. At several locations, refusal was encountered at shallower depths, in most part because of tuff, concrete, or other debris present in the subsurface. Table 2.2-1 summarizes the location IDs, the intervals sampled at each location, and any comments regarding the location.

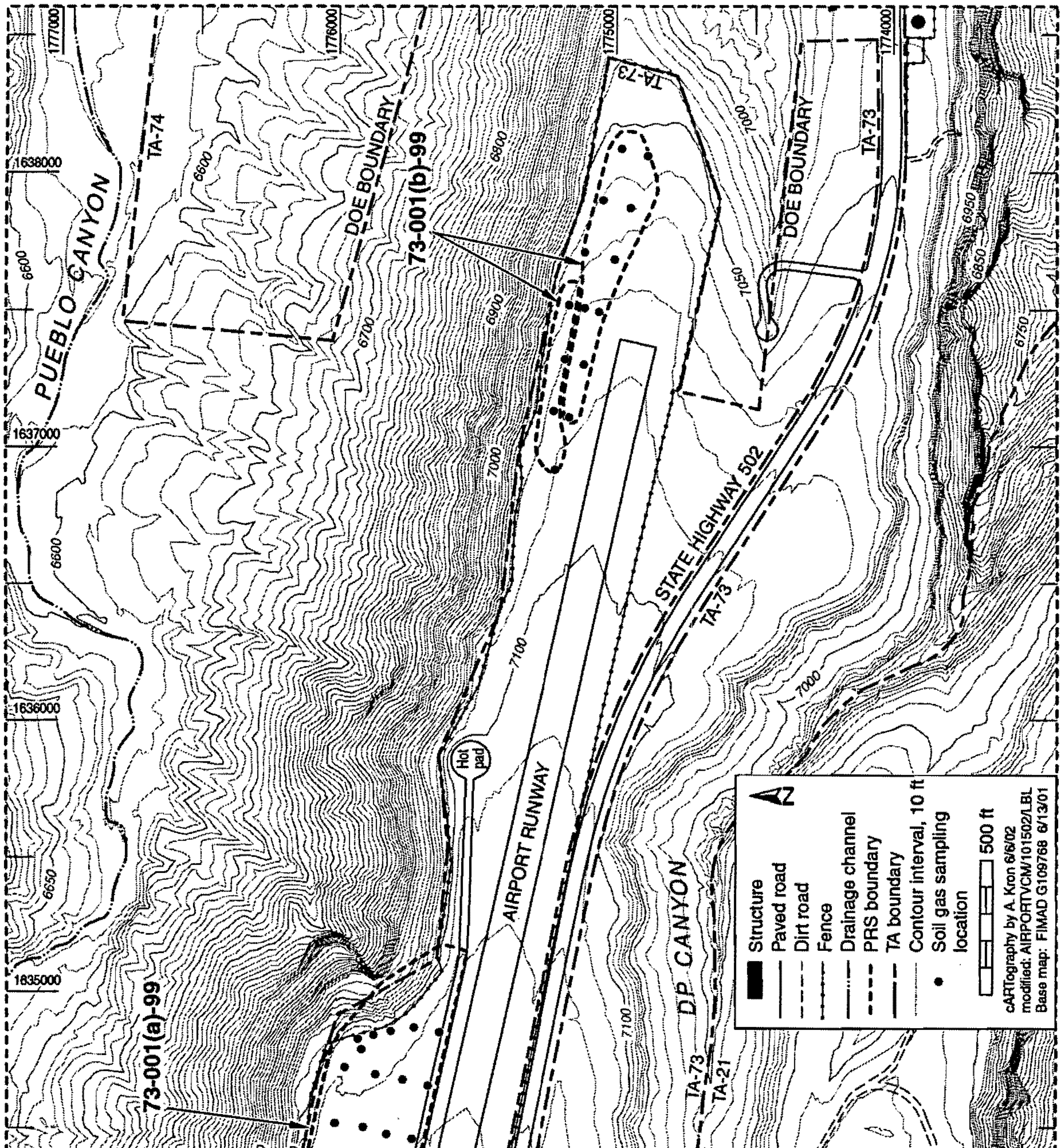


Figure 2.2-1. Overview of soil gas sampling locations

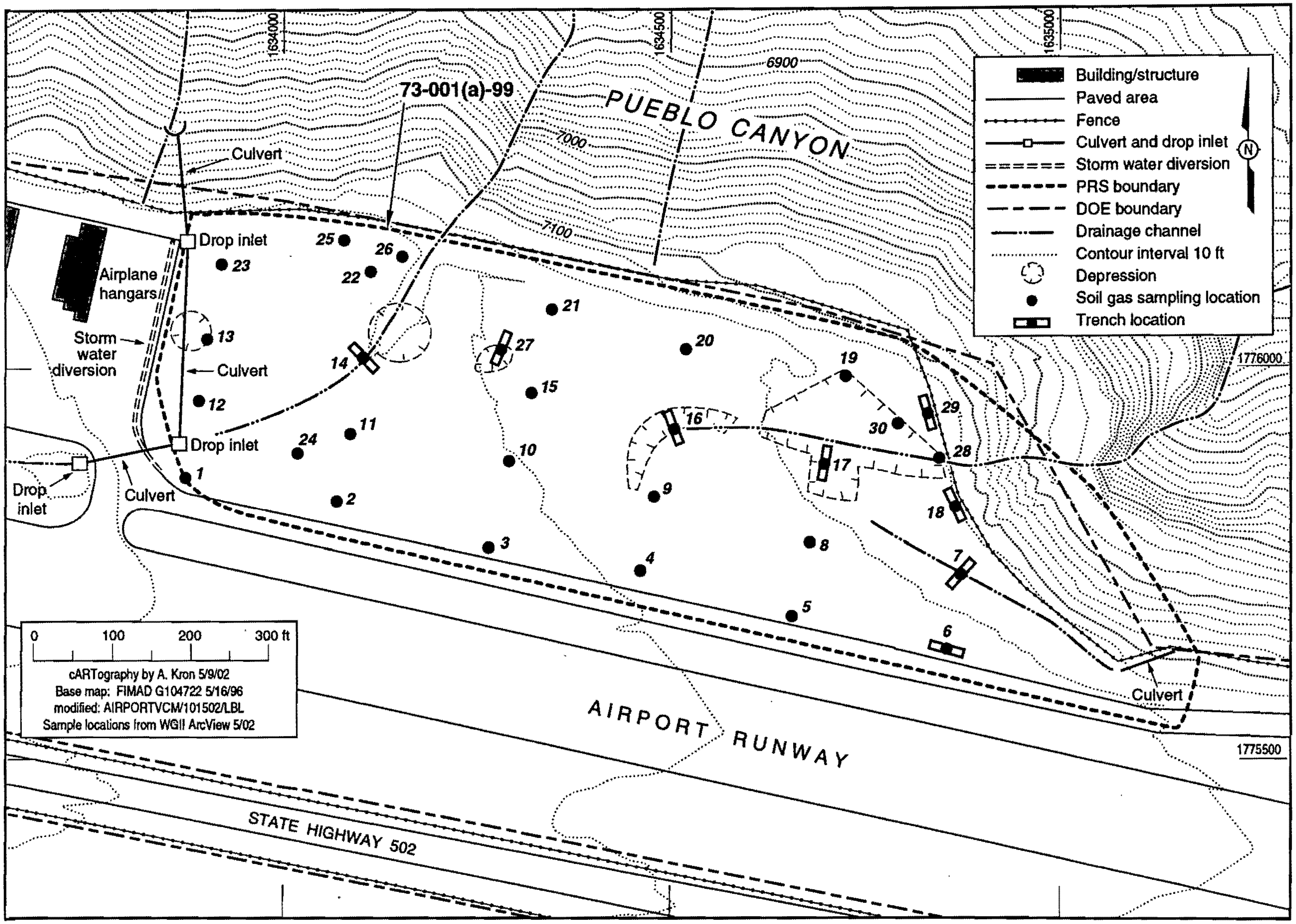


Figure 2.2-2. Soil gas sampling locations and trenching locations at 73-001(a)-99

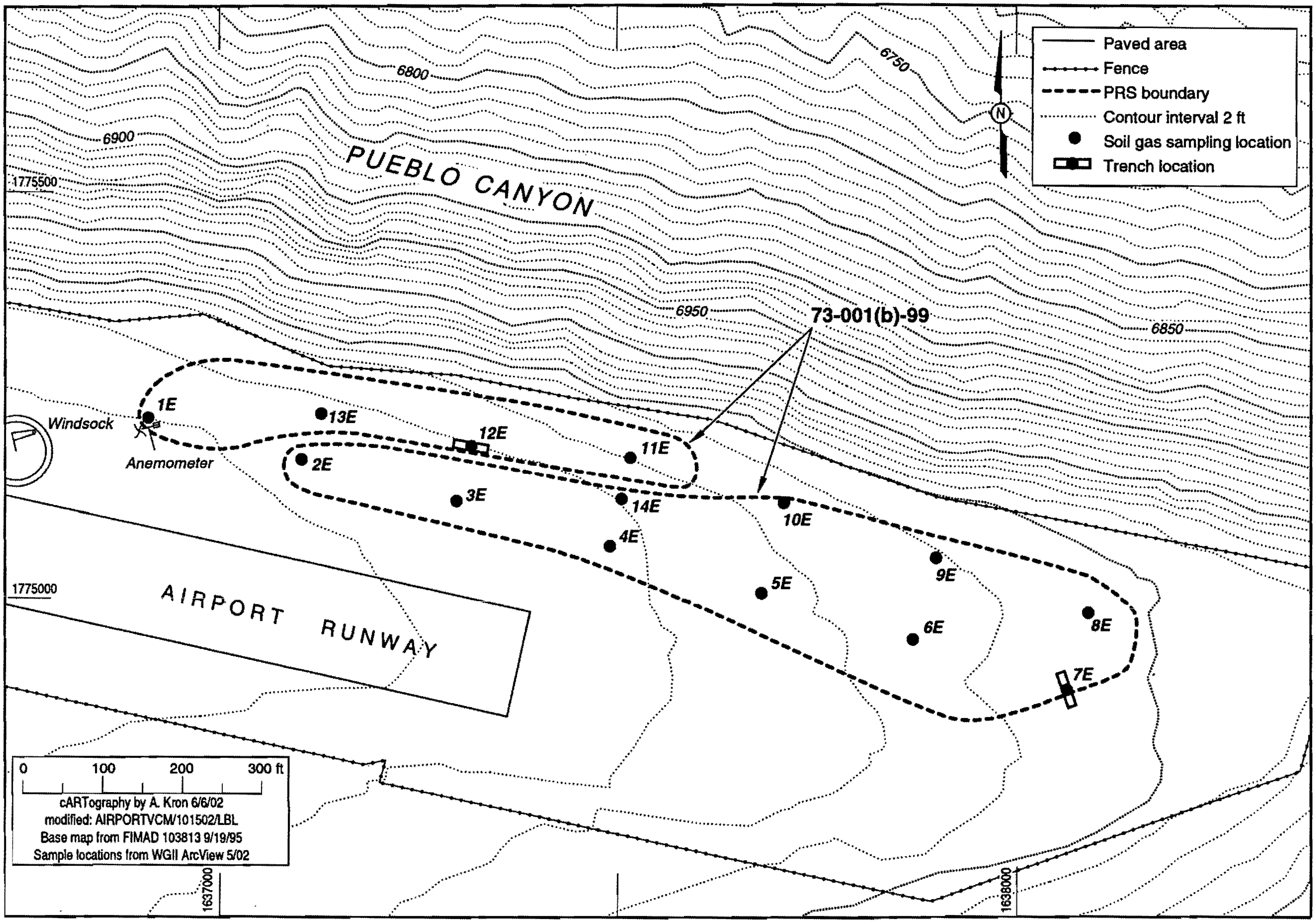


Figure 2.2-3. Soil gas sampling locations and trenching locations at 73-001(b)-99

Table 2.2-1
Soil Gas Sampling Summary

Location ID	Depths Sampled (in.)	Comments
Main Landfill Sampling		
1	6	Refusal at 6 in. Probable tuff.
2	6, 11	Refusal at 11 in. Probable tuff.
3	6, 12	Refusal at 12 in. Probable tuff.
4	6, 12, 18, 24, 30	Refusal at 30 in. Probable tuff.
5	6, 12, 18, 24, 30	Soil compacted. Difficult to obtain reliable data.
6	6, 12, 18	Refusal at 18 in. Probable tuff.
7	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
8	6, 8	Refusal at 8 in.
9	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
10	6	Refusal at 6 in.
11	6, 12, 18, 24	Refusal at 24 in.
12	6, 12	Refusal at 12 in. Soil tight; pump laboring.
13	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
14	6, 12, 18, 24	Refusal at 24 in.
15	6, 12, 24, 30, 36, 42, 45	Refusal at 45 in.
16	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
17	6, 12, 18, 24, 30, 36, 42	Soil too tight to obtain reliable data.
18	6, 12, 18, 24, 30, 36	Soil very tight. Stopped driving probe at 36 in.
19	6, 12, 18, 24, 30, 36, 42, 48	—
20	6, 12, 18, 24, 36, 42, 48, 54	Tight formation; pump laboring.
21	6, 12, 18, 24, 36, 42, 48, 54	Tight formation; pump laboring.
22	6, 11	Refusal at 11 in.
23	6, 12, 18, 24, 29	Refusal at 29 in.
24	6, 8	Refusal at 8 in.
25	12, 18, 24, 30, 36, 42, 48, 53	Refusal at 53 in.
26	12, 18, 24, 30	Refusal at 30.5 in. Fracture at surface.
27	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
28	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
29	6, 12, 18, 24, 30, 36, 42, 48, 54	Refusal at 55 in.
30	6, 12, 18, 24, 30, 36, 42	Tight formation; pump laboring.
DDA Sampling		
1E	6, 12, 18, 24, 30, 36	Refusal at 36 in.
2E	6, 12, 18, 24, 30, 36, 42, 48, 51	Refusal at 51 in.
3E	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—
4E	6, 12, 18, 24	Refusal at 24 in.
5E	6, 12, 18, 24, 30	Tight formation. Readings unreliable after 24 in.
6E	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44	Refusal at 44 in.
7E	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72	—

Table 2.2-1 (continued)

Location ID	Depths Sampled (in.)	Comments
8E	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72	—
9E	4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68	—
10E	6, 12, 18, 21	Refusal at 21 in.
11E	6, 12, 18, 24, 30, 36	Refusal at 36 in.
12E	6, 12, 18, 24, 30, 36, 42, 48	Refusal at 48 in.
13E	6, 12	Refusal at 14 in.
14E	6, 12, 18, 24, 30, 36, 42, 48, 54, 60	—

2.2.2.3 Backhoe Trenching and Soil Sampling

Following completion of soil gas sampling, ten locations were selected at which to excavate trenches (Figures 2.2-2 and 2.2-3). These locations were selected and trenched to provide information regarding areas of maximum subsidence, areas with stressed vegetation, areas with abundant vegetation, and areas with reduced root growth from presence of landfill gasses. A backhoe was used to excavate the shallow trenches either to the top of landfill debris or tuff or to a maximum depth of 4 ft below ground surface, whichever occurred first. A knife was then used to scrape a portion of the trench sidewall to facilitate examination of the soil profile and rooting depths. The observations were recorded in the field logbook.

Bulk soil samples were also collected from five of the trenching locations for geotechnical analyses. At five locations (locations 6, 16, 17, 18, and 27), samples were collected for permeability testing by driving brass sleeves into the soil profile. At three of these locations (locations 17, 18, and 27), 5-gal. buckets were filled with soil for additional geotechnical testing. These samples were collected under the premise that the existing cover material might be made part of the final cover and that its hydrogeological properties would need to be taken into account in the modeling simulations. However, none of the modeling scenarios used the existing cover as part of the final cover because the waste needed to be regraded or reconfigured. Therefore, these data were not used in the modeling simulations and are not presented in this document.

2.3 Results of Previous Investigations

2.3.1 RFI-Related Activities

Results of the previous RFI were summarized in the RFI report (LANL 1998, 63070.1). The RFI was designed to characterize the airport landfills and provide adequate data with which to determine an appropriate plan for corrective action. The investigation provided extensive data regarding potential contaminants in surface and subsurface soils, in shallow and deep soil gas, and in pore water. The data were compared with data collected from over 60 municipal nonhazardous landfills in California (CARB 1990, 59084). These comparisons indicated that the nature of the contaminants and the contaminant concentrations detected in the soil gas and pore water were consistent with those found at other municipal landfills. This evaluation led to the recommendation that the airport landfill remedy be consistent with other municipal nonhazardous landfills. In the RFI report, sections 2.3.4.3 and 2.3.5.1 focused on this comparison.

Under current conditions, landfill gas, primarily methane and carbon dioxide associated with the decomposing refuse, is present in the subsurface. Temporal variation in the nature of landfill gas constituents and spatial concentration trends are documented by the existing analytical data. Measurements of the soil water potentials confirm relatively wet, but unsaturated, conditions within the refuse and within the tuff immediately surrounding the refuse. These wet zones in the refuse contribute to the generation of landfill gas as the disposed-of material decomposes. The areas with the greatest moisture content tend to experience the greatest landfill gas generation. Samples collected from the tuff bordering the landfill indicate increasingly dry conditions, demonstrating a decreasing trend in the potential for horizontal and vertical migration.

2.3.2 Supplemental Investigations

2.3.2.1 Monitoring Well Sampling

The primary objective of the monitoring well sampling was to collect data with which to document current landfill conditions, thereby confirming that the stormwater run-on controls installed in 1998 had reduced moisture levels and landfill gas concentrations. A reduction in available moisture from implementing the surface water run-on controls should further reduce the potential for contaminant migration. However, the lack of precipitation due to extended drought conditions and an extremely dry winter will influence the moisture and landfill gas generation conditions in the main landfill to a much greater degree than the stormwater run-on controls. Therefore, the new data are of little or no use when evaluating the effectiveness of the run-on controls, and the monitoring well sampling results are not presented in this plan.

2.3.2.2 Soil Gas Sampling

Tables 2.3-1 and 2.3-2 summarize the soil gas survey results for the main landfill and DDA, respectively. The soil gas survey results for the main landfill showed methane concentrations ranging from a minimum of 0.0 to a maximum of 54.3% at several locations. The soil gas survey completed at the DDA resulted in methane detects at only 3 of the 14 sampling locations (locations 7E, 8E, and 9E). The concentrations at these locations ranged from a minimum of 0.3 to a maximum of 10.9%.

Table 2.3-1
Soil Gas Data for the Main Landfill

Date	Time	Location ID	Depth (in.)	CH_4%[a]	CO_2%[b]	O_2%[c]	mb[d]	Remarks
11/7/01	10:45	1	6	N/A[e]	N/A	N/A	N/A	Refusal at 6 in.
11/7/01	10:25	2	6	0.0	0.3	19.5	792	Refusal at 11 in.
	10:30		11	0.0	0.0	19.6	791	
11/6/01	11:49	3	6	0.0	0.0	19.7	790	Refusal at 6 in.
	11:55		12	0.0	0.2	19.4	790	
11/6/01	10:24	4	6	0.3	0.1	19.4	791	Refusal at 30 in.
	10:30		12	0.0	0.0	17.7	791	
	10:51		18	0.7	5.6	12.8	792	
	10:55		24	4.5	14.0	5.0	791	
	11:00		30	8.0	19.3	0.9	791	

Table 2.3-1 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/2/01	3:44	5	6	0.0	0.0	19.8	788	Soil highly compacted; difficulty obtaining reliable data
	3:46		12	0.0	0.2	19.7	788	
	4:48		18	0.0	0.3	19.4	788	
	3:51		24	0.0	2.5	17.2	788	
	3:53		30	N/A	N/A	N/A	N/A	
11/2/01	3:22	6	6	0.0	0.0	19.3	789	Probe going in with difficulty; appears to be solid tuff
	3:24		12	0.0	0.1	19.5	788	
	3:27		18	0.0	0.2	19.6	789	
11/2/01	2:30	7	6	0.0	0.8	18.8	788	
	2:32		12	0.0	2.2	17.5	788	
	2:35		18	0.0	3.4	16.1	788	
	2:37		24	0.0	3.0	16.6	788	
	2:40		30	0.0	5.4	13.8	788	
	2:42		36	0.0	7.7	11.1	788	
	2:47		42	0.0	11.3	7.4	788	
	2:51		48	0.0	12.4	6.0	788	
	2:54		54	0.0	12.7	5.6	788	
	2:58		60	0.0	14.3	4.0	788	
11/5/01	9:35	8	6	0.0	0.1	19.4	795	Refusal at 8 in.
	9:40		8	0.0	0.4	19.4	793	
11/6/01	9:15	9	6	0.0	2.1	17.6	792	
	9:17		12	0.0	6.0	13.8	792	
	9:19		18	0.0	9.8	9.7	792	
	9:21		24	0.0	15.3	4.2	792	
	9:24		30	1.1	18.6	2.0	791	
	9:35		36	3.1	11.9	8.6	791	
	9:54		42	23.6	20.9	7.1	792	
	10:00		48	44.0	37.3	0.5	791	
	10:05		54	49.8	40.8	0.4	791	
	10:11		60	48.6	39.3	1.1	792	
11/6/01	12:05	10	6	0.0	0.0	19.9	789	Refusal at 6 in.
11/7/01	10:03	11	6	0.0	0.0	19.6	792	Refusal at 24 in.
	10:05		12	0.0	0.3	19.4	792	
	10:07		18	0.0	0.6	19.4	792	
	10:10		24	0.0	0.4	19.5	791	
11/7/01	10:53	12	6	0.0	0.0	20.0	792.0	Refusal at 12 in.; formation tight; pump laboring
	10:55		12	0.0	0.0	20.0	791.0	

Table 2.3-1 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/7/01	11:12	13	6	0.0	0.2	19.4	792	
	11:15		12	0.0	0.7	19.1	792	
	11:17		18	0.0	5.3	13.3	792	
	11:20		24	0.0	11.9	6.2	791	
	11:22		30	0.0	11.0	7.2	792	
	11:30		36	0.0	15.0	3.4	792	
	11:33		42	0.0	16.7	1.2	792	
	11:35		48	15.7	27.2	0.0	792	
	11:40		54	20.6	26.2	3.1	792	
	11:45		60	25.0	30.4	1.0	792	
11/7/01	9:34	14	6	0.0	0.6	18.8	794	Refusal at 24 in.
	9:37		12	0.0	1.5	18.7	793	
	9:41		18	0.0	5.9	14.8	792	
	9:44		24	0.0	8.2	12.5	792	
11/6/01	12:25	15	6	0.0	0.4	19.5	789	Refusal at 45 in.
	12:30		12	0.0	1.9	18.1	788	
	12:35		24	0.0	5.0	15.1	788	
	12:37		30	0.0	9.0	10.5	788	
	12:40		36	1.1	20.2	1.1	788	
	12:42		42	3.5	23.0	0.0	788	
	12:45		45	5.5	23.9	0.0	788	
11/5/01	15:47	16	6	0.0	0.1	19.8	790	
	15:51		12	0.2	0.9	19.4	790	
	15:53		18	0.5	1.9	18.5	790	
	15:55		24	6.1	6.8	14.1	790	
	15:57		30	36.9	34.0	0.0	790	
	16:00		36	48.1	39.2	0.0	790	
	16:08		42	48.5	38.8	0.5	790	
	16:10		48	54.3	41.9	0.0	790	
	16:13		54	54.0	41.8	0.1	790	
	16:18		60	47.3	36.2	2.9	790	
11/5/01	9:48	17	6	0.0	0.1	19.8	793	Formation too tight for gas measurements
	9:52		12	0.0	0.4	19.5	793	
	9:55		18	0.0	0.8	19.2	793	
	9:57		24	0.6	7.5	8.1	793	
	10		30	0.6	4.9	12.9	793	
	10:05		36	0.5	3.4	15.2	793	
	10:08		42	N/A	N/A	N/A	N/A	

Table 2.3-1 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/2/01	1:54	18	6	0.0	0.3	18.8	788	At 36 in. removed probe; two segments would have been very difficult to remove
	1:58		12	0.0	1.1	18.4	788	
	2		18	0.0	2.1	17.6	788	
	2:03		24	0.0	3.1	16.6	789	
	2:05		30	0.0	3.7	15.9	789	
	2:07		36	0.0	4.3	15.2	788	
11/5/01	11:05	19	6	0.0	0.3	19.7	794	
	11:08		12	0.0	6.2	14.0	793	
	11:11		18	0.5	14.1	5.9	793	
	11:13		24	3.5	19.8	2.0	794	
	11:15		30	14.7	25.5	0.1	795	
	11:21		36	27.4	29.2	0.0	794	
	11:24		42	29.6	29.9	0.0	795	
	11:30		48	N/A	N/A	N/A	N/A	
11/5/01	1449	20	6	0.0	0.4	19.7	792	Tight formation; pump laboring
	1452		12	0.0	2.6	18.0	791	
	1456		18	0.4	6.9	13.7	791	
	1500		24	18.6	31.3	0.0	790	
	1502		36	42.1	40.9	0.5	790	
	1504		42	26.1	21.6	9.2	790	
	1506		48	36.3	29.4	6.2	790	
	1510		54	N/A	N/A	N/A	N/A	
11/6/01	13:05	21	6	0.0	0.7	19.0	788	Tight formation; pump laboring
	13:07		12	0.1	3.8	16.3	788	
	13:10		18	0.8	16.8	4.1	788	
	13:12		24	18.5	27.7	1.1	788	
	13:14		30	24.3	31.5	0.0	788	
	13:18		36	25.7	32.1	0.0	788	
	13:21		42	46.0	37.0	2.7	788	
	13:25		48	48.4	37.7	3.0	788	
	13:40		54	7.1	6.5	15.7	788	
11/6/01	15:45	22	6	0.2	0.6	19.1	788	Refusal at 11 in.
	15:47		11	0.1	1.4	18.7	788	
11/7/01	13:30	23	6	0.0	0.4	19.2	791	Refusal at 29 in.
	13:35		12	0.0	0.8	18.7	791	
	13:37		18	0.0	0.9	18.6	791	
	13:39		24	0.0	2.9	15.2	791	
	13:42		29	0.0	9.6	7.8	791	
11/7/01	10:35	24	6	0.0	0.4	19.4	791	Refusal at 8 in.
	10:38		8	0.0	0.7	19.3	791	

Table 2.3-1 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/6/01	15:58	25	12	0.0	3.6	17.1	788	Refusal at 53 in.
	16:00		18	0.1	7.6	12.8	787	
	16:02		24	0.0	13.2	7.4	787	
	16:04		30	0.3	16.0	4.6	788	
	16:06		36	1.0	18.7	2.1	787	
	16:08		42	2.6	20.8	0.0	788	
	16:10		48	2.6	20.6	0.0	788	
	16:15		53	2.5	20.4	0.0	788	
11/6/01	15:25	26	12	0.3	0.2	19.5	788	Refusal at 30.5 in.; fracture at surface
	15:30		18	0.3	3.9	16.2	788	
	15:32		24	0.2	6.6	13.9	788	
	15:34		30	0.3	17.1	2.6	787	
11/6/01	14:30	27	6	1.8	4.1	16.7	788	
	14:35		12	7.7	17.4	6.5	788	
	14:36		18	21.1	32.4	0.0	788	
	14:38		24	25.9	34.4	0.0	788	
	14:40		30	31.0	36.3	0.0	788	
	14:42		36	32.3	36.9	0.0	788	
	14:44		42	32.9	36.7	0.0	788	
	14:50		48	33.5	36.9	0.0	788	
	14:55		54	33.0	37.1	0.0	788	
	14:58		60	33.0	37.2	0.0	788	
11/2/01	1:12	28	6	0.0	0.3	19.3	790	
	1:15		12	0.0	1.1	18.7	789	
	1:17		18	0.0	2.0	17.8	789	
	1:19		24	0.0	1.5	18.2	789	
	1:22		30	0.0	4.6	15.1	789	
	1:25		36	0.0	6.2	13.1	789	
	1:29		42	0.0	8.4	10.7	788	
	1:32		48	0.4	17.5	1.6	789	
	1:35		54	4.5	17.9	2.5	789	
	1:37		60	5.3	18.2	2.4	788	
11/2/01	11:19	29	6	0.0	0.2	19.5	791	Refusal at 55 in.
	11:21		12	0.0	1.2	18.5	792	
	11:23		18	19.3	27.2	0.0	791	
	11:27		24	21.0	28.3	0.0	791	
	11:31		30	22.0	29.3	0.0	791	
	11:33		36	24.6	31.8	0.0	791	
	11:39		42	26.2	31.5	0.0	790	
	11:41		48	25.1	30.1	0.0	790	
	11:44		54	23.6	29.1	0.0	791	

Table 2.3-1 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/5/01	13:22	30	6	0.2	0.0	20.1	793	Tight formation; pump laboring
	13:25		12	0.1	1.4	18.9	793	
	13:28		18	0.1	4.8	15.6	792	
	13:30		24	0.0	12.0	7.9	793	
	13:32		30	0.0	14.7	5.6	792	
	13:34		36	9.5	19.7	4.2	792	
	13:40		42	0.0	0.0	20.1	792	

[a] Percent methane in landfill gas.

[b] Percent carbon dioxide in landfill gas.

[c] Percent oxygen in landfill gas.

[d] Atmospheric pressure in millibars.

[e] N/A = Not applicable.

Table 2.3-2
Soil Gas Data for the DDA

Date	Time	Location ID	Depth (in.)	CH_4%[a]	CO_2%[b]	O_2%[c]	mb[d]	Remarks
11/2/01	10:25	1E	6	0.0	0.0	20.0	792	Refusal at 36 in.
	10:28		12	0.0	0.0	19.9	792	
	10:32		18	0.0	0.0	19.8	792	
	10:35		24	0.0	0.1	19.8	792	
	10:42		30	0.0	0.1	19.7	792	
	10:49		36	0.0	0.1	19.7	792	
11/2/01	9:15	2E	6	0.0	0.2	19.6	792	Refusal at 51 in.
	9:17		12	0.0	1	19.4	792	
	9:34		18	0.0	2.1	18.5	792	
	9:37		24	0.0	3.4	17.5	792	
	9:39		30	0.0	5.2	16.1	792	
	9:41		36	0.0	5.6	15.3	792	
	9:45		42	0.0	7.1	14.4	792	
	9:47		48	0.0	7.3	14.3	792	
	9:49		51	0.0	7.3	14.1	792	

Table 2.3-2 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/1/01	2:10	3E	6	0.0	0.2	19.5	785	
	2:14		12	0.0	1.8	18.4	786	
	2:16		18	0.0	4.6	15.7	786	
	2:19		24	0.0	7.1	13.0	786	
	2:21		30	0.0	9.1	11	786	
	2:24		36	0.0	12.8	7.4	785	
	2:28		42	0.0	11.9	6.8	784	
	2:30		48	0.0	16.1	4.5	785	
	2:34		54	0.0	16.5	4.1	785	
	2:36		60	0.0	15.7	4.3	785	
11/1/01	11:49	4E	6	0.0	0.3	19.6	787	Refusal at 24 in.
	11:52		12	0.0	0.8	19.2	788	
	11:55		18	0.0	1.4	18.6	787	
	11:59		24	0.0	3	17	787	
11/1/01	10:07	5E	6	0.0	0.0	19.5	788	Instrument readings unreliable after 24 in. Changed to larger probe tip but hit refusal at 18 in. with this tip
	10:15		12	0.0	0.2	19.5	788	
	10:17		18	0.0	0.7	19.3	788	
	10:20		24	0.0	0.0	19,8	788	
	10:24		30	NA	NA	NA	NA	
	10:47		18	0.0	0.3	19.5	789	
11/1/01	9:20	6E	4	0.0	0.1	19.8	788	Refusal at 44 in.
	9:25		8	0.0	1.1	19.1	788	
	9:28		12	0.0	2.1	18.2	788	
	9:31		16	0.0	3.3	17.2	788	
	9:34		20	0.0	8	12.7	788	
	9:36		24	0.0	9.4	10.9	788	
	9:39		28	0.0	10.5	9.7	788	
	9:41		32	0.0	10.8	9.1	788	
	9:44		36	0.0	11.6	8.2	788	
	9:47		40	0.0	12.8	6.7	788	
	9:51		44	0.0	12.8	6.7	788	

Table 2.3-2 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
10/31/01	10:00	7E	4	0.0	0.2	20	788	
	10:04		8	0.0	1.2	19	788	
	10:07		12	0.0	1.1	19.1	788	
	10:11		16	0.0	3.7	15.8	788	
	10:20		20	0.0	4.8	14.2	790	
	10:23		24	0.0	5.4	13.3	789	
	10:26		28	0.0	5.8	12.7	788	
	10:29		32	0.0	6.4	12.1	788	
	10:34		36	0.0	7	11.2	788	
	10:42		40	0.0	7.7	10.1	788	
	10:44		44	0.0	7.9	10	789	
	10:45		48	0.0	9	8.1	789	
	10:47		52	0.0	10.7	6.5	788	
	10:51		56	0.0	11.5	5.6	788	
	10:55		60	0.0	15.2	2.5	788	
	10:59		64	2.2	19.2	0.0	788	
	11:04		68	2.9	20	0.0	788	
	11:09		72	3.5	20.1	0.0	789	
10/31/01	1:30	8E	4	0.0	0.3	19.6	784	
	1:35		8	0.0	0.8	19.3	784	
	1:37		12	0.0	2	18.2	784	
	1:39		16	0.0	3.4	16.7	784	
	1:42		20	0.0	4.9	15.2	784	
	1:45		24	0.0	7.2	12.6	784	
	1:47		28	0.0	8.5	11	784	
	1:51		32	0.0	8.9	10.7	784	
	1:54		36	0.0	12.3	6.9	784	
	1:56		40	0.0	15.9	3.3	784	
	1:59		44	0.0	20.2	0.0	784	
	2:05		48	0.0	20.6	0.0	783	
	2:08		52	0.0	20.6	0.0	784	
	2:11		56	0.0	20.6	0.0	784	
	2:14		60	0.3	20.7	0.0	783	
	2:17		64	0.7	20.5	0.0	784	
	2:19		68	1.3	20.6	0.0	784	
	2:21		72	1.6	20.6	0.0	784	

Table 2.3-2 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
10/31/01	3:06	9E	4	0.0	0.8	18.9	784	
	3:09		8	0.0	2.2	17.9	784	
	3:13		12	0.0	4.7	15.4	784	
	3:31		16	0.0	6.7	13.2	784	
	3:35		20	0.0	12.6	6.9	783	
	3:37		24	0.0	16.3	3.3	784	
	3:39		28	0.3	19.8	0.5	783	
	3:41		32	0.6	18.4	1.5	783	
	3:44		36	1.2	20.5	0.0	784	
	3:48		40	1.7	21	0.0	784	
	3:51		44	1.9	20.8	0.0	784	
	3:54		48	0.4	7.6	12.1	783	
	3:58		52	0.0	5.9	13.9	783	
	4:01		56	8.9	23.1	0.0	783	
	4:04		60	4.8	19.1	2.3	783	
	4:07		64	2.6	19.9	0.6	783	
	4:11		68	10.9	23.9	0.0	783	
11/1/01	11:24	10E	6	0.0	0.0	20	788	Refusal at 21 in.
	11:26		12	0.0	0.0	20.1	788	
	11:29		18	0.0	0.4	19.5	788	
	11:33		21	0.0	0.6	19.5	788	
11/1/01	12:11	11E	6	0.0	0.0	19.9	787	Refusal at 36 in.
	12:14		12	0.0	0.1	19.7	788	
	12:17		18	0.0	0.2	19.8	786	
	12:19		24	0.0	0.7	19.4	786	
	12:22		30	0.0	1.1	18.9	787	
	12:26		36	0.0	1.6	18.5	787	
11/1/01	2:52	12E	6	0.0	0.2	19.3	785	Refusal at 48 in.
	2:55		12	0.0	2.1	17.6	785	
	2:58		18	0.0	3.5	16.4	784	
	3:02		24	0.0	4.8	14.9	785	
	4:17		30	0.0	6.3	13.9	786	
	4:20		36	0.0	10.5	9.3	786	
	4:26		42	0.0	13.2	6.3	786	
	4:29		48	0.0	14	5.5	786	
11/2/01	10:08	13E	6	0.0	0.3	19.4	792	Refusal at 14 in.
	10:11		12	0.0	1.5	18.9	792	

Table 2.3-2 (continued)

Date	Time	Location ID	Depth (in.)	CH_4%	CO_2%	O_2%	mb	Remarks
11/1/01	12:40	14E	6	0.0	0.7	19.3	786	
	12:44		12	0.0	3.2	16.9	786	
	12:46		18	0.0	4	15.9	786	
	12:48		24	0.0	4.3	15.6	787	
	12:51		30	0.0	7.4	12.1	787	
	12:54		36	0.0	10.8	8.8	786	
	12:59		42	0.0	12	6.9	786	
	1:02		48	0.0	13.7	6.3	786	
	1:04		54	0.0	16.4	3.9	786	
	1:06		60	0.0	18.1	2.5	786	

[a] Percent methane in landfill gas.

[b] Percent carbon dioxide in landfill gas.

[c] Percent oxygen in landfill gas.

[d] Atmospheric pressure in millibars.

2.3.2.3 Backhoe Trenching and Soil Sampling

Observations and measurements from the ten trench locations are summarized in Table 2.3-3.

The soil gas/vegetation survey summary shows that areas with high methane concentrations in the soil profile had stressed vegetation or bare ground and reduced rooting depths. Figures 2.2-2 and 2.2-3 illustrate the specific site locations summarized in Table 2.3-3. Based on the very low methane concentrations at location 17 and the nondetect for methane at location 12E, the survey results suggest that other factors such as soil chemistry, thickness of soil profile, and physical characteristics of soil may control vegetation density.

Table 2.3-3
Soil Gas/Vegetation Survey Summary

Soil Gas Sampling Location	Plant Density*	Rooting Depth (ft)	Cover Thickness (ft)	Comments Regarding Methane Concentrations (see Table 2.3-1)
6	M	1.5	2.8	No methane to 18 in.
7	A/T	3.7+	1	No methane to 60 in.
14	M/A	1	1.1	Shallow bedrock. No methane to 24 in.
16	S/M	1	1.8	High methane at 30 in.
17	S	2	2	Low methane at 24 in.
18	T	4.0+	2	No methane to 36 in.
27	S/M	1.5	1	Area of subsidence. High methane at 18 in.
29	S	1.5	1.5	Area of subsidence. High methane at 18 in.
6E	A/T	3.8+	1.5	No methane to 44 in.
12E	S/M	4.0+	1	No methane to 48 in.

* Plant density: S = sparse; M = moderate; A = abundant; T = thriving.

3.0 BASIS FOR CLEANUP LEVELS

The primary objectives of this VCM are to gather any supplemental data required for the final cover designs, complete the final cover designs, and construct the landfill covers. The VCM will require no soil or waste removal; therefore, the development of cleanup levels is not applicable.

4.0 PROPOSED CORRECTIVE ACTION

4.1 Conceptual Model

The preliminary and revised site conceptual models (including discussions of the nature and extent and fate and transport) were both presented in the RFI report, sections 2.3.4 and 2.3.5 (LANL 1998, 63070.1). The objective of this VCM is to prepare the final cover designs and construct the landfill covers. The conceptual model for contaminant occurrence and distribution has only marginal relevance to this objective. Therefore, no further discussion of the conceptual model is provided in this VCM plan.

4.2 Conceptual Design

Evapotranspiration (ET) covers are planned under the conceptual cover design. ET covers minimize moisture percolation through the refuse by the processes of soil moisture storage and plant uptake of soil moisture from the rooting zone. The main landfill and the DDA ET covers will be multilayered systems. However, rather than relying on synthetic components that may degrade over time, the ET covers will seek to minimize percolation through the refuse by maximizing the ET processes in the soil. In addition, ET covers are susceptible to erosion from increased runoff, making erosion a major threat to long-term performance. Therefore, the ET covers will also be designed to minimize erosion.

To achieve these goals, the soil cover layer will have a thickness of at least 30 cm. Because the results of the soil gas survey and the projected landfill gas flux suggest that landfill gas controls may be needed to ensure vegetative growth over most of the main landfill cover, a gravel venting layer, 15 cm thick, will be used below the soil layer in areas of the main landfill with high methane levels. Because the soil gas survey showed minimal methane concentrations at only three locations within the DDA, no venting will be needed in this area.

4.2.1 Water-Balance Modeling

Water-balance modeling of the ET covers for the main landfill and DDA must demonstrate that the cover thickness and water-holding capacity characteristics will provide infiltration reduction equivalent to the standard RCRA Subtitle C cover design (40 CFR 124). The modeling presented in this VCM plan demonstrates that the performance of the proposed ET covers is equivalent to the regulation. Field monitoring of moisture levels during the post-construction maintenance period will also be conducted to demonstrate performance equivalence.

4.2.1.1 Model Description

Predicting long-term performance of a soil cover over a subsurface waste site with regard to minimizing percolation requires a model capable of simulating water flow in the unsaturated soils above the waste. The UNSAT-H model is designed for calculating water flow in unsaturated media (Fayer et al. 1992, 72735). The model was developed at Pacific Northwest National Laboratory to assess water dynamics of near-surface waste disposal sites at the Hanford Site. UNSAT-H 3.0 is a FORTRAN computer code that uses a one-dimensional finite element version of Richard's equation to simulate flow of water, vapor, and heat in soils. The code is designed for use in water-balance studies and is primarily used to predict deep percolation as a function of environmental conditions such as climate, soil type, and vegetation. The model has been verified against analytical solutions and validated against lysimeter data by Fayer et al. (1992, 72735). The model has been widely used when permitting alternative landfill covers in the western US.

The modeling was performed using an unmodified version of UNSAT-H 3.0 obtained from the internet at `http://etd.pnl.gov:2080/~mj_fayer/unsath.htm`. Full model documentation is also available at the same site. The hydrologic water balance is expressed in the UNSAT-H model according to the following general soil-water budget formula:

$$\Delta S = P - E - T - D$$

where: ΔS = Change in water stored in soil profile

P = Precipitation

E = Evaporation

T = Transpiration

D = Drainage

As discussed above, the key to alternative cover performance is the storage of water until it has evaporated or transpired. Drainage or percolation is calculated in the model by subtracting evaporation, transpiration, runoff, and storage changes from precipitation. For reasonable modeling of drainage, mass balance errors should be numerically smaller than the drainage term.

Runoff is not explicitly calculated. Instead, the model infiltrates rainfall into the soil profile at a rate based upon measured hydraulic conductivity and soil water/content potential relationships and classifies all the water that does not infiltrate into the profile as runoff (Rogers and Gallaher 1995, 12968). Higher rainfall intensities are more likely to exceed the soil infiltration rate and result in increased runoff.

Vapor flux can be calculated but not when transpiration is being used in the model. Thus, for normal ET covers, UNSAT-H ignores water vapor movement. The factors most affecting evaporation and transpiration are discussed below.

UNSAT-H was thoroughly evaluated for modeling alternative landfill cover performance at Rocky Mountain Arsenal (RMA) in Denver, Colorado, and was also used for design of a large ongoing lysimeter study at the same site (Fayer 2000, 72734). In addition to predicting the water budget, the model accurately predicts daily soil-water content, soil-water potential energy, and water-flux rates as a function of soil depth.

4.2.1.2 Input Parameters

Evaporation input to the model is driven by weather data using the Penman equation (Monteith 1980, 73271). Transpiration is based upon the Ritchie equation (Ritchie 1972, 73272), which drives transpiration as a function of leaf area index (LAI). Transpiration is also dependent upon rooting distribution in the soil profile and upon soil-water potential. These and other parameters are used as input to UNSAT-H. Some of the parameters are straightforward, such as site elevation and height of the wind velocity measurements, or have standard values. The more important site-specific parameters, such as the climatological, soil, and vegetation parameters and/or data input, are discussed below. Table 4.2-1 summarizes the sources of input into UNSAT-H for modeling the ET covers.

Table 4.2-1
Sources of UNSAT-H Climatological, Soil, and Vegetation Parameters

Input Parameter	Source
Climatological Data[a]	
Precipitation	From LANL's Meteorological Monitoring Program, TA-49 station
Temperature	From LANL's Meteorological Monitoring Program , TA-49 station
Dew point	From LANL's Meteorological Monitoring Program, TA-49 station
Solar radiation	From LANL's Meteorological Monitoring Program, TA-49 station
Wind speed	From LANL's Meteorological Monitoring Program, TA-49 station
Cloud cover	Calculated from LANL's Meteorological Monitoring Program, TA-49 station
Plant Data	
LAI	Pawnee grasslands data[b]
Rooting depth	Trenching observations, soil gas data
Rooting density	Root density function AA = 0.8705, B1 = 0.06108, B2 = 0.0144 (same parameters as RMA)
Soil Data	
Cover material hydrologic characteristics	Hydraulic properties statistics for the Tshirege Member (Rogers and Gallaher 1995, 55334.3)
Number of layers	Multiple layer systems

a For information about LANL's Meteorological Monitoring Program and its data, go to `http://weather.lanl.gov/html/monplan/sites/stn_doc_band.html`

b From Knight 1973, 73275.

(a) Weather

Nearly complete climatological data are available from the LANL meteorological monitoring program for TA-49 where such data have been collected since June 24, 1987. Individual precipitation events may vary between TA-49 and TA-73, but the long-term trends, variability, and averages are expected to be similar. Therefore, climatological data from TA-49 were used as input for UNSAT-H modeling of the TA-73 ET covers.

(b) Soil

The mean hydraulic parameter values for the Tshirege Member of the Bandelier Tuff were calculated from Rogers and Gallaher (1995, 55334.3). The dry bulk density of the material is 1.29 g/cm^3. The saturated hydraulic conductivity is 2.84×10^{-4} cm/s. These values are representative of probable borrow materials (not yet identified) to be used in the final cover.

The van Genuchten parameters characterize the relationships among soil-water potential, soil-water content, and unsaturated hydraulic conductivity (van Genuchten et al., 1991, 72740). These relationships, which area described below, are needed to quantify the dynamics of water movement and storage within a landfill cover profile.

- The parameter α (1/cm) is closely related to the largest pores in a soil. Coarser soils typically have larger pores and larger α.
- The parameter N (unitless) represents a pore-size distribution. A large N (greater than 2) is typical of well-sorted sandy soils and indicates that most pores are of similar size. A small N (close to 1) indicates a range of pore sizes in the soil and is typical of finer-textured soils.
- Residual moisture content is the water content at which liquid water flow ceases in a soil. Soils typically have some water absorbed in clays or on surfaces which does not undergo flow. A soil albedo value (percent of solar radiation reflected) of 0.2 was used for modeling (Houghton 1985, 72737).
- Saturated moisture content is the water content at complete saturation and is equivalent to the total porosity.

The RETention Curve (RETC) program (van Genuchten et al., 1991, 72740) was used to obtain the van Genuchten fitting parameters for UNSAT-H model input. RETC is a computer program that is used to analyze the soil-water retention and hydraulic conductivity functions of unsaturated soils, both of which are key parameters in any quantitative description of water flow into and through the unsaturated zone of soils. The program uses the parametric models of Brooks-Corey (Fayer and Simmons 1995, 73273) and van Genuchten to represent the soil-water retention curve and the theoretical pore-size distribution models of Mualem and Burdine (Mualem 1976, 63543) to predict the unsaturated hydraulic conductivity function from observed soil-water retention data.

Average van Genuchten parameters used are

- $\alpha = 0.0078\ cm^{-1}$
- $N = 1.85$
- Residual moisture content (θ_r) = 0.02 cm^3 water per cubic centimeter of soil (cm^3/cm^3)
- Saturated moisture content (θ_s) = 0.49 cm^3/cm^3

Because of the soil gas results and the rooting observations, the efficacy of a 15-cm landfill gas venting system for reducing adverse impacts of soil gas on the rooting depth was numerically evaluated. A 15-cm layer can provide more than adequate airflow but is near the minimal practical thickness for constructibility. Such a venting system will consist of a gravel, cobble, or rubblized concrete waste layer (minimum diameter of 1.25 cm) with a minimum layer thickness of 15 cm overlain by a geosynthetic fabric layer to prevent soil intrusion. The geosynthetic fabric will last for the duration of methane generation. Over the long term, as methane generation ceases and the geosynthetic fabric ultimately decays, roots in the landfill as well as the DDA will penetrate more deeply into the soil profile. The properties—from Carsel and Parrish (1988, 70224)—that were used for the venting layer are

- Saturated hydraulic conductivity = 29.7 cm/hr
- Saturated moisture content (θ_s) = 0.43 cm^3/cm^3
- Residual moisture content (θ_r) = 0.045 cm^3/cm^3
- $\alpha = 0.145$
- $N = 2.68$

These soil data were input into UNSAT-H using the van Genuchten function model option.

(c) Vegetation

UNSAT-H requires the input of various parameters in order to predict the amount of ET from the soil profile. For vegetation, these parameters include LAI, percentage of bare soil, and root density.

LAI. One important set of vegetative parameters describes the LAI distribution throughout the year. LAI is the ratio of leaf area to land area. One square meter of leaves per square meter of land surface gives an LAI of 1.0. The LAI input into UNSAT-H was based on the prairie shortgrass LAIs developed at Pawnee National Grasslands in northern Colorado (Knight 1973, 73275) and previously used at RMA, which has a climate similar to Los Alamos. The ET cover modeling scenarios assumed a standard annual distribution of LAI and did not consider the initial several seasons of reduced LAI while vegetation is being established on the covers. The number of seasons until a vegetative cover is fully established will depend upon the weather during establishment.

UNSAT-H linearly interpolates between dates for which the user specifies the LAI. Dates for the last frost in the spring and the first frost in the fall were used, along with other site-specific knowledge, to determine the growing season at TA-73.

Percentage of Vegetation-Free Patches. Areas without vegetation undergo evaporation but not transpiration. Studies conducted at RMA in Denver show that the average percentage of bare patches for cool season– and warm season–dominated grassland areas was 5% and 2%, respectively. Visual inspection of undisturbed vegetated areas at LANL confirmed these values. The higher value, 5%, was used as input into UNSAT-H for the TA-73 scenarios.

Root Density. UNSAT-H requires three parameters to describe the root density function. These parameters were determined by fitting an exponential curve (used by UNSAT-H) to data reported by Liang, Hazlett, and Lauenroth (1989, 72738) for grassland vegetation on clay/loam soils at the Pawnee National Grasslands. The three parameters are AA = 0.8705, B1 = 0.06108, and B2 = 0.0144. These three parameters define root density distribution in the soil profile. Based upon root distributions in local road cuts, this root density function is considered reasonable for a well-developed vegetative cover of the type proposed for the TA-73 ET covers.

4.2.1.3 Initial and Boundary Conditions

Initially, the suction head corresponding to the water content below which plants wilt and stop transpiring (HW in UNSAT-H) is set at 20,000 cm (approximately 20 bar). The suction head corresponding to the water content below which plant transpiration starts to decrease, sometimes referred to as the root-soil water potential inflection point (HD in UNSAT-H), is set at 3000 cm, based on information presented by Gardner (1983, 72736) for loamy soils. The suction head corresponding to water content above which plants do not transpire because of anaerobic conditions (HN in UNSAT-H) is set at –1 cm of water potential.

The surface boundary in the ET cover models was specified as a flux boundary for all simulations, while the bottom boundary for all simulations was specified as a unit gradient boundary. Tradeoffs in program control variables are necessary for optimizing solution accuracy and computer time, and the guidelines recommended by Fayer (2000, 72734) were used to determine the nodal spacing. Near the surface, the nodal spacing was small (0.1 cm) to avoid numerical instabilities caused by rapid change in suction heads because of evaporation, transpiration, and precipitation. Nodal spacing was also reduced at boundaries within a soil cover profile, again to decrease the potential for numerical instability within the modeled soil profile.

The hydrologic parameters used in UNSAT-H are presented in Table 4.2-2.

Table 4.2-2
Hydrologic Parameters Used in UNSAT-H Model

Location	Description	K_{sat}		Volumetric Water Content (cm^3/cm^3)		α	N
		(cm/s)	(cm/hr)	θ_s	θ_r	(cm^{-1})	
Main landfill evapotranspiration cover	Soil	2.84×10^{-4}	1.0224	0.49	0.02	0.0078	1.85
	Venting Layer	8.25×10^{-3}	29.700	0.43	0.045	0.1450	2.68
	Waste	1.42×10^{-4}	0.5112	0.25	0.01	0.0078	1.85
DDA evapotranspiration cover	Soil	2.84×10^{-4}	1.0224	0.49	0.02	0.0078	1.85
	Waste	1.42×10^{-4}	0.5112	0.25	0.01	0.0078	1.85

K_{sat} = Saturated hydraulic conductivity.
α = Fitting parameter.
N = Fitting parameter (dimensionless).
θ_s = Saturated moisture content.
θ_r = Residential moisture content.
Note: Parameters averaged from Rogers and Gallaher (1995, 55334.3).

Daily weather records from TA-49 were used to develop the precipitation portion of the input files. For each simulation, the sequential weather data for 1993–2001 were run twice (for a total of 18 years) to allow the initial soil-water conditions in the model domain to attain a steady state with respect to typical climatic conditions. In these modeling runs, nearly all water was allowed to infiltrate into the soil profile with virtually no runoff. The combination of nearly eliminating runoff and using a wet weather period for modeling increases the confidence that the cover thicknesses suggested by the modeling results are conservative.

4.2.1.4 Modeling Results

The results of each main landfill and each DDA modeling run are presented in Appendix G. Each run is represented by three graphs showing (1) mass balance error, (2) a summary of each year's water balance, and (3) the dynamics of the 5-yr water balance. These graphs provide detailed information about the dynamics of the proposed cover water balance.

In the model, infiltration represents the flux into the top surface of the model domain. Infiltration represents recharge through the waste material. Once meteoric water enters the model domain as infiltration, it is redistributed across nodes by evaporation, transpiration, or drainage. Water can be lost through the top surface by evaporation and transpiration. Water can also move downward and eventually out of the model domain by drainage.

Mass balance error graphs are shown as a standard check on landfill cover design runs where desired maximum cover percolation is a small fraction of the water balance.

DDA Modeling Results. Trenches in the DDA showed abundant root growth to the bottom (approximately 4 ft) of all excavated trenches. The soil gas investigation showed only traces of methane at the DDA. Thus, the DDA has a profile similar to an ET cover. However, some areas of the DDA do not have positive drainage and do contain exposed concrete or other construction debris. In Figure 4.2-1, the DDA has been modeled with a nominal 1 ft (30 cm) of soil cover over exposed debris. The results suggest that the performance of the existing cover (15 cm) reduces percolation to approximately 1 cm/yr and that a 1-ft cover under positive drainage conditions will reduce percolation to a level below 0.25 cm/yr.

Landfill Cover Modeling Results. Figure 4.2-2 shows the performance of a single monolithic soil cover over waste where rooting occurs to the bottom of the soil cover. The results show that 30 cm of soil with roots provides adequate (i.e., less than 1 cm/yr) control of percolation. Flux through the simple soil cover is slightly lower than flux at the DDA (Figure 4.2-1) primarily because the debris present in the DDA soil profile reduces water-holding capacity and leads to increased percolation.

4.2.2 Landfill Gas

Landfill gas (LFG) generation at the main landfill was evaluated with regard to the impact it might have on the ET cover. The final cover design must consider the effects of subsurface LFG on vegetation and transpiration. The assessment of the effects of LFG on cover vegetation were based upon the expected gas flux through the cover. The effects of LFG on cover vegetation and rooting depth are important design considerations. For low rates of LFG generation (rates associated with low observed concentrations at the landfill), cover vegetation is not adversely impacted and can achieve a sufficient rooting depth.

The assessment of LFG generation is presented in the following sections of this report.

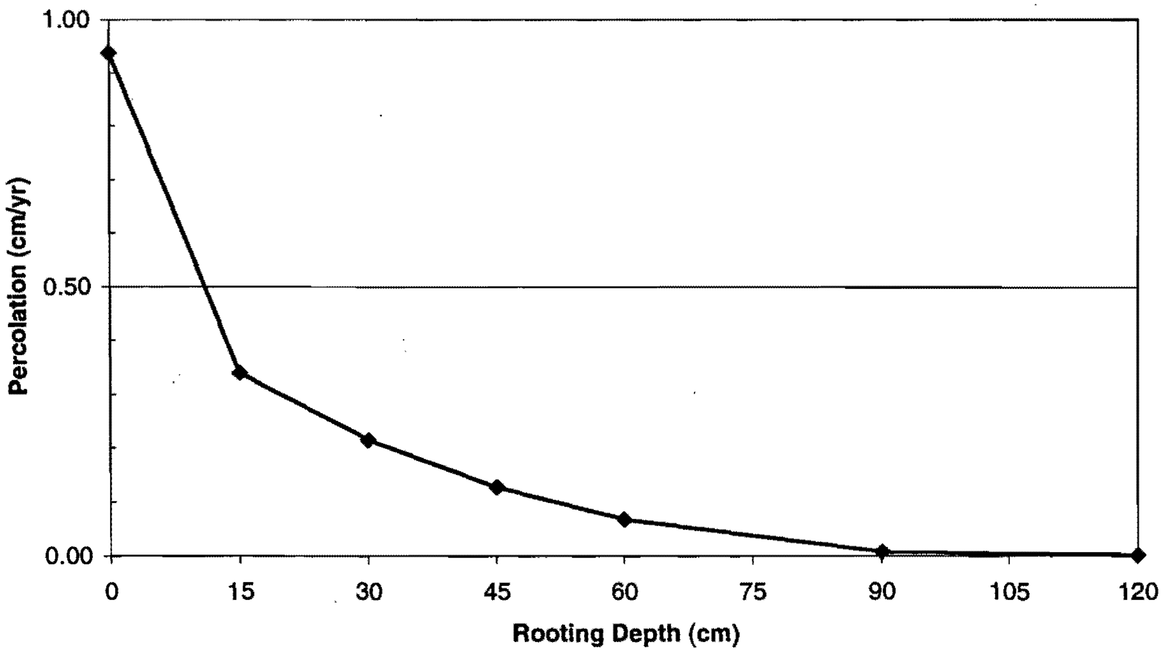


Figure 4.2-1. Performance with 30 cm cover and varied rooting depths

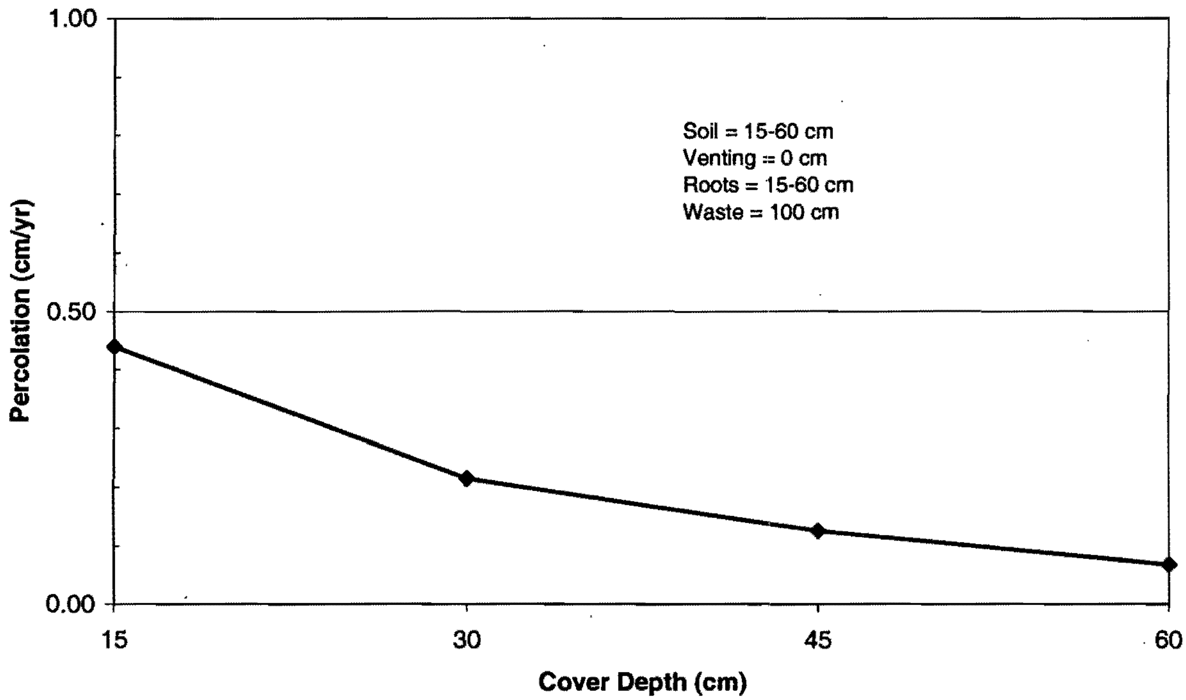


Figure 4.2-2. **Simple soil cover performance**

4.2.2.1 Background

Landfill gas is generated in a waste disposal site by the natural decomposition of the organic materials present. Methane and carbon dioxide are the primary constituents of landfill gas and are produced by microorganisms under anaerobic conditions. Transformations of methane and carbon dioxide are mediated by microbial populations that are adapted to the cycling of materials in anaerobic environments. LFG generation, including rate and composition, proceeds through four phases:

1. The first phase is aerobic (i.e., with oxygen available), and the primary gas produced is carbon dioxide.
2. The second phase is characterized by oxygen depletion, resulting in an anaerobic environment where large amounts of carbon dioxide and some hydrogen is produced.
3. In the third phase, methane production begins, with an accompanying reduction in the amount of carbon dioxide produced. Nitrogen content is initially high in landfill gas in the first phase, but it declines sharply as the landfill proceeds through the second and third phases.
4. In the fourth phase, gas production of methane, carbon dioxide, and nitrogen becomes fairly steady. The steady-state mixture ratio of methane to carbon dioxide is approximately 55% to 45%, respectively.

The total time and phase duration of gas generation varies with landfill conditions (i.e., waste composition, design management, and anaerobic state) (EPA 1997, 72733).

Methane gas concentrations may be measured using one of two reporting scales: either as the percentage of methane as gas in air (percent GIA, or simply percent) or as percentage of the lower explosive limit (percent LEL). The LEL for methane is equivalent to 5% GIA. In this report, methane and other gas constituents are reported as percent GIA unless otherwise noted.

Typically, LFG also contains a small amount of nonmethane organic compounds (NMOC). This NMOC fraction often contains various hazardous air pollutants, greenhouse gases, and compounds associated with stratospheric ozone depletion. The NMOC fraction also contains volatile organic compounds (EPA 1997, 72733).

4.2.2.2 LFG Generation Potential

LFG generation potential depends upon several factors, such as volume of waste in-place, waste composition (cellulose and lignin content), waste moisture content, waste pH, and waste carbon-to-nitrogen ratio. The most critical of the factors are the volume of waste in-place, the waste composition, and the moisture content. The following sections contain descriptions of conditions at the main landfill and their relation to gas production as well as estimates of LFG generation at the main landfill.

(a) In-Place Waste Volumes

In-place waste volumes are critical to the amount of LFG produced at a landfill. Naturally, the more material in place, the more LFG is generated and subsequently emitted. The main landfill has a relatively small volume of material in place compared to typical municipal landfills. The extent of the main landfill area is approximately 11.5 acres. Waste thickness varies from 1 to 85 ft; the most recent and thickest waste is in the eastern half of the landfill.

Based on calculations documented in Appendix H, the final projected waste in-place (including daily cover and intermediate cover) is approximately 536,750 yd^3. Waste in-place was estimated by dividing the main landfill into five sections. The area and average waste depth was then estimated for each section. Finally, to calculate the amount of waste in-place, the area was multiplied by the average waste depth. For gas modeling purposes, it was assumed that 20% (a value typical of landfill practices) of the total material in place was the daily and intermediate cover.

The breakdown of the main landfill into five equal sections was also used in LFG modeling activities, which are described in further detail in section 4.2.1 of this report. Appendix H contains additional details about the breakdown of the main landfill into sections for analytical purposes. Section 1 of the main landfill is the westernmost portion; section 5 is the easternmost portion of the landfill. Some general facts about each section:

- Section 1: length = 418 ft, width = 225 ft, average waste depth = 10 ft, total area = 2.16 acres
- Section 2: length = 436 ft, width = 225 ft, average waste depth = 15 ft, total area = 2.25 acres
- Section 3: length = 445 ft, width = 225 ft, average waste depth = 25 ft, total area = 2.30 acres
- Section 4: length = 455 ft, width = 225 ft, average waste depth = 43 ft, total area = 2.35 acres
- Section 5: length = 460 ft, width = 225 ft, average waste depth = 50 ft, total area = 2.38 acres

(b) Waste Composition and Conditions

Waste composition is a major component of total LFG generation volume and rate determinations. The two most important aspects of waste composition are (1) how much LFG will the waste produce, and (2) when will it produce it. Waste composition is typically evaluated using the following five categories and their corresponding theoretical methane yields (Pelt et al. 1998, 73274):

- *Rapidly degradable:* food waste, leaves, grass (varies from 8.38 to 8.57 liters methane per kilogram waste)
- *Moderately degradable:* paper, textiles, wood (varies from 0.48 to 30.5 liters methane per kilogram waste)
- *Slowly degradable:* rubber, plastics, asphaltic metal, wall board (0.37 liters methane per kilogram waste)
- *Inert/inorganic:* glass, metals, concrete, soil (nondegradable)
- *Fines/unknown:* typically unrecognizable, highly decomposed material and soil (nondegradable)

Typically, rapidly degradable waste will begin to decompose and generate gas shortly after being placed in the landfill. This type of waste will normally generate most of its gas within a few years, while moderately and slowly degradable waste will decompose over decades and centuries, respectively. Food waste and grass clippings tend to degrade the most quickly because they have a high moisture content when they are placed in a landfill, whereas paper and textiles have a low moisture content and require additional moisture to decompose.

The majority of waste in the main landfill is primarily typical municipal waste collected from the Laboratory and the townsite. From 1943 (when the site began operating) to 1965 (when Los Alamos County took over operations), most of the waste was burned and the ashes and noncombustible material were pushed into the landfill. This burning process would have decreased the LFG generation potential of the waste. Therefore, areas of the main landfill that contain large amounts of burned waste will generate LFG at smaller volumes and slower rates than typical landfills in the same geographic region.

The conditions of the waste and landfill are also of vital importance to the generation of LFG. The moisture content of the waste is by far the most critical variable for determining the LFG generation rate. Like the degradability categories listed above, moisture content also plays a vital role in determining how quickly waste will degrade: the more moisture, the quicker the decomposition and, therefore, the more gas produced. Moisture content does not change the total amount of gas that can be produced, but it does determine the rate and duration of gas generation. Waste at TA-73 was assumed to possess moisture contents that are typically encountered in semi-arid environments (Pelt et al. 1998, 73274).

(c) LFG Generation Rate Estimates

LFG generation estimates are useful when designing covers for the following reasons: (1) low permeability covers could force more LFG into the subsurface; (2) low permeability covers could limit oxygen movement into the cover, which could limit root growth and transpiration; and (3) LFG generation rates are needed to evaluate LFG control system requirements and the capacity of control systems, if needed.

Typically, the rate at which wet municipal waste generates gas increases for the first 5 or 6 yr after placement in a landfill and declines thereafter, if no additional waste is added. After placement of an adequate landfill cover, the waste typically becomes too dry to maintain high gas production rates. Results from field studies show that after 15 yr of landfill inactivity, between 60 and 85% of the potential methane production from landfill waste has already been produced.

LFG generation rates for the main landfill were estimated using EPA's Landfill Gas Emissions Model Version 2.0 (LandGEM) (Pelt et al. 1998, 73274). LandGEM uses a first-order decay rate equation and estimates annual emissions over any time period specified by the user. Total LFG emissions are estimated by running the model separately for methane and carbon dioxide and adding the results for total LFG emissions. Methane generation is estimated using two parameters: L_o, the potential methane generation capacity of the refuse, and k, the methane generation rate constant, which accounts for how quickly the methane generation rate decreases once it reaches peak rate. The methane generation is assumed to be at its peak upon closure of a landfill or final placement of waste at a site (Pelt et al. 1998, 73274).

$$Q_{CH4} = L_o R(e^{-kc} - e^{kt})$$

where: Q_{CH4} = Methane generation rate at time t, m^3/yr

L_o = Methane generation potential, m^3 methane/mg refuse

R = Average annual refuse acceptance rate during active life, mg/yr

e = Base log, unitless

k = Methane generation rate constant, yr^{-1}

c = Time since landfill closure, in years ($c = 0$ for active landfills)

t = Time since the initial refuse placement

The following data were taken from the compilation of air pollutant factors (EPA 1997, 72733) and put into the model:

- Methane generation rate constant (k) = 0.02/yr
- Methane generation potential (L_o) = 50 m^3/mg for Sections 1–3, and 100 m^3/mg for Sections 4 and 5 (see Appendix H)
- Landfill gas mixture is 55% methane and 45% carbon dioxide

A k value of 0.02/yr was used because it is more representative of relatively dry waste commonly found in arid and semi-arid climates. Also, as described above, a smaller landfill generation potential input value was assigned to Sections 1 through 3 (westernmost sections) because of waste-burning activities that had occurred in these sections.

The results of the model indicate low rates of gas generation. The results are depicted graphically in Figures 1 and 2 in Appendix H. The model predicted a peak LFG generation for each section immediately after closure of each section of the main landfill, and LFG generation rates are now declining. The modeled current gas generation rates for 2002 are given in Table 1 of Appendix H.

These generation rates are low because the mass of waste deposited is small. The total LFG generation rate for 2002 is 19 ft^3/min. These results, though small, are still significant enough to affect the performance of the ET cover detrimentally.

4.2.2.3 Cover Effects on LFG Emissions and Migration

To determine gas emission effects on cover performance, it is necessary to know the flux and velocity of LFG through the cover. Appendix F presents an input file for calculating soil gas generation at the main landfill (Section 1 of 5). To estimate the current flux (flow rate/unit area) of LFG from the main landfill, the calculated generation rates for 2002 were used for each section. The generation rate was divided over the entire acreage of each section to estimate an LFG flux and corresponding gas velocity (fluxes and gas velocities are reported in Table 1 of Appendix H).

Reducing water infiltration into the cover will greatly decrease the amount of LFG generated and subsequent emissions. As previously described, moisture content is typically the primary controlling factor for LFG generation. Once the ET cover is in place, the waste will slowly begin to dry out and calculated generation rates may fall by one-third or more. This drop will lead to reduced emissions of methane and NMOCs, which will benefit the air quality of the site as well as the cover performance.

In addition to reducing water infiltration, the cover will serve as a medium for the mixing of methane and NMOCs with atmospheric oxygen. This mixing will lead to the decomposition of methane and NMOCs into mainly carbon dioxide, heat, and water. The water will then be transpired by plant roots in the cover, thus preventing any infiltration into the waste below. ET covers are more effective at oxidation of organics because of their relatively high permeability and residence time compared to RCRA-prescribed covers.

4.2.2.4 LFG Impacts on Cover Performance

The main impact LFG may have on cover performance is the inhibition of plant growth on the cover. Well-established plant growth and deep root penetration are critical to the success and effectiveness of an ET cover. Therefore, it is important to evaluate the potential effects LFG may have on cover vegetation.

Methane displaces the oxygen required for a soil-rooting medium to maintain healthy root activity. Typically, even low methane levels indicate minimal oxygen concentrations. Currently, there appears to be no reliable data on what levels of methane are harmful to plants and what minimum subsurface concentrations of oxygen are required to sustain plant growth. In addition, the shallow subsurface of landfills tends to be very dynamic because of barometric pumping (the effect of the diurnal barometric cycle on a landfill). This cycle causes a landfill to "breathe" or inhale and exhale over the course of an average day. This effect can also be exaggerated by pressure fronts moving though the area. Barometric pumping will typically pull landfill gas into the cover for part of the day and push atmospheric air into the cover for part of the day. This pumping effect may or may not provide enough oxygen to the cover to sustain plant roots even during low levels of gas production.

To conservatively evaluate whether atmospheric oxygen will be able to enter the cover against the pressure of exiting LFG, the exit LFG velocity was estimated. To simplify the analysis and be conservative, barometric pumping was not considered as an oxygen-driving mechanism into the main landfill.

Section 5 of the site corresponds to approximately 2.4 acres of the easternmost portion of the main landfill. This section possesses the thickest lift of waste and, therefore, contains the most waste of any of the five sections. The estimated LFG velocity calculated for Section 5 of the main landfill is 3.86 cm/day. This velocity is greater than would typically be expected for air moving into the cover under normal atmospheric conditions. Therefore, in the absence of barometric pumping, LFG may displace all the oxygen in the ET cover as it exits the landfill, and oxygen may not be able to enter the cover to sustain adequate plant transpiration at depth.

4.2.2.5 LFG Controls

As stated earlier in this plan, LFG controls are needed to prevent methane from inhibiting deep root growth and affecting the performance of the ET cover. The final details of the venting system will depend upon the size of the system needed and upon grading of the existing waste.

Figure 3 in Appendix H shows an active air injection system. This system consists of a blower injecting ambient air into a 2-in. header pipe. The header pipe then feeds .75-in. lateral pipes equipped with air emitters spaced at a frequency of approximately 1 per 36 in.

Figure 4 in Appendix H shows a dual active air injection /wind venting system. This system also consists of a blower injecting ambient air into a 2-in. header pipe. The header pipe then feeds .75-in. lateral pipes equipped with air emitters spaced at a regular frequency. This system also includes a gravel gas mixing layer that would allow for better mixing of ambient air and methane. This mixing layer allows for more efficient methane oxidation as well as a reduction in air emitter frequency because of increased lateral permeability. Another feature of this design is the addition of a chimney at the surface. The chimney allows the blower to be turned off and to convert the system into a wind-driven venting system.

Both of the above systems would very effectively vent or oxidize methane away from the ET cover and allow for the deep root growth required for the successful operation of an ET cover. The above-proposed systems that inject ambient air into a soil cover for the purpose of methane oxidation are also known as soil carburetors. The soil carburetor simply allows ambient oxygen and methane emanating from a landfill to be mixed and oxidized within the landfill cover.

As discussed above, the total landfill gas generation rate for the main landfill is approximately 19 ft^3/min. Therefore, the required ambient air injection flow rate is 105 ft^3/min. The air injection flow rate was calculated under the assumption that methane oxidation stoichiometry requires two parts oxygen for each part methane for complete oxidation and that ambient air contains approximately 20% oxygen, as follows:

$$19\ ft^3 \times 0.55\ (\%\ \text{methane in LFG}) \times 2\ (\text{parts } O_2 \text{ to } CH_4) \times 5\ (20\%\ O_2 \text{ in air}) = 105\ ft^3$$

4.2.2.6 Conclusions and Recommendations Regarding LFG Generation and Controls

The main landfill is producing LFG at a low to moderate rate, with an overall volume of gas production that is relatively low because of the small volume of waste deposited. A projected landfill gas flux and the existing data suggest that LFG controls may still be needed to ensure that vegetative growth is not inhibited and that the effectiveness of the ET cover is not compromised. Unrestricted root growth throughout the full thickness of the cover is critical to the proper performance of the ET cover. The two designs discussed above would benefit the ET cover by preventing methane (by venting or oxidizing) from negatively affecting the cover, thereby helping to ensure successful root growth.

It is recommended at this time that both the proposed injection/venting systems be used at the main landfill. The air injection system (Figure 3, Appendix H) will be used for Sections 1 through 3 of the landfill (the western three-fifths of the landfill), and the air injection/wind venting system (Figure 4, Appendix H) will be used for Sections 4 and 5 of the landfill. Since Sections 1 through 3 contain a large amount of burned waste, LFG-generation rates are expected to stay low. Therefore, the air injection system without the gas-mixing layer should be sufficient to oxidize the methane from that portion of the landfill. In contrast, Sections 4 and 5 probably contain little to no burned waste because these areas were most likely filled by Los Alamos County. Since the County did not burn the waste that went into the landfill, it is expected that these areas of the landfill will generate more substantial amounts of LFG. Therefore, the air injection/wind venting system with a gas-mixing layer will be needed for controlling anticipated LFG emissions from this portion of the landfill.

4.2.3 Slope and Cover Configurations

Three overall objectives must be met in the engineering plan: (1) a minimum of 3% slope will be used on the landfill, (2) FAA requirements for airport facilities must be met, and (3) no waste will be moved offsite.

In FAR 77.25, "Civil airport imaginary surfaces" [Amdt. 77-9, 36 FR 5970, Apr. 1, 1971; 36 FR 6741, Apr. 8, 1971], paragraph e, the FAA makes the following statement:

> *Transitional surface.* These surfaces extend outward and upward at right angles to the runway centerline and the runway centerline extended at a slope of 7 to 1 from the sides of the primary surface and from the sides of the approach surfaces. Transitional surfaces for those portions of the precision approach surface, which project through and beyond the limits of the conical surface, extend a distance of 5,000 feet measured horizontally from the edge of the approach surface and at right angles to the runway centerline.

The primary surface, defined in paragraph c, has a width of 250 ft for utility runways with only visual approaches. This was interpreted to mean that a 7:1 slope, starting 125 ft (250 ft/2) from the centerline of the existing runway, is an acceptable slope for design.

4.2.3.1 Main Landfill

(a) Side Slopes

Slopes at the existing main landfill are excessively steep, especially at the east end, and exceed the slope recommended by NMED requirements for landfill covers. Existing slopes approach 1:1 in many areas and exceed 3:1 on most of the north and east sides of the landfill. These steep slopes will need to be flattened as part of the landfill cover construction. Typical landfill cover side slopes are 4:1; however, in some instances 3:1 is acceptable. Under the New Mexico Solid Waste Management Regulations (20.9.1 NMAC) governing municipal landfill closure, maximum slopes must not exceed 4:1. However, NMED has granted approval of 3:1 final cover slopes based on a site-specific demonstration of slope stability. During analysis of the design alternatives for the main landfill cover, both of these slopes were considered. Because of the landfill constraints (i.e., steep slopes to the north and east, the taxiway, the airplane tiedown, and the runway to the south and west), it is not feasible to expand the footprint of the landfill to flatten the side slopes. The waste will have to be pulled back onto the top surface to reduce the slopes along the north and east. For this reason, the cover design involves relocating excavated waste onto the top surface without expanding the waste footprint.

Because of the proximity to the airport and runway, FAA regulations must also be considered when constructing the final cover. According to FAA requirements, the area must be flat to 125 ft from the centerline of the runway, and the maximum slope beyond that is only 7:1. When analyzing the alternatives for the main landfill cover and side slopes, the maximum slope along the taxiway was considered to be 7:1 and the maximum slopes to the north and east were considered to be either 4:1 or 3:1.

(b) Top Surfaces

The existing slope on the top surface of the main landfill varies from 1 to 5%. The surface is uneven, and many low areas and cracks create ponding and increase infiltration. The top surface will need to be smoothed out so that the grades prevent ponding and direct surface runoff away from the waste. The airport has expressed interest in expanding its airplane tiedown area over all or part of the landfill top surface. When analyzing the design alternatives for the main landfill cover, the top surface will be constrained to approximately the same elevation and slope as the existing tiedown area. This design option also provides additional future hangar space for the airport's use.

(c) Surface Water Control

Currently, all the stormwater runoff flows to the north and east and runs into Pueblo Canyon along the north boundary of the main landfill. Some of the side drainages that originate at the landfill and extend to the bottom of the canyon contain debris which is consistent with the type of waste disposed of in the landfill. As part of the conceptual cover design, the runoff is to be directed, to the extent possible, into existing drainages that do not contain waste. Because many of the closest drainages contain waste, it may be technically and financially infeasible to divert all the stormwater to drainages that are clean. However, the goal of the conceptual cover design is to divert stormwater away from waste-containing drainages wherever possible and, in all cases, to reduce the amount of stormwater to waste-containing drainages.

(d) Erosion Control

All areas disturbed during construction of the final cover will require revegetation at least and perhaps some additional form of erosion control. The revegetation seed mixture will be determined as part of the final design. The seed mixture preferred by the Laboratory's Ecology Group is likely to be used and possibly augmented with other native grasses and shrubs.

The erosion control methods can be broken down into two categories: temporary erosion and revegetation material (TERM) and permanent erosion and revegetation material (PERM). The PERMs can be further broken down into soft and rigid armoring. Many examples of these erosion control measures are available, and selection will be determined as part of the final design. TERMs include straw, mulch, tackifiers, geofiber mulches, fiber roving systems, and erosion control blankets. Soft armor PERMs include UV-stabilized fiber roving systems, erosion-control revegetation mats, turf reinforcement mats, geofibers, and vegetated geocellular containment systems. Rigid armor PERMs include geocellular containment systems, fabric-formed revetments, vegetated concrete block systems, concrete block systems, stone rip-rap, and gabions. Which areas require PERMs or TERMs will be determined as part of the final design process.

(e) Slope Stabilization

Unknown loads from LFG and hydraulic pressures in the landfill slopes make stability a particularly difficult issue in the final design process. Because the geotechnical properties of the existing soil and waste material at the main landfill site are unknown, it is not clear at this time if slopes of 4:1 and/or 3:1 will be stable. Additional soil-stabilization measures may be required to ensure long-term stability of the final cover and underlying landfill material on the side slopes. There are many options available for mechanically stabilizing the side slopes, and they may be evaluated as part of the final design. These alternatives include retaining walls and reinforced soil systems (steel strips, steel or polymeric grids, geotextiles, etc.).

Whether or not any of these slope stabilization methods are used, subsurface water flow may require management in order to prevent weakening of the soil slopes. Some methods of subsurface water control include French drains, slotted piping, and geotextile-wrapped drain piping. The need for these measures will depend on the final cover design methods and will be determined as part of the final design process.

(f) Cover Design Alternatives

Three alternatives were considered for the conceptual cover for the main landfill. The first two involve designing the maximum side slopes to the north and east at 4:1; the third uses a maximum design slope of 3:1 to the north and east. Each alternative is described below.

Alternative 1. This alternative would involve pulling the waste along the north and east, back over the entire top surface of the main landfill, to provide a maximum 4:1 slope on these sides (see Sheet 1 of 4, at the end of Appendix I). The side slopes along the west and south are designed to be 7:1 to meet FAA standards. This alternative requires a large quantity of waste to be pulled back along the north and east, resulting in the top surface being raised between 8 and 10 ft above the existing grade. This option does not provide for the possibility of expanding airport facilities. The quantity of waste to be relocated on the top surface is approximately 110,000 yd^3 of in situ material. Based on a design cover thickness of 45 cm (a 30-cm soil layer over a 15-cm gravel venting layer), the cover material quantities are approximately 18,000 yd^3 of soil and 9000 yd^3 of venting material, respectively.

Alternative 2. This alternative would involve pulling the waste along the north and east, back onto a portion of the top surface of the main landfill, to provide a maximum 4:1 slope on these sides (see Sheet 2 of 4, at the end of Appendix I). A portion of the landfill top surface is to be graded to the same elevation and slope as the existing airplane tiedown area. The side slopes along the west and south are designed to be 7:1 to meet FAA standards. This alternative requires a large quantity of waste to be pulled back along the north and east, resulting in a portion of the top surface being raised to over 25 ft above existing grade. This alternative provides an area of approximately 250 × 400 ft to be considered for expansion of airport facilities. The quantity of waste to be relocated on the top surface is approximately 110,000 yd^3 of in situ material. Based on a design cover thickness of 45 cm (a 30-cm soil layer over a 15-cm gravel venting layer), the cover material quantities are approximately 22,000 yd^3 of soil and 11,000 yd^3 of venting material, respectively.

Alternative 3. This alternative would involve pulling the waste along the north and east, back onto a portion of the top surface of the main landfill, to provide a maximum 3:1 slope on these sides (see Sheet 3 of 4, at the end of Appendix I). The side slopes along the west and south are designed to be 7:1 to meet FAA standards. This alternative requires a lesser quantity of waste to be pulled back along the north and east, resulting in the top surface being raised between 2 and 4 ft above the existing grade. This alternative provides an area of approximately 300 × 900 ft for potential expansion of airport facilities. The quantity of waste to be relocated is approximately 40,000 yd^3 of in situ material. Based on a design cover thickness of 45 cm (a 30-cm soil layer over a 15-cm gravel venting layer), the cover material quantities are approximately 18,000 yd^3 of soil and 9000 yd^3 of venting material, respectively.

4.2.3.2 TA-73 DDA

(a) Side Slopes

Existing slopes at the DDA are relatively flat across the entire disposal area. Even the steepest slopes along the north and east edges of the DDA (8–15%) are well below the maximum slope or 4:1 (25%) recommended by NMED requirements for landfill covers. Because of the existing site conditions, the slopes along the DDA boundary do not need to be flattened and the footprint of the landfill does not need to be expanded (see Sheet 4 of 4, at the end of Appendix I).

(b) Top Surfaces

The existing slope of the top surface of the DDA varies from 1 to 8%; however, the surface is uneven, and some low areas do create ponding and increase infiltration. The top surface will need to be smoothed so that the grades prevent ponding and direct surface runoff away from the waste at a minimum 3% slope.

(c) Surface Water Control

Currently, all the stormwater runoff flows to the north and east into Pueblo Canyon along the boundary of the DDA. The drainage channels around the DDA do not contain significant debris, so there are minimal issues associated with stormwater runoff.

4.2.3.3 Cover Design Control

Final design and construction activities will be performed in accordance with applicable quality assurance requirements as addressed in the ER Project's Quality Management Plan, implementing procedures (e.g., quality procedures and SOPs), and LANL requirement documents (e.g. Laboratory Implementation Requirements [LIRs] and Laboratory Performance Requirements), or equivalent LANL-approved subcontractor documents.

Specifically, the elements of the final cover and long-term monitoring system designs for the main landfill and DDA must be developed and controlled pursuant to applicable design quality procedures in the *LANL Engineering Manual,* LIR 220-03-01.1, or in equivalent ER Project design quality procedures (i.e., Washington Group International, Inc. [WGII] Quality Assurance Procedure [QAP] 6.1, Rev. 3, Design Control). The procedures used to develop, review, approve, revise, and disseminate controlled drawings will conform to the processes established in the *LANL Drafting Manual,* OST-220-03-01-DM, or in equivalent ER Project drafting procedures (i.e., WGII QAP 6.2, Rev.0, Site Drawing Control).

4.3 Supplemental Sampling

An up-to-date, higher-resolution topographical map is needed. The regrading calculations shown in Sheets 1 through 4 at the end of Appendix I were based upon old 2-ft contours. Visual inspection of the main landfill suggests that considerable subsidence of the waste has occurred since waste emplacement, from waste degradation and settlement of loosely packed waste and soil cover. Subsidence appears to have both reduced the volume of waste to be moved and increased the available storage volume on the landfill cover.

4.3.1 Additional Study Required as Part of Final Design

Additional specific data collection will be necessary to develop the final engineering design. Existing data related to the main landfill site are in some cases outdated or nonexistent. At a minimum, the following additional measurements or information will be needed prior to completing the final landfill cover design:

- a topographical survey of current conditions at 1-ft contours,
- the refined horizontal and vertical extent of waste,
- the properties and strength characteristics of waste and soil fill, and
- the borrow soil properties and strength characteristics of native soils and rock.

Other information may be deemed necessary once the final design process is underway.

4.4 Cleanup Activities

Design and completion of the main landfill and DDA covers will not require cleanup activities. All landfill refuse and existing surface materials will be left within the PRS boundaries and beneath the new covers.

4.5 Site Restoration

The final site configurations and appearance will conform to the provisions of the final cover design.

5.0 CONFIRMATION SAMPLING/COVER MONITORING

Confirmation sampling will not be required because no cleanup or removal activities are proposed. However, long-term cover monitoring will be done to ensure system performance. As-built soil properties, soil water potentials, and major soil gas concentrations are the primary components of the monitoring system. Each of these components is discussed below.

5.1 Soils Data

Soils data are needed for evaluating water flow in the final cover. Soils parameters to be measured or monitored include laboratory measurement of unsaturated hydraulic properties of the cover components and the monitoring of soil water content and potential.

5.2 Heat Dissipation Sensors

Water potentials are typically low (less than –3 bar) in the semi-arid soils at the Los Alamos Airport (DB Stephens & Assoc. 2001, 73276). At these potentials, tensiometers and suction lysimeters will not work. In addition, unsaturated hydraulic conductivity changes rapidly with changes in water content as measured by instruments such as neutron probes and time-domain reflectometry. At these water potentials, which are anticipated in the proposed ET covers, heat dissipation sensors are more sensitive when detecting both changes in the soil moisture characteristic curves and in the direction of water movement. Therefore, high-sensitivity heat dissipation sensors would be an excellent instrument with which to do long-term monitoring of the soil profile. One example of the data to be obtained is shown in Figure 5.2-1. The data in this figure came from an ongoing monitoring project of an alternative ET soil cover at a Subtitle C facility near Boise, Idaho (DB Stephens & Assoc. 2001, 73276). Each data point represents the daily vertical flux (shown as cm/yr) through the landfill cover, over a 1-ft interval. Flux is calculated using soil water potential data from the sensors, depth of the potential monitoring sensors within the cover profile, and laboratory-measured unsaturated hydraulic conductivity as a function of potential relationship. Field soil water potentials are measured and recorded daily using heat dissipation sensors wired to a data logger.

At the main landfill, two nests of six heat dissipation sensors which have been calibrated to correct for thermal conductivity biases on water potential should be installed in the final cover to measure soil water potentials. The calibration should consist of a seven-point calibration within the water potential range of at least −0.3 to −40 bar for each heat dissipation sensor. Sensors should be installed at approximately 10 cm, 20 cm, 30 cm, 45 cm, 60 cm, and 75 cm. Depending upon grade fill, the 60- and 75-cm probes may be installed in waste. Data would be collected and downloaded electronically at appropriate intervals. Fluxes within the final cover profile would then be calculated as in the above example.

5.3 Soil Gas Measurements

Soil gas should also be measured at depths of approximately 1 and 2 ft for carbon dioxide, methane, and oxygen. Soil gas measurements should be made at 3, 6, 9, and 12 months after completion of the final cover. Monitoring should then be done annually in mid-summer and should cease when free oxygen is present throughout the profile, or after 30 years, whichever occurs first.

Performance data for the final cover will be obtained by monitoring the nested heat dissipation sensors, conducting limited laboratory testing of samples collected from the final cover, and calculating fluxes using the data. Table 5.3-1 summarizes the monitoring and sampling of the final cover.

Table 5.3-1
Cover Monitoring Plan Summary

Activity	Time of Activity	Purpose
Heat dissipation sensor installation	Following final cover construction	Monitor water potential profiles and fluxes
Heat dissipation sensor monitoring	Daily for 5 years	Monitor water potential profiles and fluxes
Gas sampling port installation	Following final cover construction	Monitor soil gas concentrations near heat dissipation sensors
As-built soil sampling	Following final cover construction	Confirm assumed hydrological properties
Soil profile gas sampling	Quarterly for 1 year and then annually until methane levels fall, or until 30 years have passed	Track potential gas effects on percolation

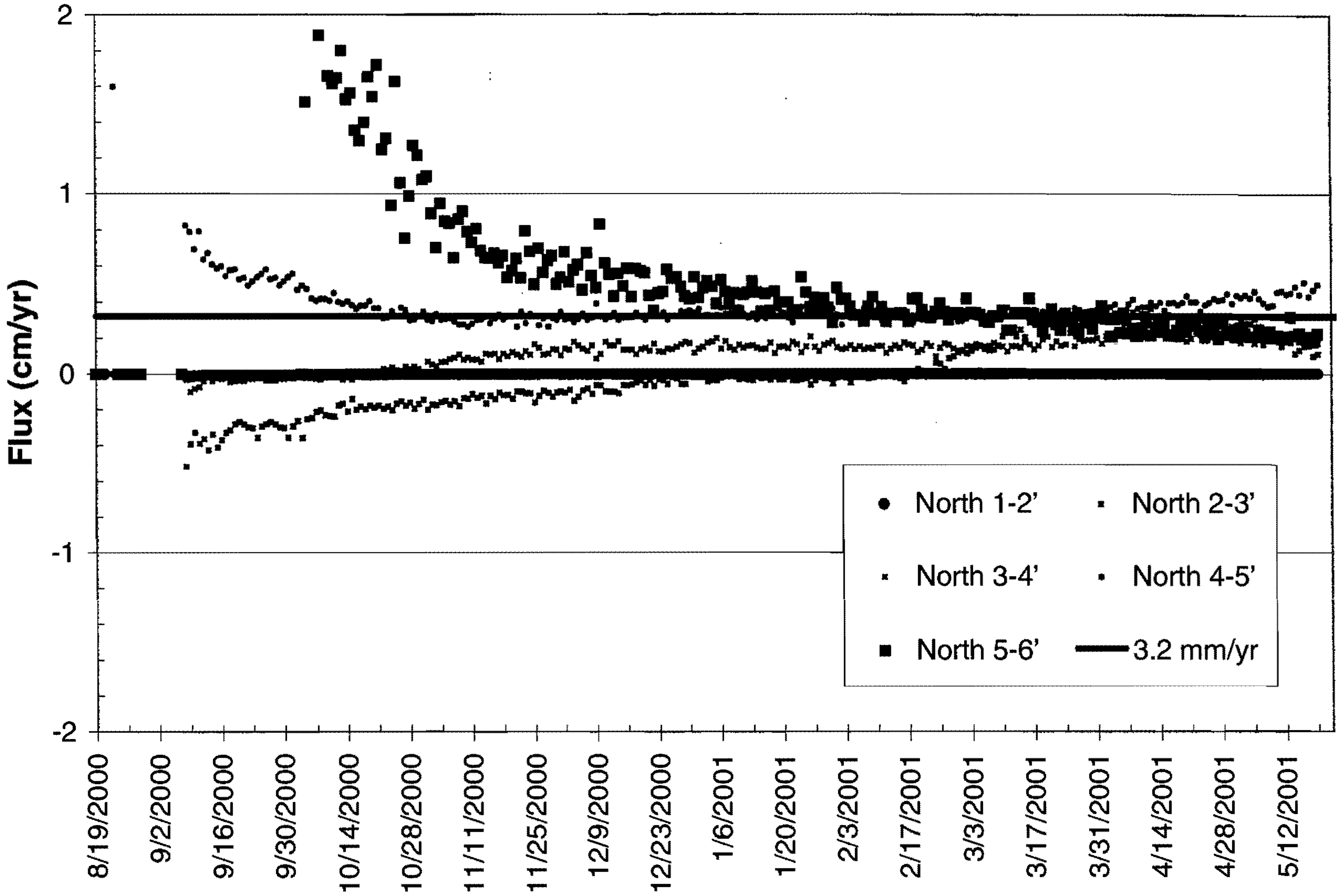


Figure 5.2-1. Example of heat dissipation sensor data

6.0 WASTE MANAGEMENT

6.1 Estimated Types and Volumes of Waste

It is anticipated that the airport landfill VCM will not generate any regulated waste. Incidental waste that might be generated during cover construction activities will probably consist of municipal and/or industrial solid waste.

6.2 Method of Management and Disposal

Waste that might be generated during cover construction activities will be either recycled or disposed of at an appropriate facility for the type of waste generated.

7.0 PROPOSED SCHEDULE AND UNCERTAINTIES

A proposed schedule for completing the supplemental sampling, the final cover designs, and the construction of the landfill covers will be prepared and submitted upon authorization and commencement of this work.

8.0 REFERENCES

The following list includes all of the documents cited in the body and appendixes of this VCM plan. The parenthetical information following each reference provides the author, publication date, and ER ID number for each document. This information is also included in the citations in the text. This information can be used to locate documents on this list.

The ER ID number is assigned by the Laboratory's ER Project to track material associated with Laboratory PRSs. This number can be used to locate the actual document at the ER Project's Records Processing Facility. All documents cited are assigned ER ID numbers.

California Air Resources Board (CARB), Stationary Source Division, September 13, 1990. "The Landfill Testing Program: Data Analysis and Evaluation Guidelines," California Air Resources Board Report, Sacramento, California. (CARB 1990, 59084)

Carsel, R., and R. Parrish, May 1988. "Developing Joint Probability Distributions of Soil Water Retention Characteristics," *Water Resources Research,* Vol. 24, No. 5, pp. 755–769. (Carsel and Parrish 1988, 70224)

Daniel B. Stephens & Assoc., Inc., 2001. "Quarterly Monitoring of Test Pad Performance USEI Site B Facility, Idaho," Albuquerque, New Mexico. (DB Stephens & Assoc. 2001, 73276)

Drennon, B., March 1990. "Dates of Operation of Old and New City Dump," record of teleconference with C. Lojek, Los Alamos, New Mexico. (Drennon 1990, 00650.1)

Fayer, M., 2000. "UNSAT-H Version 3.0: Unsaturated Soil Water and Heat Flow Model: Theory, User Manual, and Examples," Pacific Northwest National Laboratory report PNNL-13249, Richland, Washington. (Fayer 2000, 72734)

Fayer, M., and C. Simmons, 1995. "Modified Soil Water Retention Functions for All Matric Suctions," *Water Resource Research,* Vol. 31, pp. 1233–1238. (Fayer and Simmons 1995, 73273)

Fayer, M., M. Rockhold, and M. Campbell, 1992. "Hydrologic Modeling of Protective Barriers: Comparison of Field Data and Simulation Results," *Soil Science Society of America Journal,* Vol. 56, pp. 690–700. (Fayer et al. 1992, 72735)

Gardner, W., 1983. "Soil Properties and Efficient Water Use: An Overview," in H. Taylor, W. Jordan, and T Sinclair, eds., *Limitations to Efficient Water Use in Crop Production,* American Society of Agronomy, Madison, Wisconsin. (Gardner 1983, 72736)

Houghton, H., 1985. *Physical Meteorology.* MIT Press, Cambridge, Massachusetts. (Houghton 1985, 72737)

Knight, D., Summer 1973. "Leaf Area Dynamics of a Shortgrass Prairie in Colorado," *Ecology,* Vol. 54, No. 4, pp. 891–896. (Knight 1973, 73275)

Liang, Y., D. Hazlett, and W. Lauenroth, 1989. "Biomass Dynamics and Water Use Efficiencies of Five Plant Communities in the Shortgrass Steppe," *Oecologia,* Vol. 80, pp.148–153. (Liang et al. 1989, 72738)

Los Alamos National Laboratory (LANL), November 1990. "Solid Waste Management Units Report, Los Alamos National Laboratory, Revised November 1990, Vol. IV of IV (TA-51 through TA-74)," Los Alamos National Laboratory document LA-UR-90-3400, Los Alamos, New Mexico. (LANL 1990, 07514.1)

Los Alamos National Laboratory (LANL), May 1992. "RCRA Facility Investigation Work Plan for Operable Unit 1071," Los Alamos National Laboratory document LA-UR-92-810, Los Alamos, New Mexico. (LANL 1992, 07667)

Los Alamos National Laboratory (LANL), January 1996. "LANL HSWA Module VIII Permit, 1996 Revision (Guidance)." (LANL 1996, 57486.1)

Los Alamos National Laboratory (LANL), September 1997. "No Further Action Report for Potential Release Sites 0-034(a), 0-034(b). 73-001(b), 73-004(c), and 73-004(d), Field Unit 1," Los Alamos National Laboratory document LA-UR-97-3864, Los Alamos, New Mexico. (LANL 1997, 59367)

Los Alamos National Laboratory (LANL), November 1998. "Installation Work Plan for Environmental Restoration Project, Revision 7, November 1998 (Draft)," Los Alamos National Laboratory document LA-UR-98-4652, Los Alamos, New Mexico. (LANL 1998, 62060.4)

Los Alamos National Laboratory (LANL), November 1998. "RFI Report for Potential Release Sites 73-001(a,b,c,d), 73-004(d), Airport Landfill Areas, Volume 1, 2, and 3," Los Alamos National Laboratory document LA-UR-98-3824, Los Alamos, New Mexico. (LANL 1998, 63070.1)

Los Alamos National Laboratory (LANL), October 2001."Supplemental Sampling and Analysis Plan for Potential Release Sites 73-001(a) and 73-001(d)," Los Alamos National Laboratory document LA-UR-01-3987, Los Alamos, New Mexico. (LANL 2001, 71258)

Miller, R., December 1963. "Health Protection Survey Report; LAAO, LASL, and Zia," Los Alamos, New Mexico. (Miller 1963, 00684.1)

Miller R., and C. Shaykin, November 1966. "Health Protection Appraisal Report, LAAO, Zia and Los Alamos County, November 29–December 1, 1966," Los Alamos, New Mexico. (Miller 1966, 36692)

Monteith, J., 1980. "The Development and Extension of Penman's Evaporation Formula," in *Applications of Soil Physics,* D. Hillel, ed., Academic Press, New York. (Monteith 1980, 73271)

Mualem, Y., 1976. "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media," *Water Resources Res*earch, Vol. 12, No. 3, pp. 513–522. (Mualem 1976, 63543)

New Mexico Environment Department (NMED), December 1999, "Approval to Proceed, 73-001(a,b,c,d) and 73-004(d) RFI Report (Airport Landfill Areas) LANL," letter from John E. Kieling, NMED-HRMB, to Theodore Taylor, Project Manager, DOE LAAO, and John Browne, Director, Los Alamos National Laboratory, NM0890010515. (NMED 1999, 65133)

New Mexico Environment Department (NMED), November 2001. "Approval of the Supplemental Sampling and Analysis Plan for Potential Release Sites 73-001(a) and 73-001(d)," letter from John Young, LANL Corrective Action Project, NMED-HWB, to John Brown, Director, Los Alamos National Laboratory, and Theodore Taylor, Project Manager, DOE LAAO. (NMED 2001, 72812)

Pelt, R., R. Bass, R. Heaton, C. White, A. Blackard, C. Burklin, A. Reisdorph, 1998. "User's Manual Landfill Gas Emissions Model Version 2.0," Environmental Protection Agency, Office of Research and Development, Washington, D.C. pp. 4–38. (Pelt et al. 1998, 73274)

Ritchie, J., 1972. "Model for Predicting Evaporation from a Row Crop with Incomplete Cover," *Water Resources Res*earch, Vol. 8, No. 5, pp. 1204–1212. (Ritchie 1972, 73272)

Rogers, D., and B. Gallaher, September 1995. "The Unsaturated Hydraulic Characteristics of the Bandelier Tuff," Los Alamos National Laboratory report LA-12968-MS, Los Alamos, New Mexico. (Rogers and Gallaher, 1995, 55334.3)

US Environmental Protection Agency (EPA), April 1990. "Module VIII of RCRA Permit No. 0891010515, Issued to Los Alamos National Laboratory, Los Alamos, New Mexico, Effective May 23, 1990," EPA Region VI, Hazardous Waste Management Division, Dallas, Texas. (EPA 1990, 01585)

US Environmental Protection Agency (EPA), August 1997. "Emission Factor Documentation for AP-42. Section 2.4, Municipal Solid Waste Landfill Revised," Office of Air and Radiation, Research Triangle Park, North Carolina. (EPA 1997, 72733)

van Genuchten, M., F. Leij, and S. Yates, December 1991. "The RETC Code for Quantifying the Hydraulic Functions of Unsaturated Soils," report no. EPA/600/2-91/065, US Environmental Protection Agency, Office of Research and Development, Washington D.C. (van Genuchten et al. 1991, 72740)

The following documents were used to prepare this VCM plan but were not specifically cited in the text:

Bidwell, T., and D. Engle, 1992. "Relationship of Fire Behavior to Tallgrass Prairie Herbage Production." *Journal of Range Management,* Vol. 45, pp. 564–579. (Bidwell et al. 1992, 73087)

Colorado Department of Public Health and Environment, 2000. "Regulations Pertaining to Solid Waste Disposal Sites and Facilities." (CDPH&E 2000, 73088)

Emcon Associates, 1980. "Methane Generation and Recovery from Landfills." (Emcon 1980, 59075)

Los Alamos National Laboratory (LANL), August 1989. "Release Site Database, Task 26, TA-0 (Working Draft)," prepared by Roy F. Weston, Inc., for the Department of Energy, Los Alamos, New Mexico. (LANL 1989, 11966)

Los Alamos National Laboratory (LANL), November 1990. "Solid Waste Management Units Report, Los Alamos National Laboratory, Revised November 1990, Vol. I of IV (TA-0 through TA-5)," Los Alamos National Laboratory document LA-UR-90-3400, Los Alamos, New Mexico. (LANL 1990, 11646)

Los Alamos National Laboratory (LANL), May 1992. "RFI Work Plan for Operable Unit 1071," Los Alamos National Laboratory document LA-UR-92-810, Los Alamos, New Mexico. (LANL 1992, 59731)

Los Alamos National Laboratory (LANL), December 1996. "Installation Work Plan for Environmental Restoration Program, Revision 6," Los Alamos National Laboratory document LA-UR-96-4629, Los Alamos, New Mexico. (LANL 1996, 55574)

McBean, E., F. Rovers, and G. Farquhar, 1995. *Solid Waste Landfill Engineering and Design,* Prentice Hall PTR, Englewood Cliffs, New Jersey. (McBean et al. 1995, 73090)

US Department of Energy (DOE), October 1987. "Phase I: Installation Assessment, Los Alamos National Laboratory, Volumes 1 and 2," Comprehensive Environmental Assessment and Response Program, Albuquerque Operations Office, Albuquerque, New Mexico. (DOE 1987, 08660)

US Department of Energy (DOE), March 1996. "Operable Unit 7 Revised Draft IM/IRA Decision Document and Closure Plan for Rocky Flats Environmental Technology Site," RF/ER-96-0009.UN. (DOE 1996, 73089)

US Department of Transportation, December 4, 1987. "A Model Zoning Ordinance to Limit Height of Objects Around Airports," Federal Aviation Administration, Circular AC 150/5190-4A. (FAA 1987, 73086)

Appendix A

Acronyms and Abbreviations

AOC	area of concern
AP	administrative procedure
BMP	best management practice
COPC	chemical of potential concern
DDA	debris disposal area
DOE	US Department of Energy
EPA	US Environmental Protection Agency
ER	environmental restoration
ESH	Environment, Safety, and Health (a division of LANL)
ET	evapotranspiration
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FIMAD	Facility for Information Management, Analysis, and Display
FPC	field project coordinator
FPL	field project leader
GIA	gas in air
HPT	high performing team
HSWA	Hazardous and Solid Waste Amendments of 1984
LAI	leaf area index
LANL	Los Alamos National Laboratory
LEL	lower explosive limit
LFG	landfill gas
LIR	Laboratory Implementation Requirement
NFA	no further action
NMED	New Mexico Environment Department
NMOC	nonmethane organic compound
PERM	permanent erosion and revegetation material
PRS	potential release site
QAP	quality assurance procedure
RCRA	Resource Conservation and Recovery Act
RETC	RETention Curve program
RFI	RCRA facility investigation
RMA	Rocky Mountain Arsenal
SAP	sampling and analysis plan
SOP	standard operating procedure
SWAT	surface water assessment team
SWB	Solid Waste Bureau
SWMU	solid waste management unit
TA	technical area
T&E	threatened and endangered
TERM	temporary erosion and revegetation material
VCM	voluntary corrective measure
WGII	Washington Group International, Inc.

Metric to English Conversions

Multiply SI (Metric) Unit	by	To Obtain US Customary Unit
kilometers (km)	0.622	miles (mi)
kilometers (km)	3281	feet (ft)
meters (m)	3.281	feet (ft)
meters (m)	39.37	inches (in.)
centimeters (cm)	0.03281	feet (ft)
centimeters (cm)	0.394	inches (in.)
millimeters (mm)	0.0394	inches (in.)
micrometers or microns (µm)	0.0000394	inches (in.)
square kilometers (km^2)	0.3861	square miles (mi^2)
hectares (ha)	2.5	acres
square meters (m^2)	10.764	square feet (ft^2)
cubic meters (m^3)	35.31	cubic feet (ft^3)
kilograms (kg)	2.2046	pounds (lb)
grams (g)	0.0353	ounces (oz)
grams per cubic centimeter (g/cm^3)	62.422	pounds per cubic foot (lb/ft^3)
milligrams per kilogram (mg/kg)	1	parts per million (ppm)
micrograms per gram (µg/g)	1	parts per million (ppm)
liters (l)	0.26	gallons (gal.)
milligrams per liter (mg/l)	1	parts per million (ppm)
degrees Celsius (°C)	9/5 + 32	degrees Fahrenheit (°F)

Appendix B

VCM Checklist and Fieldwork Authorization Form

Voluntary Corrective Measure (VCM)

Checklist and Fieldwork Authorization Form

PRS Nos. 73-001(a)-99 and 73-001(b)-99

___ COPC(s) defined.

√ Nature and extent defined or field-screening method available to guide where not defined.

√ Remedy is obvious.

___ Time for removal is less than 6 months.

√ Remedy is final.

√ Land use assumptions straightforward.

___ Treatment, storage, disposal facilities are available for waste type and volume.

___ Cleanup cost is reasonable for the planned action, and meets accelerated decision logic criterion for decision to proceed with VCM.

Explain criteria not checked above: historical information indicates no hazardous materials should have been present. Confirmatory sampling will be done and extent will be defined, if necessary.

Through reviewing the above criteria associated with this site, I believe that a VCM is the appropriate accelerated cleanup approach.

FPL ____________________ Date 10/17/02

FPC ____________________ Date 10/17/02

The undersigned have reviewed the final plan and believe that it fully satisfies the appropriate accelerated cleanup approach.

FPL ____________________ Date 10/17/02

FPC ____________________ Date 10/17/02

Through reviewing the VCM plan for site(s) ____________________, and believing that the above criteria have been met, I authorize the fieldwork to proceed.

DOE ER Program Manager

____________________ Date 10/21/02

INFORMATION COPY ONLY

Appendix C

SOP-2.01

Los Alamos National Laboratory

Environment, Safety & Health Division
ESH-18 Water Quality & Hydrology Group

Surface Water Assessment Erosion Matrix for PRS 73-001(a)

CRITERIA EVALUATED	Value	Erosion/Sediment Transport Potential Low 0.1	Medium 0.5	High 1.0	Calculated Score
Site Setting (43)					
On mesa top	1	Defined based on topographic setting			
Within bench of canyon	4				
Within the canyon floodplain but not watercourse	13				13.0
Within bottom of canyon channel in watercourse	17				
Estimated % ground and canopy cover	13	>75%	25-75%	<25%	6.5
Slope	13	0-10%	10-30%	>30%	13.0
Surface Water Factors-Run-off (46)					
Visible evidence of runoff discharging? (Yes/No)	5	If no, score of 0 for runoff section.			5.0
		If yes, score 5 and proceed with section.			
Where does runoff terminate?	19	Other	Bench Setting	Drainage/Wetland	19.0
Has runoff caused visible erosion? (Yes/No)	22	Sheet	Rill	Gully	22.0
		If no, score as 0. If yes, calculate as appropriate.			
Surface Water Factors-Run-on (11)					
Structures adversely affecting run-on (Yes/No)	7*	If yes, score as 7. If no, score as 0.			7.0
Current operations adversely impacting (Yes/No)	4	If yes, score as 4. If no, score as 0.			0.0
Natural drainages onto site (Yes/No)	7*	If yes, score as 7. If no, score as 0.			0.0
**Select either structures or natural drainages.*					
MAX. POSSIBLE EROSION MATRIX SCORE:	**100**			**Total Score**	85.5**

** Indicates BMPs in place. Erosion potential without BMPs may be greater.

REVISED PART B

Report Printed 6/4/2002 10:46:27 AM.

Los Alamos National Laboratory
SURFACE WATER
SITE ASSESSMENT

Revised Part B. Please discard previous.

SITE INFORMATION

1a) PRS Number: 73-001(a) 1b) Structure Number: 1c) FMU Number: ER

2. Date/Time (M/D/Y H:M am/pm): 3/13/1998

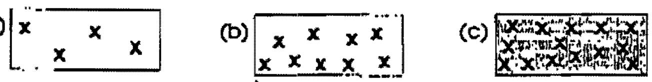
SITE SETTING (check all that apply)

3. ◉ On mesa top (a). ◉ In the canyon floor, but not in an established channel (c)
   ○ Within a bench of a canyon (b). ○ Within established channel in the canyon floor (d).

Explanation: Site of former town and laboratory landfill. Located between Pueblo Canyon and airport runway. Landfill debris also found off edge of cliff in drainages discharging into Pueblo Canyon.

4. Estimated ground and/or canopy cover at site: (deciduous leaves, pine needles, rocks, vegetation, trees,

(illustration) (a) (b) (c)

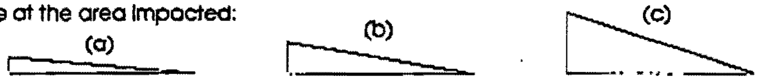


Estimated % of ground/canopy cov ○ 0% to 25% ◉ 25% to 75% ○ 75% to 100%

Explanation: Ground cover on mesa is well vegetated, debris exposed on mesa edge.

5. Steepest slope at the area impacted:

(a) (b) (c)



◉ Less than 10% ○ 10% to 30% ◉ 30% and greater

Explanation: Cliff below landfill is shear, with visible debris below site.

RUNOFF FACTORS

Y / N

☑ ☐ 6. Is there visible evidence of runoff discharging from site? If yes, answer a) - c) below:

☑ ☐ 6a) Is runoff channelized? If yes, describ ◉ Man-made channel. ○ Natural channel.

Explanation: Manmade channel extending from storm drain at edge of runway to edge of Pueblo Canyon.

RUNOFF FACTORS, CONT'D

6b) Where does evidence of runoff terminate?

- (●) **Drainage or wetland (name)** Pueblo Canyon
- ( ) **Within bench of canyon setting (name)**
- ( ) **Other (i.e., retention pond, meadow, mesa top)**

Explanation: Sheet flow and minor/severe channelization evident across entire landfill site. Termination of runoff is Pueblo Canyon.

Y / N

☑ ☐ 6c) Has runoff caused visible erosion at the site? If yes, explain below: ( ) Sheet ( ) Rill (●) Gully

Explanation: Rill erosion between perimeter fence and canyon edge. Severe gully erosion occurring in the central east facing lobe of landfill.

RUN-ON FACTORS

Please rate the potential for storm water to run on to this site: (Check EITHER #7 or #9)

☑ ☐ 7. Are structures (i.e., buildings, roof drains, parking lots, storm drains) creating run-on to the site?

Explanation: Storm drains conveying run-off from airport runway.

☐ ☑ 8. Are current operations (i.e., fire hydrants, NPDES outfalls) adversely impacting run-on to the site?

Explanation:

☐ ☑ 9. Are natural drainage patterns directing stormwater onto site?

Explanation:

ASSESSMENT FINDING:

☑ ☐ **10. Based on the above criteria and the assessment of this site, does soil erosion potential exist? (REFER TO EROSION POTENTIAL MATRIX.)**

T. Lemke

11. Signature of Water Quality/Hydrology Representative

SV Initials of independent reviewer.

Check here when information is entered in database: ☑

This page is for ESH-18 notes, recommendations, and photos.

Y / N

12. a) ◉ ○ Is there visible trash/debris on the site?

b) ◉ ○ Is there visible trash/debris in a watercourse?

Description of existing BMPs:

Run-on control above exposed north facing debris pile (culvert) has been installed as a diversion practice. Gabion was placed at end of culvert for dissipation

○ ○ Are BMPs being properly maintained? If no, describe in "Other Internal Notes."

○ ○ Are BMPs effectively keeping sediment in place and reducing erosion potential?

OTHER INTERNAL NOTES:

The site was re-evaluated due to SWAT recommendation. The entire PRS boundary is large and was not caputured in the orignal assessment completed on 10/15/97 (score 50.8). This procedure usually does not work well on large geographical areas.

Appendix D

Ecological Checklist

Ecological Scoping Checklist: Part A

Scoping Meeting Documentation

Site ID	PRS 73-001(a)	
Nature of PRS releases (indicate all that apply)	Solid Liquid Gaseous Other, explain	Yes Yes Municipal trash
List of primary impacted media (indicate all that apply)	<u>Surface soil</u> <u>Surface water/sediment</u> <u>Subsurface</u> Groundwater Other, explain	Yes Yes Yes (most material)
FIMAD vegetation class (indicate all that apply)	Water Bare ground Spruce/fir/aspen/mixed conifer Ponderosa pine <u>Piñon juniper/juniper savannah</u> <u>Grassland/shrubland</u> <u>Developed</u>	 Yes Yes (predominant) Yes
Is threatened and endangered (T&E) habitat present? List species if applicable. Are there proposed activities that might impact T&E species at the site?	Yes. North-facing slopes of Pueblo Canyon are peregrine falcon foraging habitat. This area is listed as core area for peregrine and Mexican spotted owl. The area on top of the mesa, however, is not suitable owl nesting or roosting habitat.	

Provide list and description of neighboring/ contiguous/ upgradient PRSs (Consider the need to aggregate PRSs for screening.)	PRS 73-001(b) is a waste-oil pit near the southern debris disposal landfill trench (proposed for NFA, criterion 1). PRS 73-001(c) is a series of bunker debris pits (proposed for NFA, criterion 5). PRS 73-001(d) is a DDA northeast of the runway. PRS 73-004(d) is a septic system that was not located (proposed for NFA, criterion 1). There are several PRSs in TA-73 Group 2 that are not collocated. For the purposes of ecological screening, all TA-73 Group 1 PRSs should be considered a single aggregate.
AP-4.5 Part B information: runoff score (out of 46), terminal point of surface water transport	Runoff score is 46 (of 46). There is debris in the watercourse. Terminal point of surface water transport is Pueblo Canyon.
Other scoping meeting notes	Much data on landfill gasses exist, with less data on soils and water. There is a vitrified asphalt flow to the northeast of the landfill that is not listed as a PRS but must be considered concomitantly during scoping.

Ecological Scoping Checklist: Part B

Site Visit Documentation

Site ID	PRS 73-001(a)
Date of site visit	First visit (Ryti only) 3-10-98; second visit (Ryti and Hooten) 5-11-98
Site visit conducted by	Randy Ryti and Mark M. Hooten

Receptor Information

Estimate cover	% vegetated	From 20 to 50% over entire area. Quite variable. Current mowing practices affect roughly 60% of the area.
	% wetland	0%
	% structures/asphalt, etc.	< 5% [a small portion on the west end; PRS 73-001(b) is entirely paved by the airport runway]
Field notes on the FIMAD vegetation class	Field observations concur with FIMAD vegetation assessment.	
Field notes on T&E habitat, if applicable	Pueblo Canyon is considered good habitat for both the peregrine falcon and the Mexican spotted owl. However, areas off the northern edge of the mesa would require close investigation in order to determine its suitability for owl nesting and roosting. It is unclear how much/extensively these species may have been affected by habitat alteration, landfill practices, or contamination by debris or chemical constituents.	
Are ecological receptors present at the PRS? (yes/no/uncertain) Provide explanation	There are many species of grasses and forbs on the landfill proper, with shrubs (e.g., *Artemesia sp.*), Gamble oak, piñon, and junipers on the northern rim of the mesa. There is ample evidence of fossorial animals (mammals and ants), surface-dwelling animals (mammals, birds), and invertebrates on-site.	

Contaminant Transport Information

Surface water transport Field notes on the terminal point of surface water transport (if applicable)	Many drainages north of the landfill drop steeply into Pueblo Canyon.
Are there any other off-site transport pathways? (yes/no/uncertain) Provide explanation	The northern edge of the landfill meets the native edge of the mesa top in many places. In these areas the soil layer is highly disturbed and may even be an artifact of sedimentation from fill materials eroding from the landfill and airport proper. There are some areas where the landfill materials are exposed on the northern mesa edge. These areas may provide pathways for leachate discharge. Sediments appear to be carried by stormwater over the edge of the mesa in many places. In some areas, the vegetation on the mesa top, as well as some geologic features, appear to be sediment traps. Landfill gasses also act to carry contaminants off-site.

Ecological Effects Information

Physical disturbance (provide list of major types of disturbances)	Historically, the landfill and airport have been extraordinary disturbances to the mesa-top biotic communities. The landfill and its operations have significantly altered the northern portion of the mesa, including the north-facing slope of Pueblo Canyon. Most vegetation over the landfill proper is either sparse or dominated by invasive types of annual forbs and grasses, many non-native. Areas less impacted or indirectly impacted by the landfill (and airport) activities contain many remaining woody shrubs (e.g., *Artemesia sp.*) and trees (e.g., Gamble oak, piñon, and various junipers). Some of the runoff channels exit into Pueblo Canyon and receive ample sediments from fill material. In some portions of the landfill, it was clear that historical activities had resulted in large amounts of debris being pushed over the northern edge of the mesa. The eastern fill area of the main landfill has historically eroded, which has lead to the installation of a drainage diversion ditch at that end of the landfill.
Are there obvious ecological effects? (yes/no/uncertain) Provide explanation	The current surface of the main landfill has a low density of vegetation. It is unclear how much of this is attributable to physical disturbance, plant successional processes, contamination (gasses, soil-borne), or any combination thereof. There appears to be a low incidence of ant colonies in landfill cap material versus material not lying directly over the landfill proper (trenches?). This latter observation may need to be quantified and mapped for verification. The level of activities of fossorial mammals does not appear to be reduced in the landfill cap versus elsewhere.

No Receptor/No Pathways

If there are no receptors and no offsite transport pathways, the remainder of the checklist should not be completed. Stop here and provide any additional explanation/justification for proposing an ecological NFA recommendation (if needed).

Data Adequacy

Do existing data provide information on the nature, rate, and extent of contamination? (yes/no/uncertain) Provide explanation (consider if the maximum value was captured by existing sample data)	It is likely that the maximum value for surface soil samples was captured due to biased sampling procedures. There is probably a need for a few additional samples in drainages off the mesa edge, depending upon the applicability of Pueblo Canyon sediment results to this extent issue. Good data exist for landfill gasses. Soil pore water samples have been collected from the landfill, but no groundwater samples currently exist for this site. It is assumed that groundwater samples will be taken as part of the LANL site-wide groundwater characterization and monitoring plan. There is no current information indicating that groundwater may be affected.
Do existing data for the PRS address potential pathways of off-site contamination? (yes/no/uncertain) Provide explanation (consider if other sites could be affecting this PRS)	All landfill-specific media have been sampled.

Additional Field Notes

Provide additional field notes on the site setting and potential ecological receptors. Recommend taking quantitative measurements on plant cover versus other factors (e.g., soil depth and character, soil moisture content, level of physical disturbance). Study on the occurrence of ant activities may provide valuable information for assessing soil-dwelling invertebrate activities and may be coupled with biouptake measurements for selected contaminants.

Ecological Scoping Checklist: Part C

Ecological Pathways Conceptual Exposure Model

Provide answers to questions A through Q and use this information to complete the ecological pathways conceptual exposure model.

Question A

Could soil contaminants reach receptors via vapors?

- Volatility of the hazardous substance (volatile chemicals generally have Henry's Law constant > 10^{-5} atm-me/mol and molecular weight < 200 g/mol).

Answer (yes/no/uncertain): Yes.

Provide explanation: Evidence of gasses already reaching receptors on landfill surface.

Question B

Could the soil contaminants identified above reach receptors through fugitive dust carried in air?

- Soil contamination would have to be on the actual surface of the soil to become available for dust.
- In the case of dust exposure to burrowing animals, the contamination would have to occur in the depth interval where these burrows occur.

Answer (yes/no/uncertain): Yes.

Provide explanation: Some obvious surface contaminants (debris, waste tar, oil, paraffin) may affect surface soil composition. Much of the surface is bare ground and subject to wind erosion.

Question C:

Can contaminated soil be transported to aquatic ecological communities (use AP-4.5 runoff score and terminal point of surface water runoff to help answer this question)?

- If the AP-4.5 runoff score is equal to zero, this suggests that erosion at the PRS is not a transport pathway. (Note that the runoff score is not the entire erosion potential score, rather it is a subtotal of this score with a maximum value of 46 points.)
- If erosion is a transport pathway, evaluate the terminal point to see if aquatic receptors could be affected.

Answer (yes/no/uncertain): Yes.

Provide explanation: This is an obvious and viable pathway, which will be considered in canyon reach reports. Thus, the aquatic communities in Pueblo Canyon are directly considered in the assessment of the airport landfill. The landfill is one of many potential contaminant sources for Pueblo Canyon.

Question D:

Is contaminated groundwater potentially available to biological receptors through seeps or springs?

- Known or suspected presence of contaminants in groundwater.
- The potential for contaminants to migrate via groundwater and discharge into habitats and/or surface waters.
- Contaminants may be taken up by terrestrial and rooted aquatic plants whose roots are in contact with groundwater present within the root zone (depth of ~1 m).
- Terrestrial wildlife receptors generally will not contact groundwater unless it is discharged to the surface.

Answer (yes/no/uncertain): Uncertain.

Provide explanation: Groundwater modeling would help answer this question, but it is unlikely that constituents will reach groundwater that would further affect ecological receptors. Investigation into groundwater recharge and hydrology for this area is part of an ongoing LANL-wide investigation.

Question E:

Is infiltration/percolation from contaminated subsurface material a viable transport pathway?

- Suspected ability of contaminants to migrate to groundwater.
- The potential for contaminants to migrate via groundwater and discharge into habitats and/or surface waters.
- Contaminants may be taken up by terrestrial and rooted aquatic plants whose roots are in contact with groundwater present within the root zone (depth of ~1 m).
- Terrestrial wildlife receptors generally will not contact groundwater unless it is discharged to the surface.
- Also consider the importance of mass wasting as a potential release mechanism for subsurface material.

Answer (yes/no/uncertain): Uncertain.

Provide explanation: See Question D, above.

Question F:

Could airborne contaminants interact with plants or animals through respiration of vapors?

- Contaminants must be present as volatiles in the air.
- Consider the importance of inhalation of vapors for burrowing animals.

- Foliar uptake of organic vapors is typically not a significant pathway.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 3

Provide explanation: This pathway is judged to be major due to the prevalence of landfill gasses in the near subsurface.

Question G:

Could airborne contaminants interact with plants or animals through deposition of particulates, or with animals through inhalation of fugitive dust?

- Contaminants must be present as particulates in the air or as dust for this pathway to be viable.
- Exposure via inhalation of fugitive dust is particularly applicable to ground-dwelling species that would be exposed to dust disturbed by their foraging or burrowing activities or by wind movement.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 2

Provide explanation: The majority of the waste and contamination is subsurface.

Question H:

Could contaminants interact with plants through root uptake or rain splash from surface soils?

- Contaminants in bulk soil may partition into soil solution, making them available to roots.
- Exposure of terrestrial plants to contaminants present in particulates deposited on leaf and stem surfaces by rain striking contaminated soils (i.e., rain splash).

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 2

Provide explanation: Root uptake of contaminants is typically considered to be a major contaminant pathway until further investigation demonstrates otherwise. However, in this case, it is more likely that this pathway is minor due to the fact that most contaminants are buried below the root-bearing zone of the soil.

Question I:

Could contaminants interact with receptors through food web transport from surface soils?

- The chemicals may bioaccumulate in animals (see list of potentially persistent bioaccumulators and biomagnifiers, presented in Table D-1).
- Animals may ingest contaminated prey.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 2

Provide explanation: Potential persistent bioaccumulators are present; however, most contamination is subsurface. This pathway cannot be ruled out as a potentially major pathway to fossorial animals.

Question J:

Could contaminants interact with receptors via incidental ingestion of surface soils?

- Incidental ingestion of contaminated soil could occur while animals grub for food resident in the soil, feed on plant matter covered with contaminated soil, or groom themselves clean of soil.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 2

Provide explanation: This pathway cannot be ruled out as a potentially major pathway to fossorial animals; however, most contamination is buried at a depth that fossorial activities (ants, squirrels) will not generally reach. It is unlikely that contaminants are being delivered to the surface due to biotic activity.

Question K:

Could contaminants interact with receptors through dermal contact with surface soils?

- Significant exposure via dermal contact would generally be limited to organic contaminants, which are lipophilic and can cross epidermal barriers.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 1

Provide explanation: For fossorial invertebrates and vertebrates, this is a viable pathway. Dermal/cutaneous contact is unlikely to affect fossorial and ground-dwelling organisms to the degree of incidental ingestion, thus dermal contact is considered an unlikely pathway.

Question L:

Could contaminants interact with plants or animals through external irradiation?

- External irradiation effects are most relevant for gamma-emitting radionuclides.
- Burial of contamination severely attenuates radiological exposure.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 2

Provide explanation: The activity of three gamma-emitting radiological constituents is marginally different from background, thus external radiological exposure is not viewed as a significant pathway.

Question M:

Could contaminants interact with plants through direct uptake from water and sediment or sediment rain splash?

- Contaminants may be taken up by terrestrial plants whose roots are in contact with surface waters.
- Terrestrial plants may be exposed to particulates deposited on leaf and stem surfaces by rain striking contaminated sediments (i.e., rain splash on sediments, *not* soils) in an area that is only periodically inundated with water.
- Contaminants in sediment may partition into soil solution, making them available to roots.
- Aquatic plants are in direct contact with water.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 1

Provide explanation: Surface water is ephemeral and limited in quantity at the landfill.

Question N:

Could contaminants interact with receptors through food web transport from water and sediment?

- The chemicals may bioaccumulate in animals (see list of potentially persistent bioaccumulators and biomagnifiers, presented in Table D-1.)
- Animals may ingest contaminated prey.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 1

Provide explanation: Potential persistent bioaccumulators are present in the surface soil, but this pathway is judged unlikely because the landfill does not support an aquatic ecological community. Possible impacts from the landfill on the aquatic community present in Pueblo Canyon should be assessed in the Pueblo Canyon reach report.

Question O:

Could contaminants interact with receptors via incidental ingestion of water and sediment?

- If sediments are present in an area that is only periodically inundated with water, terrestrial receptors may incidentally ingest sediments.
- Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source.
- Aquatic receptors may regularly or incidentally ingest sediment while foraging.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 1

Provide explanation: The availability of surface water to receptors on the mesa top or the north-facing slope is highly ephemeral, and most of the landfill's contamination is subsurface, further reducing the likelihood of this pathway.

Question P:

Could contaminants interact with receptors through dermal contact with water and sediment?

- If sediments are present in an area that is only periodically inundated with water, terrestrial species may be dermally exposed during dry periods.
- Terrestrial organisms may be dermally exposed to water-borne contaminants as a result of wading or swimming in contaminated waters.
- Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration, or ventilation of sediment pore waters.
- Aquatic receptors may be exposed through osmotic exchange, respiration, or ventilation of surface waters.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 1

Provide explanation: The availability of surface water to receptors on the mesa top or the north-facing slope is highly ephemeral, and most of the landfill's contamination is subsurface, further reducing the likelihood of this pathway.

Question Q:

Could contaminants interact with plants or animals through external irradiation via water and sediment exposure?

- External irradiation effects are most relevant for gamma-emitting radionuclides.
- Burial of contamination severely attenuates radiological exposure.
- The water column acts to absorb radiation; thus, external irradiation is typically more important for sediment-dwelling organisms.

Provide quantification of pathway (0 = no pathway, 1 = unlikely pathway, 2 = minor pathway, 3 = major pathway): 1

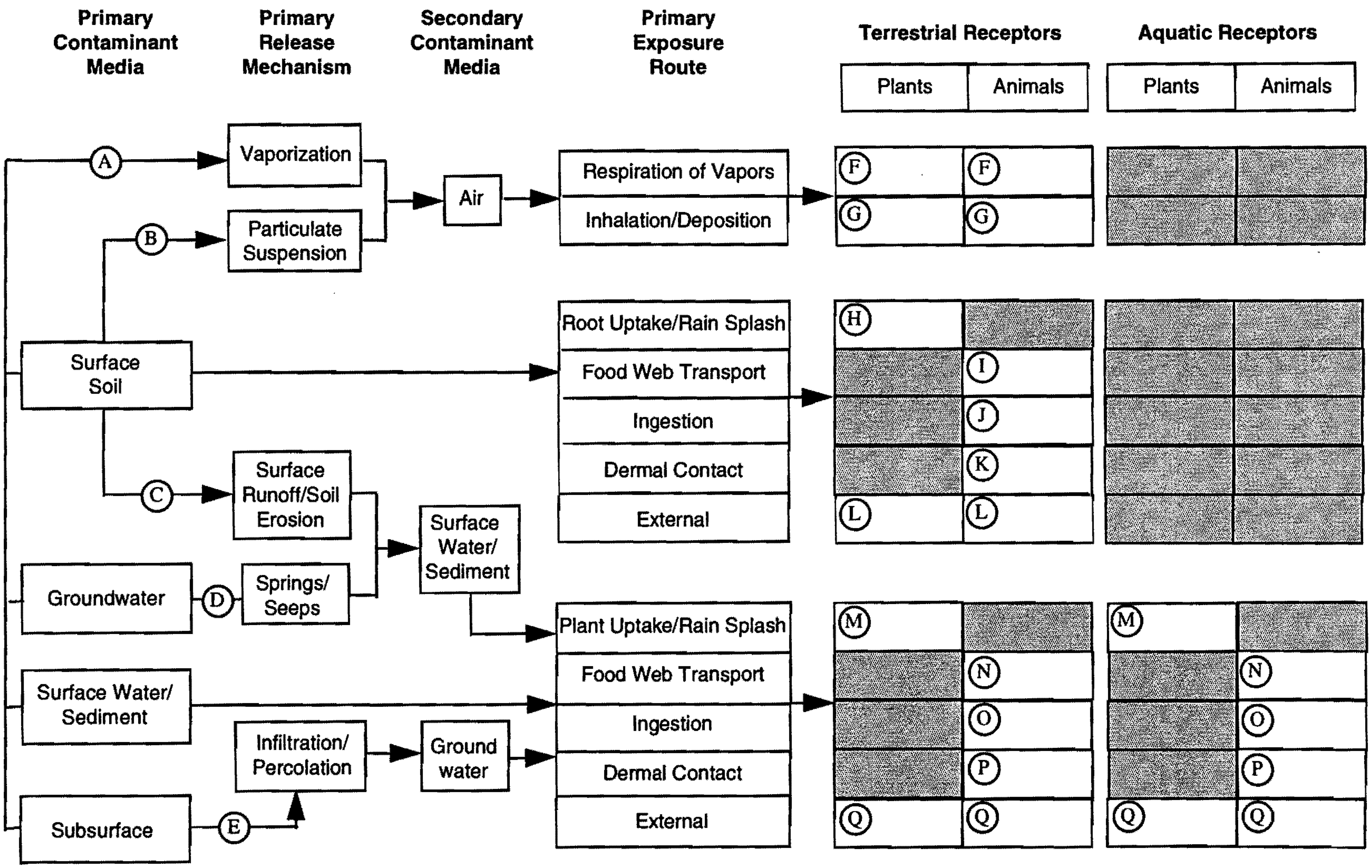
Provide explanation: Sedimentary deposits are extensive along the northern border of the landfill and cannot be viewed as less than a minor pathway; however, most of the landfill's contamination is subsurface, further reducing the likelihood of this pathway. The availability of surface water to receptors on the mesa top or the north-facing slope is highly ephemeral.

Table D-1
List of Bioaccumulating Chemicals

Volatile Organics Dichlorobenzene[1,4-] Trichlorobenzene[1,2,4-] Xylene (mixed isomers) *Semivolatile Organics* Acenaphthene Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(g,h,i)perylene Benzo(k)fluoranthene Bis(2-ethylhexyl)phthalate Butyl benzyl phthalate Chrysene Dibenzo(a,h)anthracene Di-n-butyl phthalate Di-n-octyl phthalate Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene Phenanthrene Pyrene Pentachloronitrobenzene Pentachlorophenol *Dioxins/Furans* Dibenzofuran 2,3,7,8-tetrachloro-dibenzo(p)dioxin 2,3,7,8-tetrachloro-dibenzo(p)furan	*PCBs/Pesticides* All Aroclors beta-BHC BHC-mixed isomers Chlordane Chlorecone (Kepone) DDT and metabolites Dieldrin Endosulfan Endrin Heptaclor Lindane Methoxyclor Toxaphene *Inorganics* Aluminum Cadmium Copper Lead Mercury Nickel Selenium *Radionuclides* Americium-241 Cesium-137 Plutonium-238, 239 Radium-226,-228 Strontium-90 Thorium-228,-230,-232 Uranium-234,-235,-238

Ecological Scoping Checklist
Ecological Pathways Conceptual Exposure Model

KEY
0 - No Pathway
1 - Unlikely Pathway
2 - Minor Pathway
3 - Major Pathway



Signatures and certifications:

Checklist completed by (provide name, organization and phone number)

Name (printed):	Randall T. Ryti
Name (signature):	Randall Ryti
Organization:	Neptune and Co., Inc.
Phone number:	505-662-2121
Date completed:	May 11, 1998

Verification by a member of ER Project Ecological Risk Task Team (provide name, organization and phone number)

Name (printed):	Mark M. Hooten
Name (signature):	Mark M. Hooten
Organization:	Neptune and Co., Inc.
Phone number:	505-662-2121
Date completed:	May 11, 1998

Appendix E

Estimated Costs

Estimated costs are not provided in this VCM plan. The conceptual landfill cover and long-term monitoring system designs are not adequate for the purpose of cost estimating. Cost estimates will be developed and provided in conjunction with preparation of the final designs.

Appendix F

Input File for Soil Gas Generation Calculations

LandGEM Landfill Gas Generation Estimates for the Present Landfill
LANL TA-73 Main Landfill Section 1

Year	Methane					Carbon Dioxide			Total LFG	Total LFG Velocity	Total LFG Velocity
	m3/yr	m3/min	ft3/min	ft/min	cm/day	m3/yr	m3/min	ft3/min	ft3/min	ft/min	cm/day
1944	2.11E+03	0.004	0.141	0.0000015	0.066	1.72E+03	0.003	0.116	0.257	0.0000027	0.120
1945	4.17E+03	0.008	0.280	0.0000030	0.131	3.41E+03	0.006	0.229	0.509	0.0000054	0.238
1946	6.19E+03	0.012	0.416	0.0000044	0.194	5.07E+03	0.010	0.340	0.757	0.0000080	0.353
1947	8.18E+03	0.016	0.549	0.0000058	0.256	6.69E+03	0.013	0.450	0.999	0.0000106	0.466
1948	1.01E+04	0.019	0.680	0.0000072	0.317	8.28E+03	0.016	0.556	1.236	0.0000131	0.577
1949	1.20E+04	0.023	0.808	0.0000086	0.377	9.84E+03	0.019	0.661	1.469	0.0000156	0.686
1950	1.18E+04	0.022	0.792	0.0000084	0.370	9.65E+03	0.018	0.648	1.440	0.0000153	0.672
1951	1.16E+04	0.022	0.777	0.0000083	0.362	9.46E+03	0.018	0.635	1.412	0.0000150	0.659
1952	1.13E+04	0.022	0.761	0.0000081	0.355	9.27E+03	0.018	0.623	1.384	0.0000147	0.646
1953	1.11E+04	0.021	0.746	0.0000079	0.348	9.08E+03	0.017	0.610	1.356	0.0000144	0.633
1954	1.09E+04	0.021	0.731	0.0000078	0.341	8.90E+03	0.017	0.598	1.329	0.0000141	0.620
1955	1.07E+04	0.020	0.717	0.0000076	0.335	8.73E+03	0.017	0.586	1.303	0.0000139	0.608
1956	1.05E+04	0.020	0.703	0.0000075	0.328	8.56E+03	0.016	0.575	1.277	0.0000136	0.596
1957	1.03E+04	0.020	0.689	0.0000073	0.321	8.39E+03	0.016	0.563	1.252	0.0000133	0.584
1958	1.01E+04	0.019	0.675	0.0000072	0.315	8.22E+03	0.016	0.552	1.227	0.0000131	0.573
1959	9.85E+03	0.019	0.662	0.0000070	0.309	8.06E+03	0.015	0.541	1.203	0.0000128	0.561
1960	9.65E+03	0.018	0.648	0.0000069	0.303	7.90E+03	0.015	0.531	1.179	0.0000125	0.550
1961	9.46E+03	0.018	0.636	0.0000068	0.297	7.74E+03	0.015	0.520	1.156	0.0000123	0.539
1962	9.27E+03	0.018	0.623	0.0000066	0.291	7.59E+03	0.014	0.510	1.133	0.0000120	0.529
1963	9.09E+03	0.017	0.611	0.0000065	0.285	7.44E+03	0.014	0.500	1.110	0.0000118	0.518
1964	8.91E+03	0.017	0.599	0.0000064	0.279	7.29E+03	0.014	0.490	1.088	0.0000116	0.508
1965	8.73E+03	0.017	0.587	0.0000062	0.274	7.15E+03	0.014	0.480	1.067	0.0000113	0.498
1966	8.56E+03	0.016	0.575	0.0000061	0.268	7.00E+03	0.013	0.471	1.046	0.0000111	0.488
1967	8.39E+03	0.016	0.564	0.0000060	0.263	6.87E+03	0.013	0.461	1.025	0.0000109	0.478
1968	8.23E+03	0.016	0.553	0.0000059	0.258	6.73E+03	0.013	0.452	1.005	0.0000107	0.469
1969	8.06E+03	0.015	0.542	0.0000058	0.253	6.60E+03	0.013	0.443	0.985	0.0000105	0.460
1970	7.90E+03	0.015	0.531	0.0000056	0.248	6.47E+03	0.012	0.434	0.965	0.0000103	0.450
1971	7.75E+03	0.015	0.520	0.0000055	0.243	6.34E+03	0.012	0.426	0.946	0.0000101	0.442
1972	7.59E+03	0.014	0.510	0.0000054	0.238	6.21E+03	0.012	0.417	0.927	0.0000099	0.433
1973	7.44E+03	0.014	0.500	0.0000053	0.233	6.09E+03	0.012	0.409	0.909	0.0000097	0.424
1974	7.30E+03	0.014	0.490	0.0000052	0.229	5.97E+03	0.011	0.401	0.891	0.0000095	0.416
1975	7.15E+03	0.014	0.480	0.0000051	0.224	5.85E+03	0.011	0.393	0.873	0.0000093	0.408
1976	7.01E+03	0.013	0.471	0.0000050	0.220	5.74E+03	0.011	0.385	0.856	0.0000091	0.400
1977	6.87E+03	0.013	0.462	0.0000049	0.215	5.62E+03	0.011	0.378	0.839	0.0000089	0.392
1978	6.73E+03	0.013	0.452	0.0000048	0.211	5.51E+03	0.010	0.370	0.823	0.0000087	0.384
1979	6.60E+03	0.013	0.443	0.0000047	0.207	5.40E+03	0.010	0.363	0.806	0.0000086	0.376
1980	6.47E+03	0.012	0.435	0.0000046	0.203	5.29E+03	0.010	0.356	0.790	0.0000084	0.369
1981	6.34E+03	0.012	0.426	0.0000045	0.199	5.19E+03	0.010	0.349	0.775	0.0000082	0.362
1982	6.22E+03	0.012	0.418	0.0000044	0.195	5.09E+03	0.010	0.342	0.759	0.0000081	0.354
1983	6.09E+03	0.012	0.409	0.0000044	0.191	4.99E+03	0.009	0.335	0.744	0.0000079	0.347
1984	5.97E+03	0.011	0.401	0.0000043	0.187	4.89E+03	0.009	0.328	0.730	0.0000078	0.340
1985	5.86E+03	0.011	0.393	0.0000042	0.184	4.79E+03	0.009	0.322	0.715	0.0000076	0.334
1986	5.74E+03	0.011	0.386	0.0000041	0.180	4.70E+03	0.009	0.315	0.701	0.0000075	0.327
1987	5.63E+03	0.011	0.378	0.0000040	0.176	4.60E+03	0.009	0.309	0.687	0.0000073	0.321
1988	5.51E+03	0.010	0.370	0.0000039	0.173	4.51E+03	0.009	0.303	0.673	0.0000072	0.314
1989	5.40E+03	0.010	0.363	0.0000039	0.169	4.42E+03	0.008	0.297	0.660	0.0000070	0.308
1990	5.30E+03	0.010	0.356	0.0000038	0.166	4.33E+03	0.008	0.291	0.647	0.0000069	0.302
1991	5.19E+03	0.010	0.349	0.0000037	0.163	4.25E+03	0.008	0.285	0.634	0.0000067	0.296
1992	5.09E+03	0.010	0.342	0.0000036	0.160	4.16E+03	0.008	0.280	0.622	0.0000066	0.290
1993	4.99E+03	0.009	0.335	0.0000036	0.156	4.08E+03	0.008	0.274	0.609	0.0000065	0.284
1994	4.89E+03	0.009	0.329	0.0000035	0.153	4.00E+03	0.008	0.269	0.597	0.0000064	0.279
1995	4.79E+03	0.009	0.322	0.0000034	0.150	3.92E+03	0.007	0.263	0.585	0.0000062	0.273
1996	4.70E+03	0.009	0.316	0.0000034	0.147	3.84E+03	0.007	0.258	0.574	0.0000061	0.268
1997	4.61E+03	0.009	0.309	0.0000033	0.144	3.77E+03	0.007	0.253	0.563	0.0000060	0.263
1998	4.51E+03	0.009	0.303	0.0000032	0.142	3.69E+03	0.007	0.248	0.551	0.0000059	0.257
1999	4.43E+03	0.008	0.297	0.0000032	0.139	3.62E+03	0.007	0.243	0.540	0.0000057	0.252
2000	4.34E+03	0.008	0.291	0.0000031	0.136	3.55E+03	0.007	0.238	0.530	0.0000056	0.247
2001	4.25E+03	0.008	0.286	0.0000030	0.133	3.48E+03	0.007	0.234	0.519	0.0000055	0.242
2002	4.17E+03	0.008	0.280	0.0000030	0.131	3.41E+03	0.006	0.229	0.509	0.0000054	0.238

LandGEM Landfill Gas Generation Estimates for the Present Landfill
LANL TA-73 Main Landfill Section 1

Year	Methane					Carbon Dioxide			Total LFG	Total LFG Velocity	Total LFG Velocity
	m3/yr	m3/min	ft3/min	ft/min	cm/day	m3/yr	m3/min	ft3/min	ft3/min	ft/min	cm/day
2003	4.09E+03	0.008	0.274	0.0000029	0.128	3.34E+03	0.006	0.225	0.499	0.0000053	0.233
2004	4.00E+03	0.008	0.269	0.0000029	0.126	3.28E+03	0.006	0.220	0.489	0.0000052	0.228
2005	3.92E+03	0.007	0.264	0.0000028	0.123	3.21E+03	0.006	0.216	0.479	0.0000051	0.224
2006	3.85E+03	0.007	0.258	0.0000027	0.121	3.15E+03	0.006	0.211	0.470	0.0000050	0.219
2007	3.77E+03	0.007	0.253	0.0000027	0.118	3.09E+03	0.006	0.207	0.461	0.0000049	0.215
2008	3.70E+03	0.007	0.248	0.0000026	0.116	3.02E+03	0.006	0.203	0.451	0.0000048	0.211
2009	3.62E+03	0.007	0.243	0.0000026	0.114	2.96E+03	0.006	0.199	0.443	0.0000047	0.207
2010	3.55E+03	0.007	0.239	0.0000025	0.111	2.91E+03	0.006	0.195	0.434	0.0000046	0.202
2011	3.48E+03	0.007	0.234	0.0000025	0.109	2.85E+03	0.005	0.191	0.425	0.0000045	0.198
2012	3.41E+03	0.006	0.229	0.0000024	0.107	2.79E+03	0.005	0.188	0.417	0.0000044	0.194
2013	3.34E+03	0.006	0.225	0.0000024	0.105	2.74E+03	0.005	0.184	0.408	0.0000043	0.191
2014	3.28E+03	0.006	0.220	0.0000023	0.103	2.68E+03	0.005	0.180	0.400	0.0000043	0.187
2015	3.21E+03	0.006	0.216	0.0000023	0.101	2.63E+03	0.005	0.177	0.392	0.0000042	0.183
2016	3.15E+03	0.006	0.212	0.0000022	0.099	2.58E+03	0.005	0.173	0.385	0.0000041	0.180
2017	3.09E+03	0.006	0.207	0.0000022	0.097	2.53E+03	0.005	0.170	0.377	0.0000040	0.176
2018	3.03E+03	0.006	0.203	0.0000022	0.095	2.48E+03	0.005	0.166	0.370	0.0000039	0.172
2019	2.97E+03	0.006	0.199	0.0000021	0.093	2.43E+03	0.005	0.163	0.362	0.0000039	0.169
2020	2.91E+03	0.006	0.195	0.0000021	0.091	2.38E+03	0.005	0.160	0.355	0.0000038	0.166
2021	2.85E+03	0.005	0.191	0.0000020	0.089	2.33E+03	0.004	0.157	0.348	0.0000037	0.162
2022	2.79E+03	0.005	0.188	0.0000020	0.088	2.29E+03	0.004	0.154	0.341	0.0000036	0.159
2023	2.74E+03	0.005	0.184	0.0000020	0.086	2.24E+03	0.004	0.150	0.334	0.0000036	0.156
2024	2.68E+03	0.005	0.180	0.0000019	0.084	2.20E+03	0.004	0.148	0.328	0.0000035	0.153
2025	2.63E+03	0.005	0.177	0.0000019	0.082	2.15E+03	0.004	0.145	0.321	0.0000034	0.150
2026	2.58E+03	0.005	0.173	0.0000018	0.081	2.11E+03	0.004	0.142	0.315	0.0000033	0.147
2027	2.53E+03	0.005	0.170	0.0000018	0.079	2.07E+03	0.004	0.139	0.309	0.0000033	0.144
2028	2.48E+03	0.005	0.166	0.0000018	0.078	2.03E+03	0.004	0.136	0.303	0.0000032	0.141
2029	2.43E+03	0.005	0.163	0.0000017	0.076	1.99E+03	0.004	0.133	0.297	0.0000032	0.138
2030	2.38E+03	0.005	0.160	0.0000017	0.075	1.95E+03	0.004	0.131	0.291	0.0000031	0.136
2031	2.33E+03	0.004	0.157	0.0000017	0.073	1.91E+03	0.004	0.128	0.285	0.0000030	0.133
2032	2.29E+03	0.004	0.154	0.0000016	0.072	1.87E+03	0.004	0.126	0.279	0.0000030	0.130
2033	2.24E+03	0.004	0.151	0.0000016	0.070	1.83E+03	0.003	0.123	0.274	0.0000029	0.128
2034	2.20E+03	0.004	0.148	0.0000016	0.069	1.80E+03	0.003	0.121	0.268	0.0000029	0.125
2035	2.15E+03	0.004	0.145	0.0000015	0.068	1.76E+03	0.003	0.118	0.263	0.0000028	0.123
2036	2.11E+03	0.004	0.142	0.0000015	0.066	1.73E+03	0.003	0.116	0.258	0.0000027	0.120
2037	2.07E+03	0.004	0.139	0.0000015	0.065	1.69E+03	0.003	0.114	0.253	0.0000027	0.118
2038	2.03E+03	0.004	0.136	0.0000014	0.064	1.66E+03	0.003	0.112	0.248	0.0000026	0.116
2039	1.99E+03	0.004	0.134	0.0000014	0.062	1.63E+03	0.003	0.109	0.243	0.0000026	0.113
2040	1.95E+03	0.004	0.131	0.0000014	0.061	1.59E+03	0.003	0.107	0.238	0.0000025	0.111
2041	1.91E+03	0.004	0.128	0.0000014	0.060	1.56E+03	0.003	0.105	0.233	0.0000025	0.109
2042	1.87E+03	0.004	0.126	0.0000013	0.059	1.53E+03	0.003	0.103	0.229	0.0000024	0.107
2043	1.84E+03	0.003	0.123	0.0000013	0.058	1.50E+03	0.003	0.101	0.224	0.0000024	0.105
2044	1.80E+03	0.003	0.121	0.0000013	0.056	1.47E+03	0.003	0.099	0.220	0.0000023	0.103
2045	1.76E+03	0.003	0.118	0.0000013	0.055	1.44E+03	0.003	0.097	0.215	0.0000023	0.101
2046	1.73E+03	0.003	0.116	0.0000012	0.054	1.41E+03	0.003	0.095	0.211	0.0000022	0.099
2047	1.69E+03	0.003	0.114	0.0000012	0.053	1.39E+03	0.003	0.093	0.207	0.0000022	0.097
2048	1.66E+03	0.003	0.112	0.0000012	0.052	1.36E+03	0.003	0.091	0.203	0.0000022	0.095
2049	1.63E+03	0.003	0.109	0.0000012	0.051	1.33E+03	0.003	0.089	0.199	0.0000021	0.093
2050	1.60E+03	0.003	0.107	0.0000011	0.050	1.31E+03	0.002	0.088	0.195	0.0000021	0.091
2051	1.56E+03	0.003	0.105	0.0000011	0.049	1.28E+03	0.002	0.086	0.191	0.0000020	0.089
2052	1.53E+03	0.003	0.103	0.0000011	0.048	1.25E+03	0.002	0.084	0.187	0.0000020	0.087
2053	1.50E+03	0.003	0.101	0.0000011	0.047	1.23E+03	0.002	0.083	0.184	0.0000020	0.086
2054	1.47E+03	0.003	0.099	0.0000011	0.046	1.21E+03	0.002	0.081	0.180	0.0000019	0.084
2055	1.44E+03	0.003	0.097	0.0000010	0.045	1.18E+03	0.002	0.079	0.176	0.0000019	0.082
2056	1.42E+03	0.003	0.095	0.0000010	0.044	1.16E+03	0.002	0.078	0.173	0.0000018	0.081
2057	1.39E+03	0.003	0.093	0.0000010	0.043	1.14E+03	0.002	0.076	0.169	0.0000018	0.079
2058	1.36E+03	0.003	0.091	0.0000010	0.043	1.11E+03	0.002	0.075	0.166	0.0000018	0.078
2059	1.33E+03	0.003	0.090	0.0000010	0.042	1.09E+03	0.002	0.073	0.163	0.0000017	0.076
2060	1.31E+03	0.002	0.088	0.0000009	0.041	1.07E+03	0.002	0.072	0.160	0.0000017	0.074
2061	1.28E+03	0.002	0.086	0.0000009	0.040	1.05E+03	0.002	0.070	0.156	0.0000017	0.073

LandGEM Landfill Gas Generation Estimates for the Present Landfill
LANL TA-73 Main Landfill Section 1

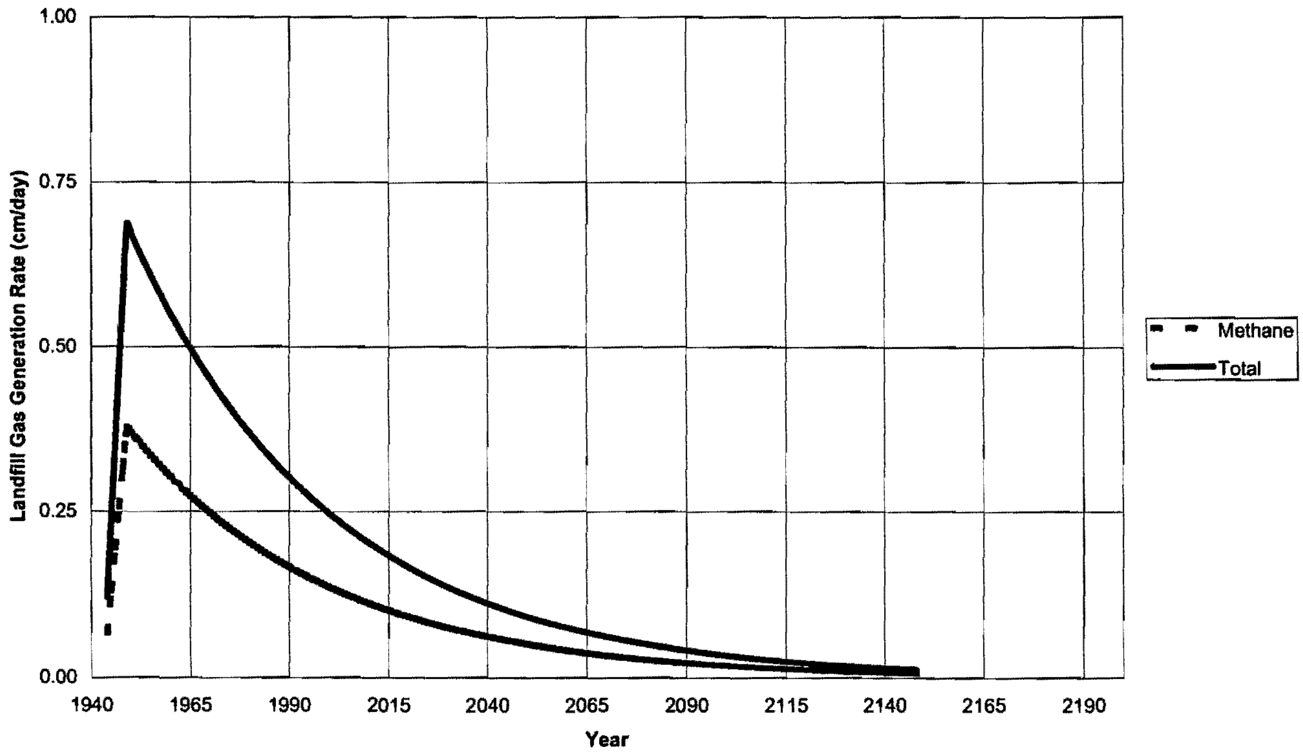
Year	Methane					Carbon Dioxide			Total LFG	Total LFG Velocity	Total LFG Velocity
	m3/yr	m3/min	ft3/min	ft/min	cm/day	m3/yr	m3/min	ft3/min	ft3/min	ft/min	cm/day
2062	1.26E+03	0.002	0.084	0.0000009	0.039	1.03E+03	0.002	0.069	0.153	0.0000016	0.072
2063	1.23E+03	0.002	0.083	0.0000009	0.039	1.01E+03	0.002	0.068	0.150	0.0000016	0.070
2064	1.21E+03	0.002	0.081	0.0000009	0.038	9.87E+02	0.002	0.066	0.147	0.0000016	0.069
2065	1.18E+03	0.002	0.079	0.0000008	0.037	9.67E+02	0.002	0.065	0.144	0.0000015	0.067
2066	1.16E+03	0.002	0.078	0.0000008	0.036	9.48E+02	0.002	0.064	0.142	0.0000015	0.066
2067	1.14E+03	0.002	0.076	0.0000008	0.036	9.29E+02	0.002	0.062	0.139	0.0000015	0.065
2068	1.11E+03	0.002	0.075	0.0000008	0.035	9.11E+02	0.002	0.061	0.136	0.0000014	0.063
2069	1.09E+03	0.002	0.073	0.0000008	0.034	8.93E+02	0.002	0.060	0.133	0.0000014	0.062
2070	1.07E+03	0.002	0.072	0.0000008	0.034	8.75E+02	0.002	0.059	0.131	0.0000014	0.061
2071	1.05E+03	0.002	0.070	0.0000007	0.033	8.58E+02	0.002	0.058	0.128	0.0000014	0.060
2072	1.03E+03	0.002	0.069	0.0000007	0.032	8.41E+02	0.002	0.056	0.126	0.0000013	0.059
2073	1.01E+03	0.002	0.068	0.0000007	0.032	8.24E+02	0.002	0.055	0.123	0.0000013	0.057
2074	9.87E+02	0.002	0.066	0.0000007	0.031	8.08E+02	0.002	0.054	0.121	0.0000013	0.056
2075	9.68E+02	0.002	0.065	0.0000007	0.030	7.92E+02	0.002	0.053	0.118	0.0000013	0.055
2076	9.49E+02	0.002	0.064	0.0000007	0.030	7.76E+02	0.001	0.052	0.116	0.0000012	0.054
2077	9.30E+02	0.002	0.062	0.0000007	0.029	7.61E+02	0.001	0.051	0.114	0.0000012	0.053
2078	9.11E+02	0.002	0.061	0.0000007	0.029	7.46E+02	0.001	0.050	0.111	0.0000012	0.052
2079	8.93E+02	0.002	0.060	0.0000006	0.028	7.31E+02	0.001	0.049	0.109	0.0000012	0.051
2080	8.76E+02	0.002	0.059	0.0000006	0.027	7.16E+02	0.001	0.048	0.107	0.0000011	0.050
2081	8.58E+02	0.002	0.058	0.0000006	0.027	7.02E+02	0.001	0.047	0.105	0.0000011	0.049
2082	8.41E+02	0.002	0.057	0.0000006	0.026	6.88E+02	0.001	0.046	0.103	0.0000011	0.048
2083	8.25E+02	0.002	0.055	0.0000006	0.026	6.75E+02	0.001	0.045	0.101	0.0000011	0.047
2084	8.08E+02	0.002	0.054	0.0000006	0.025	6.61E+02	0.001	0.044	0.099	0.0000010	0.046
2085	7.92E+02	0.002	0.053	0.0000006	0.025	6.48E+02	0.001	0.044	0.097	0.0000010	0.045
2086	7.77E+02	0.001	0.052	0.0000006	0.024	6.35E+02	0.001	0.043	0.095	0.0000010	0.044
2087	7.61E+02	0.001	0.051	0.0000005	0.024	6.23E+02	0.001	0.042	0.093	0.0000010	0.043
2088	7.46E+02	0.001	0.050	0.0000005	0.023	6.11E+02	0.001	0.041	0.091	0.0000010	0.043
2089	7.31E+02	0.001	0.049	0.0000005	0.023	5.98E+02	0.001	0.040	0.089	0.0000009	0.042
2090	7.17E+02	0.001	0.048	0.0000005	0.022	5.87E+02	0.001	0.039	0.088	0.0000009	0.041
2091	7.03E+02	0.001	0.047	0.0000005	0.022	5.75E+02	0.001	0.039	0.086	0.0000009	0.040
2092	6.89E+02	0.001	0.046	0.0000005	0.022	5.64E+02	0.001	0.038	0.084	0.0000009	0.039
2093	6.75E+02	0.001	0.045	0.0000005	0.021	5.52E+02	0.001	0.037	0.082	0.0000009	0.038
2094	6.62E+02	0.001	0.044	0.0000005	0.021	5.42E+02	0.001	0.036	0.081	0.0000009	0.038
2095	6.49E+02	0.001	0.044	0.0000005	0.020	5.31E+02	0.001	0.036	0.079	0.0000008	0.037
2096	6.36E+02	0.001	0.043	0.0000005	0.020	5.20E+02	0.001	0.035	0.078	0.0000008	0.036
2097	6.23E+02	0.001	0.042	0.0000004	0.020	5.10E+02	0.001	0.034	0.076	0.0000008	0.036
2098	6.11E+02	0.001	0.041	0.0000004	0.019	5.00E+02	0.001	0.034	0.075	0.0000008	0.035
2099	5.99E+02	0.001	0.040	0.0000004	0.019	4.90E+02	0.001	0.033	0.073	0.0000008	0.034
2100	5.87E+02	0.001	0.039	0.0000004	0.018	4.80E+02	0.001	0.032	0.072	0.0000008	0.033
2101	5.75E+02	0.001	0.039	0.0000004	0.018	4.71E+02	0.001	0.032	0.070	0.0000007	0.033
2102	5.64E+02	0.001	0.038	0.0000004	0.018	4.61E+02	0.001	0.031	0.069	0.0000007	0.032
2103	5.53E+02	0.001	0.037	0.0000004	0.017	4.52E+02	0.001	0.030	0.068	0.0000007	0.032
2104	5.42E+02	0.001	0.036	0.0000004	0.017	4.43E+02	0.001	0.030	0.066	0.0000007	0.031
2105	5.31E+02	0.001	0.036	0.0000004	0.017	4.35E+02	0.001	0.029	0.065	0.0000007	0.030
2106	5.21E+02	0.001	0.035	0.0000004	0.016	4.26E+02	0.001	0.029	0.064	0.0000007	0.030
2107	5.10E+02	0.001	0.034	0.0000004	0.016	4.18E+02	0.001	0.028	0.062	0.0000007	0.029
2108	5.00E+02	0.001	0.034	0.0000004	0.016	4.09E+02	0.001	0.027	0.061	0.0000006	0.029
2109	4.90E+02	0.001	0.033	0.0000004	0.015	4.01E+02	0.001	0.027	0.060	0.0000006	0.028
2110	4.81E+02	0.001	0.032	0.0000003	0.015	3.93E+02	0.001	0.026	0.059	0.0000006	0.027
2111	4.71E+02	0.001	0.032	0.0000003	0.015	3.85E+02	0.001	0.026	0.058	0.0000006	0.027
2112	4.62E+02	0.001	0.031	0.0000003	0.014	3.78E+02	0.001	0.025	0.056	0.0000006	0.026
2113	4.53E+02	0.001	0.030	0.0000003	0.014	3.70E+02	0.001	0.025	0.055	0.0000006	0.026
2114	4.44E+02	0.001	0.030	0.0000003	0.014	3.63E+02	0.001	0.024	0.054	0.0000006	0.025
2115	4.35E+02	0.001	0.029	0.0000003	0.014	3.56E+02	0.001	0.024	0.053	0.0000006	0.025
2116	4.26E+02	0.001	0.029	0.0000003	0.013	3.49E+02	0.001	0.023	0.052	0.0000006	0.024
2117	4.18E+02	0.001	0.028	0.0000003	0.013	3.42E+02	0.001	0.023	0.051	0.0000005	0.024
2118	4.10E+02	0.001	0.028	0.0000003	0.013	3.35E+02	0.001	0.023	0.050	0.0000005	0.023
2119	4.01E+02	0.001	0.027	0.0000003	0.013	3.28E+02	0.001	0.022	0.049	0.0000005	0.023
2120	3.94E+02	0.001	0.026	0.0000003	0.012	3.22E+02	0.001	0.022	0.048	0.0000005	0.022

LandGEM Landfill Gas Generation Estimates for the Present Landfill
LANL TA-73 Main Landfill Section 1

Year	Methane					Carbon Dioxide			Total LFG	Total LFG Velocity	Total LFG Velocity
	m3/yr	m3/min	ft3/min	ft/min	cm/day	m3/yr	m3/min	ft3/min	ft3/min	ft/min	cm/day
2121	3.86E+02	0.001	0.026	0.0000003	0.012	3.16E+02	0.001	0.021	0.047	0.0000005	0.022
2122	3.78E+02	0.001	0.025	0.0000003	0.012	3.09E+02	0.001	0.021	0.046	0.0000005	0.022
2123	3.71E+02	0.001	0.025	0.0000003	0.012	3.03E+02	0.001	0.020	0.045	0.0000005	0.021
2124	3.63E+02	0.001	0.024	0.0000003	0.011	2.97E+02	0.001	0.020	0.044	0.0000005	0.021
2125	3.56E+02	0.001	0.024	0.0000003	0.011	2.91E+02	0.001	0.020	0.043	0.0000005	0.020
2126	3.49E+02	0.001	0.023	0.0000002	0.011	2.86E+02	0.001	0.019	0.043	0.0000005	0.020
2127	3.42E+02	0.001	0.023	0.0000002	0.011	2.80E+02	0.001	0.019	0.042	0.0000004	0.020
2128	3.35E+02	0.001	0.023	0.0000002	0.011	2.74E+02	0.001	0.018	0.041	0.0000004	0.019
2129	3.29E+02	0.001	0.022	0.0000002	0.010	2.69E+02	0.001	0.018	0.040	0.0000004	0.019
2130	3.22E+02	0.001	0.022	0.0000002	0.010	2.64E+02	0.001	0.018	0.039	0.0000004	0.018
2131	3.16E+02	0.001	0.021	0.0000002	0.010	2.58E+02	0.000	0.017	0.039	0.0000004	0.018
2132	3.10E+02	0.001	0.021	0.0000002	0.010	2.53E+02	0.000	0.017	0.038	0.0000004	0.018
2133	3.03E+02	0.001	0.020	0.0000002	0.010	2.48E+02	0.000	0.017	0.037	0.0000004	0.017
2134	2.97E+02	0.001	0.020	0.0000002	0.009	2.43E+02	0.000	0.016	0.036	0.0000004	0.017
2135	2.92E+02	0.001	0.020	0.0000002	0.009	2.39E+02	0.000	0.016	0.036	0.0000004	0.017
2136	2.86E+02	0.001	0.019	0.0000002	0.009	2.34E+02	0.000	0.016	0.035	0.0000004	0.016
2137	2.80E+02	0.001	0.019	0.0000002	0.009	2.29E+02	0.000	0.015	0.034	0.0000004	0.016
2138	2.75E+02	0.001	0.018	0.0000002	0.009	2.25E+02	0.000	0.015	0.034	0.0000004	0.016
2139	2.69E+02	0.001	0.018	0.0000002	0.008	2.20E+02	0.000	0.015	0.033	0.0000003	0.015
2140	2.64E+02	0.001	0.018	0.0000002	0.008	2.16E+02	0.000	0.014	0.032	0.0000003	0.015
2141	2.59E+02	0.000	0.017	0.0000002	0.008	2.12E+02	0.000	0.014	0.032	0.0000003	0.015
2142	2.53E+02	0.000	0.017	0.0000002	0.008	2.07E+02	0.000	0.014	0.031	0.0000003	0.014
2143	2.48E+02	0.000	0.017	0.0000002	0.008	2.03E+02	0.000	0.014	0.030	0.0000003	0.014
2144	2.44E+02	0.000	0.016	0.0000002	0.008	1.99E+02	0.000	0.013	0.030	0.0000003	0.014
2145	2.39E+02	0.000	0.016	0.0000002	0.007	1.95E+02	0.000	0.013	0.029	0.0000003	0.014
2146	2.34E+02	0.000	0.016	0.0000002	0.007	1.91E+02	0.000	0.013	0.029	0.0000003	0.013
2147	2.29E+02	0.000	0.015	0.0000002	0.007	1.88E+02	0.000	0.013	0.028	0.0000003	0.013
2148	2.25E+02	0.000	0.015	0.0000002	0.007	1.84E+02	0.000	0.012	0.027	0.0000003	0.013

Notes: k = 0.02, Lo = 50, CH_4 = 55%

Landfill Gas Generation at the Main Landfill Section 1
Los Alamos National Laboratory TA-73



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Model Parameters

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Lo : 50.00 m^3 / Mg ***** User Mode Selection *****

k : 0.0200 1/yr ***** User Mode Selection *****

NMOC : 4000.00 ppmv ***** User Mode Selection *****

Methane : 55.0000 % volume

Carbon Dioxide : 45.0000 % volume

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Landfill Parameters

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Landfill type : Co-Disposal

Year Opened : 1943 Current Year : 1949 Closure Year: 1949

Capacity : 12637 Mg

Average Acceptance Rate Required from

Current Year to Closure Year : 0.00 Mg/year

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Model Results

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		Methane Emission Rate	
Year	Refuse In Place (Mg)	(Mg/yr)	(Cubic m/yr)
1944	2.106E+03	1.405E+00	2.106E+03

1945	4.212E+03	2.782E+00	4.171E+03
1946	6.319E+03	4.132E+00	6.194E+03
1947	8.425E+03	5.456E+00	8.178E+03
1948	1.053E+04	6.753E+00	1.012E+04
1949	1.264E+04	8.024E+00	1.203E+04
1950	1.264E+04	7.865E+00	1.179E+04
1951	1.264E+04	7.710E+00	1.156E+04
1952	1.264E+04	7.557E+00	1.133E+04
1953	1.264E+04	7.407E+00	1.110E+04
1954	1.264E+04	7.261E+00	1.088E+04
1955	1.264E+04	7.117E+00	1.067E+04
1956	1.264E+04	6.976E+00	1.046E+04
1957	1.264E+04	6.838E+00	1.025E+04
1958	1.264E+04	6.702E+00	1.005E+04
1959	1.264E+04	6.570E+00	9.847E+03
1960	1.264E+04	6.440E+00	9.652E+03
1961	1.264E+04	6.312E+00	9.461E+03
1962	1.264E+04	6.187E+00	9.274E+03
1963	1.264E+04	6.065E+00	9.090E+03
1964	1.264E+04	5.945E+00	8.910E+03
1965	1.264E+04	5.827E+00	8.734E+03
1966	1.264E+04	5.711E+00	8.561E+03
1967	1.264E+04	5.598E+00	8.391E+03

1968	1.264E+04	5.487E+00	8.225E+03
1969	1.264E+04	5.379E+00	8.062E+03
1970	1.264E+04	5.272E+00	7.903E+03
1971	1.264E+04	5.168E+00	7.746E+03
1972	1.264E+04	5.066E+00	7.593E+03
1973	1.264E+04	4.965E+00	7.443E+03
1974	1.264E+04	4.867E+00	7.295E+03
1975	1.264E+04	4.771E+00	7.151E+03
1976	1.264E+04	4.676E+00	7.009E+03
1977	1.264E+04	4.584E+00	6.870E+03
1978	1.264E+04	4.493E+00	6.734E+03
1979	1.264E+04	4.404E+00	6.601E+03
1980	1.264E+04	4.317E+00	6.470E+03
1981	1.264E+04	4.231E+00	6.342E+03
1982	1.264E+04	4.147E+00	6.217E+03
1983	1.264E+04	4.065E+00	6.093E+03
1984	1.264E+04	3.985E+00	5.973E+03
1985	1.264E+04	3.906E+00	5.855E+03
1986	1.264E+04	3.828E+00	5.739E+03
1987	1.264E+04	3.753E+00	5.625E+03
1988	1.264E+04	3.678E+00	5.514E+03
1989	1.264E+04	3.606E+00	5.404E+03
1990	1.264E+04	3.534E+00	5.297E+03

1991	1.264E+04	3.464E+00	5.192E+03
1992	1.264E+04	3.396E+00	5.090E+03
1993	1.264E+04	3.328E+00	4.989E+03
1994	1.264E+04	3.262E+00	4.890E+03
1995	1.264E+04	3.198E+00	4.793E+03
1996	1.264E+04	3.134E+00	4.698E+03
1997	1.264E+04	3.072E+00	4.605E+03
1998	1.264E+04	3.012E+00	4.514E+03
1999	1.264E+04	2.952E+00	4.425E+03
2000	1.264E+04	2.894E+00	4.337E+03
2001	1.264E+04	2.836E+00	4.251E+03
2002	1.264E+04	2.780E+00	4.167E+03
2003	1.264E+04	2.725E+00	4.085E+03
2004	1.264E+04	2.671E+00	4.004E+03
2005	1.264E+04	2.618E+00	3.924E+03
2006	1.264E+04	2.566E+00	3.847E+03
2007	1.264E+04	2.515E+00	3.771E+03
2008	1.264E+04	2.466E+00	3.696E+03
2009	1.264E+04	2.417E+00	3.623E+03
2010	1.264E+04	2.369E+00	3.551E+03
2011	1.264E+04	2.322E+00	3.481E+03
2012	1.264E+04	2.276E+00	3.412E+03
2013	1.264E+04	2.231E+00	3.344E+03

2014	1.264E+04	2.187E+00	3.278E+03
2015	1.264E+04	2.144E+00	3.213E+03
2016	1.264E+04	2.101E+00	3.149E+03
2017	1.264E+04	2.060E+00	3.087E+03
2018	1.264E+04	2.019E+00	3.026E+03
2019	1.264E+04	1.979E+00	2.966E+03
2020	1.264E+04	1.940E+00	2.907E+03
2021	1.264E+04	1.901E+00	2.850E+03
2022	1.264E+04	1.864E+00	2.793E+03
2023	1.264E+04	1.827E+00	2.738E+03
2024	1.264E+04	1.790E+00	2.684E+03
2025	1.264E+04	1.755E+00	2.631E+03
2026	1.264E+04	1.720E+00	2.579E+03
2027	1.264E+04	1.686E+00	2.527E+03
2028	1.264E+04	1.653E+00	2.477E+03
2029	1.264E+04	1.620E+00	2.428E+03
2030	1.264E+04	1.588E+00	2.380E+03
2031	1.264E+04	1.557E+00	2.333E+03
2032	1.264E+04	1.526E+00	2.287E+03
2033	1.264E+04	1.496E+00	2.242E+03
2034	1.264E+04	1.466E+00	2.197E+03
2035	1.264E+04	1.437E+00	2.154E+03
2036	1.264E+04	1.408E+00	2.111E+03

2037	1.264E+04	1.381E+00	2.069E+03
2038	1.264E+04	1.353E+00	2.028E+03
2039	1.264E+04	1.326E+00	1.988E+03
2040	1.264E+04	1.300E+00	1.949E+03
2041	1.264E+04	1.274E+00	1.910E+03
2042	1.264E+04	1.249E+00	1.872E+03
2043	1.264E+04	1.224E+00	1.835E+03
2044	1.264E+04	1.200E+00	1.799E+03
2045	1.264E+04	1.176E+00	1.763E+03
2046	1.264E+04	1.153E+00	1.728E+03
2047	1.264E+04	1.130E+00	1.694E+03
2048	1.264E+04	1.108E+00	1.661E+03
2049	1.264E+04	1.086E+00	1.628E+03
2050	1.264E+04	1.064E+00	1.596E+03
2051	1.264E+04	1.043E+00	1.564E+03
2052	1.264E+04	1.023E+00	1.533E+03
2053	1.264E+04	1.002E+00	1.503E+03
2054	1.264E+04	9.826E-01	1.473E+03
2055	1.264E+04	9.632E-01	1.444E+03
2056	1.264E+04	9.441E-01	1.415E+03
2057	1.264E+04	9.254E-01	1.387E+03
2058	1.264E+04	9.071E-01	1.360E+03
2059	1.264E+04	8.891E-01	1.333E+03

2060	1.264E+04	8.715E-01	1.306E+03
2061	1.264E+04	8.543E-01	1.280E+03
2062	1.264E+04	8.373E-01	1.255E+03
2063	1.264E+04	8.208E-01	1.230E+03
2064	1.264E+04	8.045E-01	1.206E+03
2065	1.264E+04	7.886E-01	1.182E+03
2066	1.264E+04	7.730E-01	1.159E+03
2067	1.264E+04	7.577E-01	1.136E+03
2068	1.264E+04	7.426E-01	1.113E+03
2069	1.264E+04	7.279E-01	1.091E+03
2070	1.264E+04	7.135E-01	1.070E+03
2071	1.264E+04	6.994E-01	1.048E+03
2072	1.264E+04	6.856E-01	1.028E+03
2073	1.264E+04	6.720E-01	1.007E+03
2074	1.264E+04	6.587E-01	9.873E+02
2075	1.264E+04	6.456E-01	9.677E+02
2076	1.264E+04	6.328E-01	9.486E+02
2077	1.264E+04	6.203E-01	9.298E+02
2078	1.264E+04	6.080E-01	9.114E+02
2079	1.264E+04	5.960E-01	8.933E+02
2080	1.264E+04	5.842E-01	8.757E+02
2081	1.264E+04	5.726E-01	8.583E+02
2082	1.264E+04	5.613E-01	8.413E+02

2083	1.264E+04	5.502E-01	8.247E+02
2084	1.264E+04	5.393E-01	8.083E+02
2085	1.264E+04	5.286E-01	7.923E+02
2086	1.264E+04	5.181E-01	7.766E+02
2087	1.264E+04	5.079E-01	7.613E+02
2088	1.264E+04	4.978E-01	7.462E+02
2089	1.264E+04	4.880E-01	7.314E+02
2090	1.264E+04	4.783E-01	7.169E+02
2091	1.264E+04	4.688E-01	7.027E+02
2092	1.264E+04	4.595E-01	6.888E+02
2093	1.264E+04	4.504E-01	6.752E+02
2094	1.264E+04	4.415E-01	6.618E+02
2095	1.264E+04	4.328E-01	6.487E+02
2096	1.264E+04	4.242E-01	6.359E+02
2097	1.264E+04	4.158E-01	6.233E+02
2098	1.264E+04	4.076E-01	6.109E+02
2099	1.264E+04	3.995E-01	5.988E+02
2100	1.264E+04	3.916E-01	5.870E+02
2101	1.264E+04	3.838E-01	5.753E+02
2102	1.264E+04	3.762E-01	5.640E+02
2103	1.264E+04	3.688E-01	5.528E+02
2104	1.264E+04	3.615E-01	5.418E+02
2105	1.264E+04	3.543E-01	5.311E+02

2106	1.264E+04	3.473E-01	5.206E+02
2107	1.264E+04	3.404E-01	5.103E+02
2108	1.264E+04	3.337E-01	5.002E+02
2109	1.264E+04	3.271E-01	4.903E+02
2110	1.264E+04	3.206E-01	4.806E+02
2111	1.264E+04	3.143E-01	4.711E+02
2112	1.264E+04	3.080E-01	4.617E+02
2113	1.264E+04	3.019E-01	4.526E+02
2114	1.264E+04	2.960E-01	4.436E+02
2115	1.264E+04	2.901E-01	4.348E+02
2116	1.264E+04	2.844E-01	4.262E+02
2117	1.264E+04	2.787E-01	4.178E+02
2118	1.264E+04	2.732E-01	4.095E+02
2119	1.264E+04	2.678E-01	4.014E+02
2120	1.264E+04	2.625E-01	3.935E+02
2121	1.264E+04	2.573E-01	3.857E+02
2122	1.264E+04	2.522E-01	3.780E+02
2123	1.264E+04	2.472E-01	3.705E+02
2124	1.264E+04	2.423E-01	3.632E+02
2125	1.264E+04	2.375E-01	3.560E+02
2126	1.264E+04	2.328E-01	3.490E+02
2127	1.264E+04	2.282E-01	3.421E+02
2128	1.264E+04	2.237E-01	3.353E+02

2129	1.264E+04	2.193E-01	3.286E+02
2130	1.264E+04	2.149E-01	3.221E+02
2131	1.264E+04	2.107E-01	3.158E+02
2132	1.264E+04	2.065E-01	3.095E+02
2133	1.264E+04	2.024E-01	3.034E+02
2134	1.264E+04	1.984E-01	2.974E+02
2135	1.264E+04	1.945E-01	2.915E+02
2136	1.264E+04	1.906E-01	2.857E+02
2137	1.264E+04	1.868E-01	2.800E+02
2138	1.264E+04	1.831E-01	2.745E+02
2139	1.264E+04	1.795E-01	2.691E+02
2140	1.264E+04	1.760E-01	2.637E+02
2141	1.264E+04	1.725E-01	2.585E+02
2142	1.264E+04	1.691E-01	2.534E+02
2143	1.264E+04	1.657E-01	2.484E+02
2144	1.264E+04	1.624E-01	2.435E+02
2145	1.264E+04	1.592E-01	2.386E+02
2146	1.264E+04	1.561E-01	2.339E+02
2147	1.264E+04	1.530E-01	2.293E+02
2148	1.264E+04	1.499E-01	2.247E+02

Source: S:\PROJECTS\9372TA73\SOILGAS\LANDGEM\SECT1-LO50.PRM

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Model Parameters

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Lo : 50.00 m^3 / Mg ***** User Mode Selection *****

k : 0.0200 1/yr ***** User Mode Selection *****

NMOC : 4000.00 ppmv ***** User Mode Selection *****

Methane : 55.0000 % volume

Carbon Dioxide : 45.0000 % volume

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Landfill Parameters

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Landfill type : Co-Disposal

Year Opened : 1943 Current Year : 1949 Closure Year: 1949

Capacity : 12637 Mg

Average Acceptance Rate Required from

Current Year to Closure Year : 0.00 Mg/year

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Model Results

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Year	Refuse In Place (Mg)	Carbon Dioxide Emission Rate (Mg/yr)	Carbon Dioxide Emission Rate (Cubic m/yr)
1944	2.106E+03	3.154E+00	1.723E+03
1945	4.212E+03	6.246E+00	3.412E+03

1946	6.319E+03	9.277E+00	5.068E+03
1947	8.425E+03	1.225E+01	6.691E+03
1948	1.053E+04	1.516E+01	8.282E+03
1949	1.264E+04	1.801E+01	9.841E+03
1950	1.264E+04	1.766E+01	9.646E+03
1951	1.264E+04	1.731E+01	9.455E+03
1952	1.264E+04	1.696E+01	9.268E+03
1953	1.264E+04	1.663E+01	9.084E+03
1954	1.264E+04	1.630E+01	8.904E+03
1955	1.264E+04	1.598E+01	8.728E+03
1956	1.264E+04	1.566E+01	8.555E+03
1957	1.264E+04	1.535E+01	8.386E+03
1958	1.264E+04	1.505E+01	8.220E+03
1959	1.264E+04	1.475E+01	8.057E+03
1960	1.264E+04	1.446E+01	7.897E+03
1961	1.264E+04	1.417E+01	7.741E+03
1962	1.264E+04	1.389E+01	7.588E+03
1963	1.264E+04	1.361E+01	7.438E+03
1964	1.264E+04	1.334E+01	7.290E+03
1965	1.264E+04	1.308E+01	7.146E+03
1966	1.264E+04	1.282E+01	7.004E+03
1967	1.264E+04	1.257E+01	6.866E+03
1968	1.264E+04	1.232E+01	6.730E+03

1969	1.264E+04	1.207E+01	6.597E+03
1970	1.264E+04	1.184E+01	6.466E+03
1971	1.264E+04	1.160E+01	6.338E+03
1972	1.264E+04	1.137E+01	6.212E+03
1973	1.264E+04	1.115E+01	6.089E+03
1974	1.264E+04	1.093E+01	5.969E+03
1975	1.264E+04	1.071E+01	5.851E+03
1976	1.264E+04	1.050E+01	5.735E+03
1977	1.264E+04	1.029E+01	5.621E+03
1978	1.264E+04	1.009E+01	5.510E+03
1979	1.264E+04	9.886E+00	5.401E+03
1980	1.264E+04	9.690E+00	5.294E+03
1981	1.264E+04	9.498E+00	5.189E+03
1982	1.264E+04	9.310E+00	5.086E+03
1983	1.264E+04	9.126E+00	4.986E+03
1984	1.264E+04	8.945E+00	4.887E+03
1985	1.264E+04	8.768E+00	4.790E+03
1986	1.264E+04	8.595E+00	4.695E+03
1987	1.264E+04	8.424E+00	4.602E+03
1988	1.264E+04	8.258E+00	4.511E+03
1989	1.264E+04	8.094E+00	4.422E+03
1990	1.264E+04	7.934E+00	4.334E+03
1991	1.264E+04	7.777E+00	4.248E+03

1992	1.264E+04	7.623E+00	4.164E+03
1993	1.264E+04	7.472E+00	4.082E+03
1994	1.264E+04	7.324E+00	4.001E+03
1995	1.264E+04	7.179E+00	3.922E+03
1996	1.264E+04	7.037E+00	3.844E+03
1997	1.264E+04	6.897E+00	3.768E+03
1998	1.264E+04	6.761E+00	3.693E+03
1999	1.264E+04	6.627E+00	3.620E+03
2000	1.264E+04	6.496E+00	3.549E+03
2001	1.264E+04	6.367E+00	3.478E+03
2002	1.264E+04	6.241E+00	3.409E+03
2003	1.264E+04	6.117E+00	3.342E+03
2004	1.264E+04	5.996E+00	3.276E+03
2005	1.264E+04	5.877E+00	3.211E+03
2006	1.264E+04	5.761E+00	3.147E+03
2007	1.264E+04	5.647E+00	3.085E+03
2008	1.264E+04	5.535E+00	3.024E+03
2009	1.264E+04	5.426E+00	2.964E+03
2010	1.264E+04	5.318E+00	2.905E+03
2011	1.264E+04	5.213E+00	2.848E+03
2012	1.264E+04	5.110E+00	2.791E+03
2013	1.264E+04	5.008E+00	2.736E+03
2014	1.264E+04	4.909E+00	2.682E+03

2015	1.264E+04	4.812E+00	2.629E+03
2016	1.264E+04	4.717E+00	2.577E+03
2017	1.264E+04	4.623E+00	2.526E+03
2018	1.264E+04	4.532E+00	2.476E+03
2019	1.264E+04	4.442E+00	2.427E+03
2020	1.264E+04	4.354E+00	2.379E+03
2021	1.264E+04	4.268E+00	2.332E+03
2022	1.264E+04	4.183E+00	2.285E+03
2023	1.264E+04	4.101E+00	2.240E+03
2024	1.264E+04	4.019E+00	2.196E+03
2025	1.264E+04	3.940E+00	2.152E+03
2026	1.264E+04	3.862E+00	2.110E+03
2027	1.264E+04	3.785E+00	2.068E+03
2028	1.264E+04	3.710E+00	2.027E+03
2029	1.264E+04	3.637E+00	1.987E+03
2030	1.264E+04	3.565E+00	1.947E+03
2031	1.264E+04	3.494E+00	1.909E+03
2032	1.264E+04	3.425E+00	1.871E+03
2033	1.264E+04	3.357E+00	1.834E+03
2034	1.264E+04	3.291E+00	1.798E+03
2035	1.264E+04	3.226E+00	1.762E+03
2036	1.264E+04	3.162E+00	1.727E+03
2037	1.264E+04	3.099E+00	1.693E+03

2038	1.264E+04	3.038E+00	1.660E+03
2039	1.264E+04	2.978E+00	1.627E+03
2040	1.264E+04	2.919E+00	1.594E+03
2041	1.264E+04	2.861E+00	1.563E+03
2042	1.264E+04	2.804E+00	1.532E+03
2043	1.264E+04	2.749E+00	1.502E+03
2044	1.264E+04	2.694E+00	1.472E+03
2045	1.264E+04	2.641E+00	1.443E+03
2046	1.264E+04	2.589E+00	1.414E+03
2047	1.264E+04	2.537E+00	1.386E+03
2048	1.264E+04	2.487E+00	1.359E+03
2049	1.264E+04	2.438E+00	1.332E+03
2050	1.264E+04	2.390E+00	1.305E+03
2051	1.264E+04	2.342E+00	1.280E+03
2052	1.264E+04	2.296E+00	1.254E+03
2053	1.264E+04	2.250E+00	1.229E+03
2054	1.264E+04	2.206E+00	1.205E+03
2055	1.264E+04	2.162E+00	1.181E+03
2056	1.264E+04	2.119E+00	1.158E+03
2057	1.264E+04	2.077E+00	1.135E+03
2058	1.264E+04	2.036E+00	1.112E+03
2059	1.264E+04	1.996E+00	1.090E+03
2060	1.264E+04	1.956E+00	1.069E+03

2061	1.264E+04	1.918E+00	1.048E+03
2062	1.264E+04	1.880E+00	1.027E+03
2063	1.264E+04	1.843E+00	1.007E+03
2064	1.264E+04	1.806E+00	9.866E+02
2065	1.264E+04	1.770E+00	9.671E+02
2066	1.264E+04	1.735E+00	9.479E+02
2067	1.264E+04	1.701E+00	9.292E+02
2068	1.264E+04	1.667E+00	9.108E+02
2069	1.264E+04	1.634E+00	8.927E+02
2070	1.264E+04	1.602E+00	8.751E+02
2071	1.264E+04	1.570E+00	8.577E+02
2072	1.264E+04	1.539E+00	8.408E+02
2073	1.264E+04	1.509E+00	8.241E+02
2074	1.264E+04	1.479E+00	8.078E+02
2075	1.264E+04	1.449E+00	7.918E+02
2076	1.264E+04	1.421E+00	7.761E+02
2077	1.264E+04	1.393E+00	7.607E+02
2078	1.264E+04	1.365E+00	7.457E+02
2079	1.264E+04	1.338E+00	7.309E+02
2080	1.264E+04	1.311E+00	7.164E+02
2081	1.264E+04	1.285E+00	7.023E+02
2082	1.264E+04	1.260E+00	6.883E+02
2083	1.264E+04	1.235E+00	6.747E+02

2084	1.264E+04	1.211E+00	6.614E+02
2085	1.264E+04	1.187E+00	6.483E+02
2086	1.264E+04	1.163E+00	6.354E+02
2087	1.264E+04	1.140E+00	6.228E+02
2088	1.264E+04	1.118E+00	6.105E+02
2089	1.264E+04	1.095E+00	5.984E+02
2090	1.264E+04	1.074E+00	5.866E+02
2091	1.264E+04	1.052E+00	5.750E+02
2092	1.264E+04	1.032E+00	5.636E+02
2093	1.264E+04	1.011E+00	5.524E+02
2094	1.264E+04	9.912E-01	5.415E+02
2095	1.264E+04	9.715E-01	5.308E+02
2096	1.264E+04	9.523E-01	5.202E+02
2097	1.264E+04	9.334E-01	5.099E+02
2098	1.264E+04	9.150E-01	4.998E+02
2099	1.264E+04	8.968E-01	4.899E+02
2100	1.264E+04	8.791E-01	4.802E+02
2101	1.264E+04	8.617E-01	4.707E+02
2102	1.264E+04	8.446E-01	4.614E+02
2103	1.264E+04	8.279E-01	4.523E+02
2104	1.264E+04	8.115E-01	4.433E+02
2105	1.264E+04	7.954E-01	4.345E+02
2106	1.264E+04	7.797E-01	4.259E+02

2107	1.264E+04	7.642E-01	4.175E+02
2108	1.264E+04	7.491E-01	4.092E+02
2109	1.264E+04	7.343E-01	4.011E+02
2110	1.264E+04	7.197E-01	3.932E+02
2111	1.264E+04	7.055E-01	3.854E+02
2112	1.264E+04	6.915E-01	3.778E+02
2113	1.264E+04	6.778E-01	3.703E+02
2114	1.264E+04	6.644E-01	3.630E+02
2115	1.264E+04	6.512E-01	3.558E+02
2116	1.264E+04	6.383E-01	3.487E+02
2117	1.264E+04	6.257E-01	3.418E+02
2118	1.264E+04	6.133E-01	3.351E+02
2119	1.264E+04	6.012E-01	3.284E+02
2120	1.264E+04	5.893E-01	3.219E+02
2121	1.264E+04	5.776E-01	3.155E+02
2122	1.264E+04	5.662E-01	3.093E+02
2123	1.264E+04	5.550E-01	3.032E+02
2124	1.264E+04	5.440E-01	2.972E+02
2125	1.264E+04	5.332E-01	2.913E+02
2126	1.264E+04	5.226E-01	2.855E+02
2127	1.264E+04	5.123E-01	2.799E+02
2128	1.264E+04	5.021E-01	2.743E+02
2129	1.264E+04	4.922E-01	2.689E+02

2130	1.264E+04	4.825E-01	2.636E+02
2131	1.264E+04	4.729E-01	2.583E+02
2132	1.264E+04	4.635E-01	2.532E+02
2133	1.264E+04	4.544E-01	2.482E+02
2134	1.264E+04	4.454E-01	2.433E+02
2135	1.264E+04	4.365E-01	2.385E+02
2136	1.264E+04	4.279E-01	2.338E+02
2137	1.264E+04	4.194E-01	2.291E+02
2138	1.264E+04	4.111E-01	2.246E+02
2139	1.264E+04	4.030E-01	2.201E+02
2140	1.264E+04	3.950E-01	2.158E+02
2141	1.264E+04	3.872E-01	2.115E+02
2142	1.264E+04	3.795E-01	2.073E+02
2143	1.264E+04	3.720E-01	2.032E+02
2144	1.264E+04	3.646E-01	1.992E+02
2145	1.264E+04	3.574E-01	1.953E+02
2146	1.264E+04	3.503E-01	1.914E+02
2147	1.264E+04	3.434E-01	1.876E+02
2148	1.264E+04	3.366E-01	1.839E+02

Appendix G

Results of Modeling Runs

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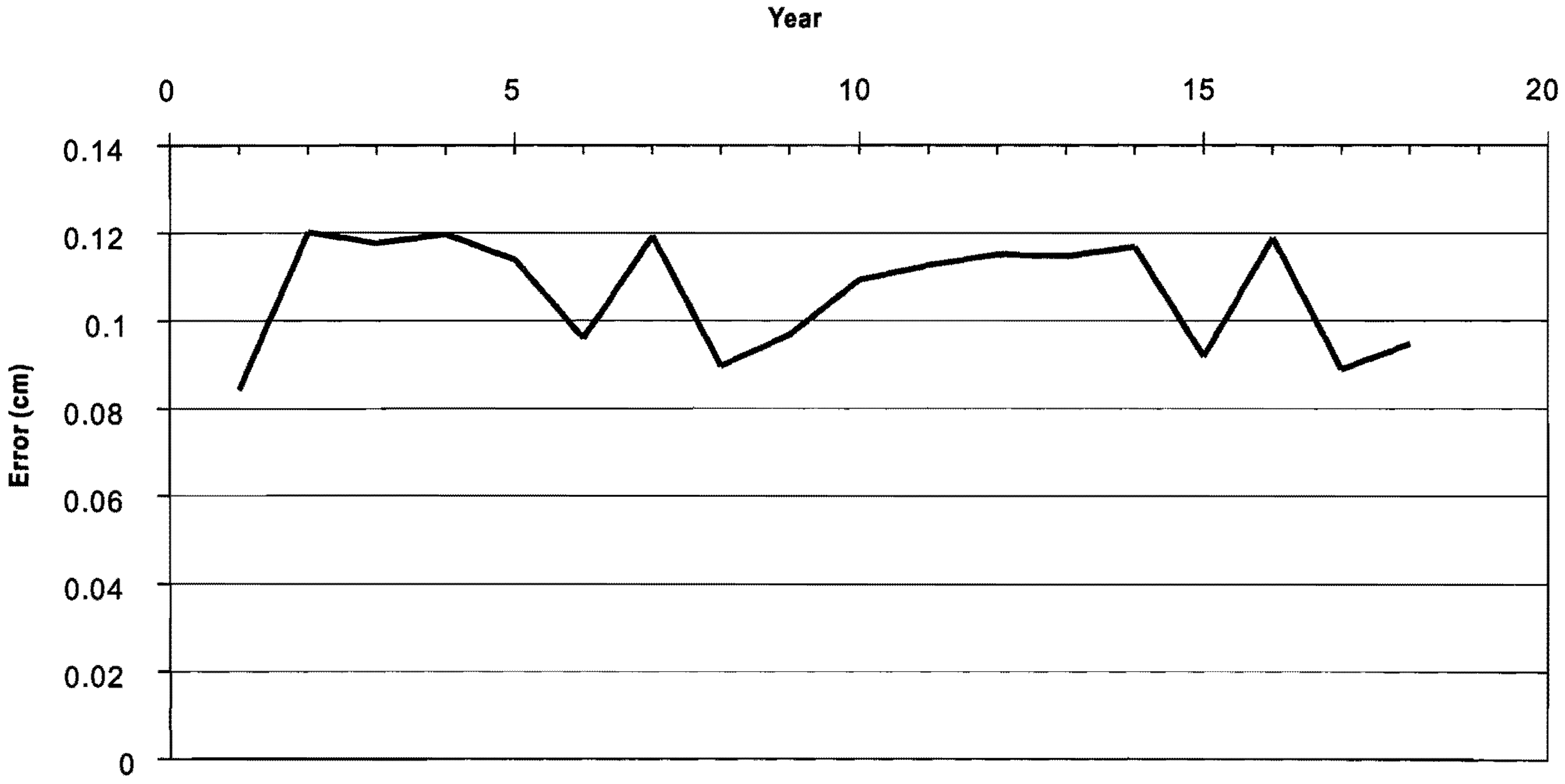

TA-73
Debris Disposal Area Cover Performance (30 cm cover over debris, roots to 30 cm) Mass Balance Error

Figure 1

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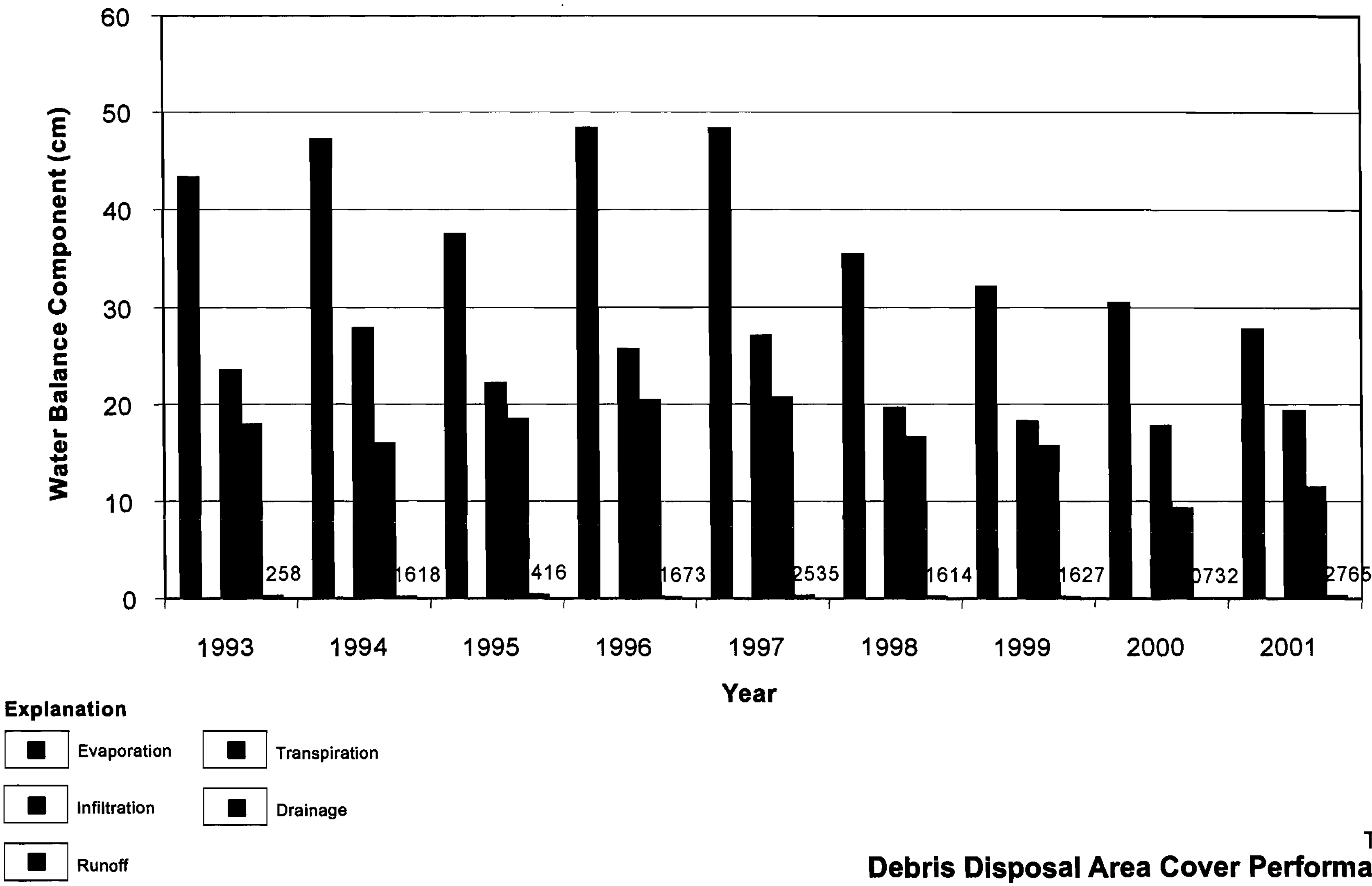

TA-73

Debris Disposal Area Cover Performance (30 cm cover over debris, roots to 30 cm) Water Balance for 1993-2001

Figure 2

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3-14-02 JN 9372

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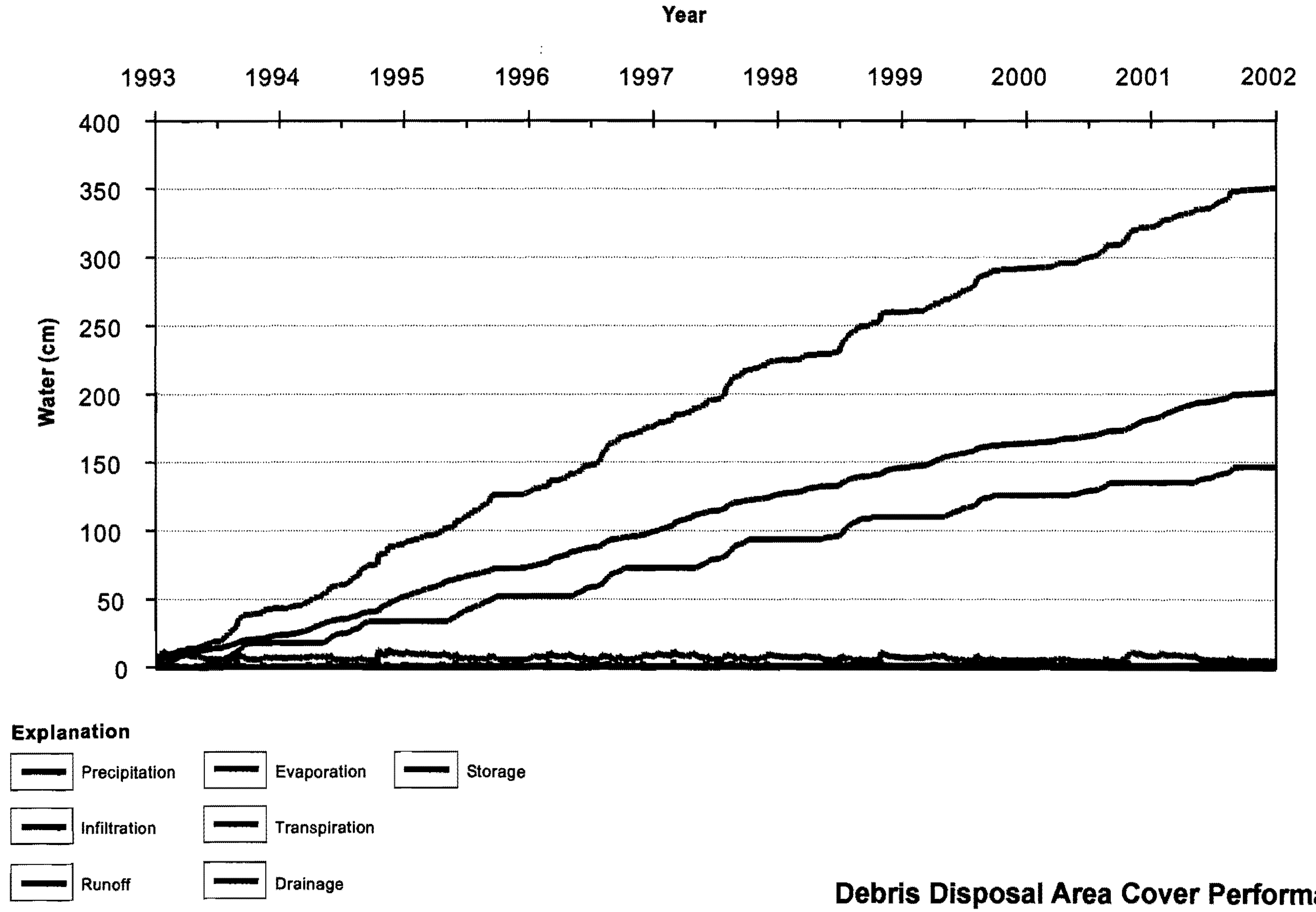


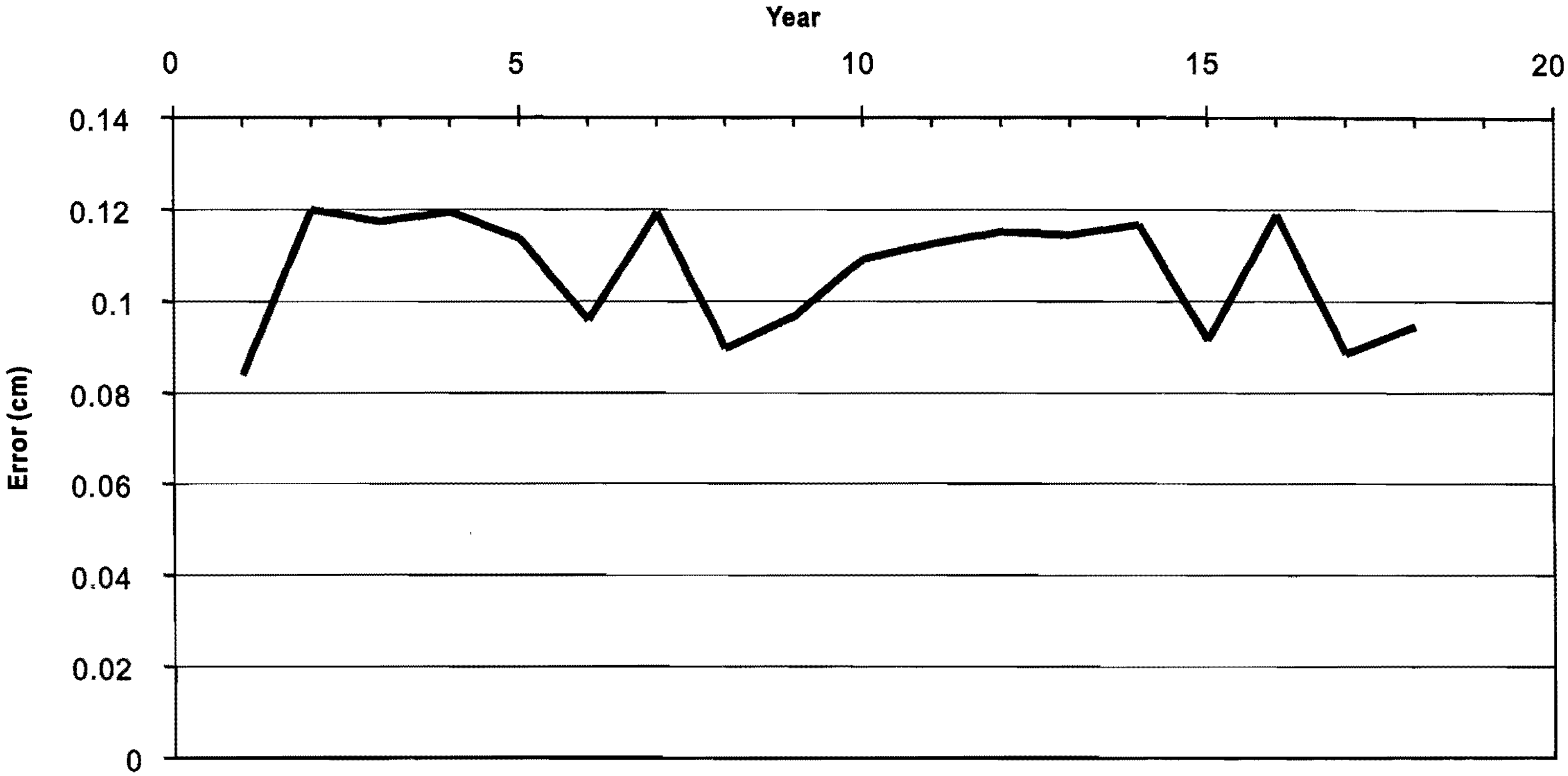
TA-73

Debris Disposal Area Cover Performance (30 cm cover over debris, roots to 30 cm) Water Flow During 1993 to 2001

Figure 3

Daniel B. Stephens & Associates, Inc.

3-14-02 JN 9372



TA-73
Simple Soil Cover Performance
(30 cm cover over debris, roots to 30 cm)
Mass Balance Error

Figure 4

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JN 9372

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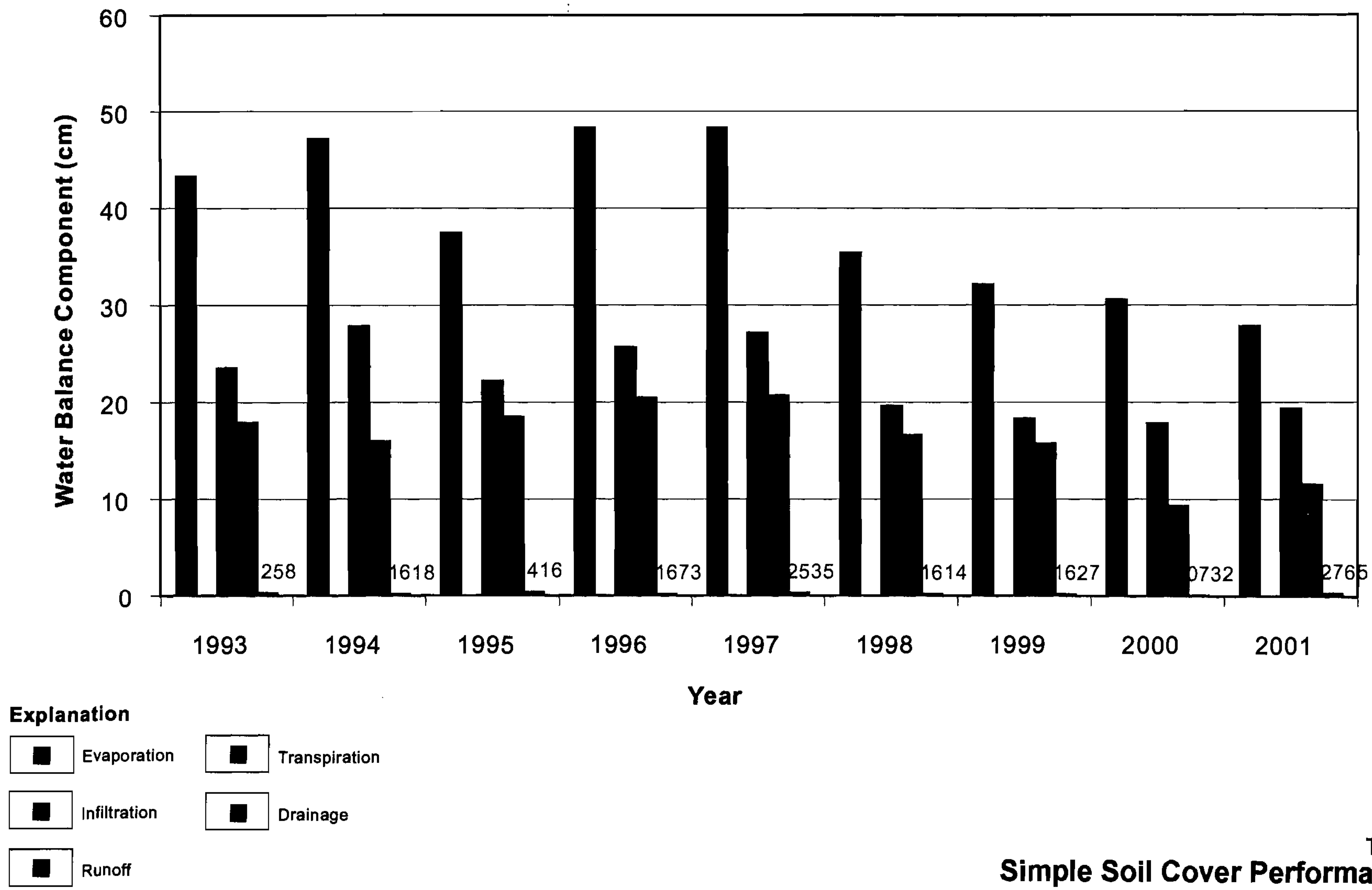

TA-73

Simple Soil Cover Performance
(30 cm cover over debris, roots to 30 cm)
Water Balance for 1993-2001

Figure 5

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3-14-02 JN 9372

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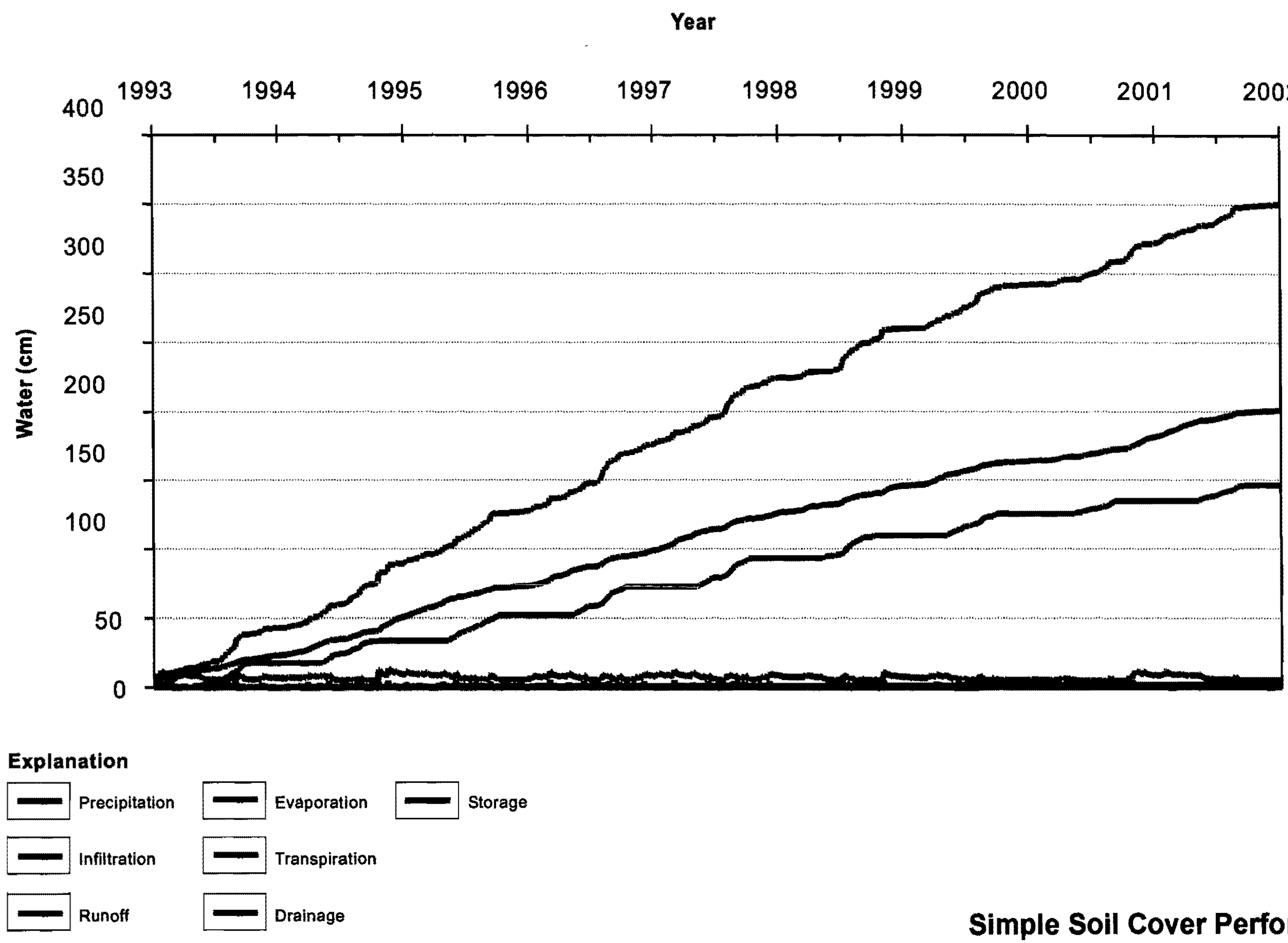

TA-73

Simple Soil Cover Performance
(30 cm cover over debris, roots to 30 cm)
Water Flow During 1993 to 2001

Figure 6

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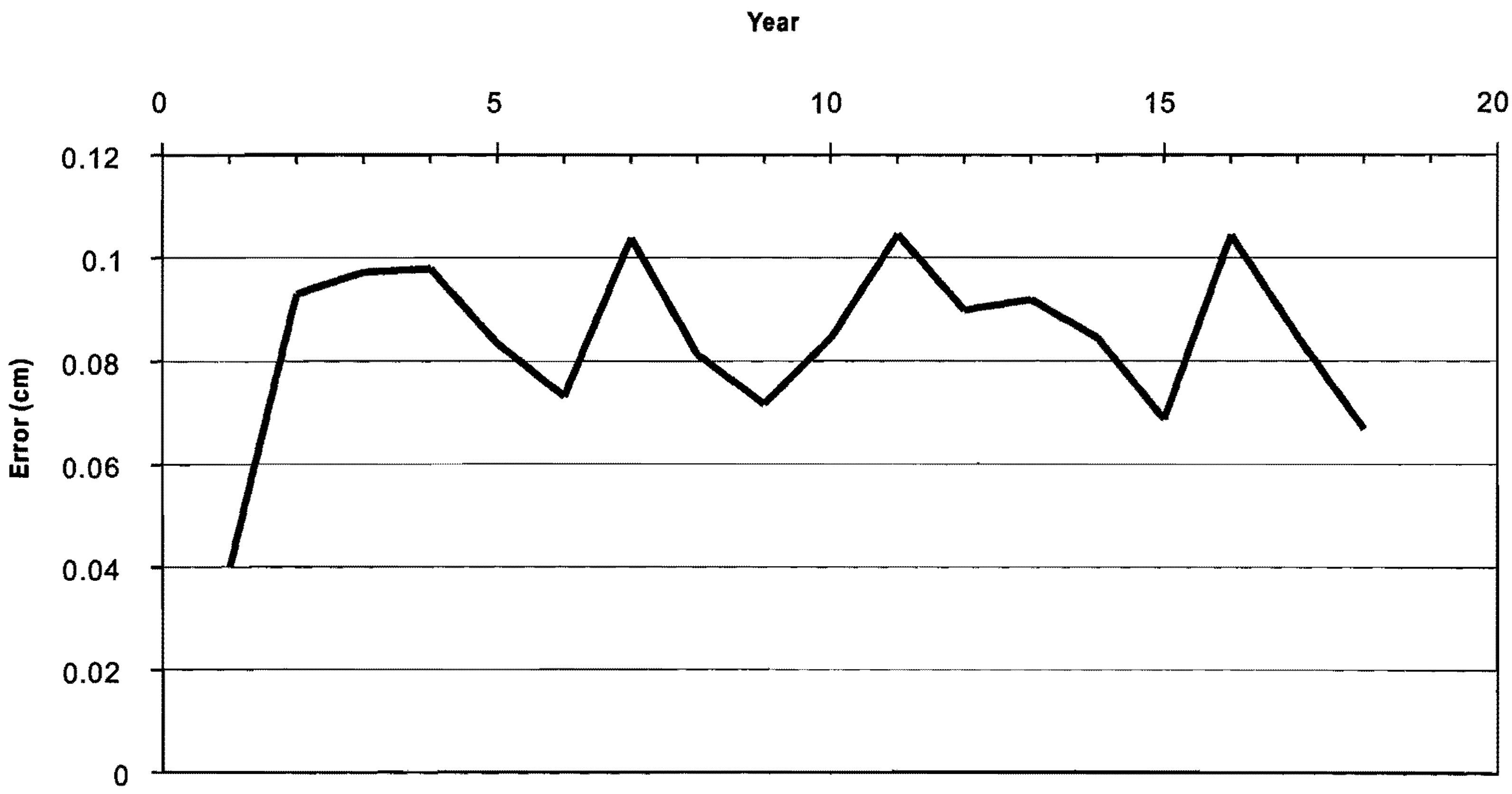

TA-73

Vented Soil Cover Performance
(30 cm soil over 15 cm venting layer, roots to 45 cm)
Mass Balance Error

Figure 7

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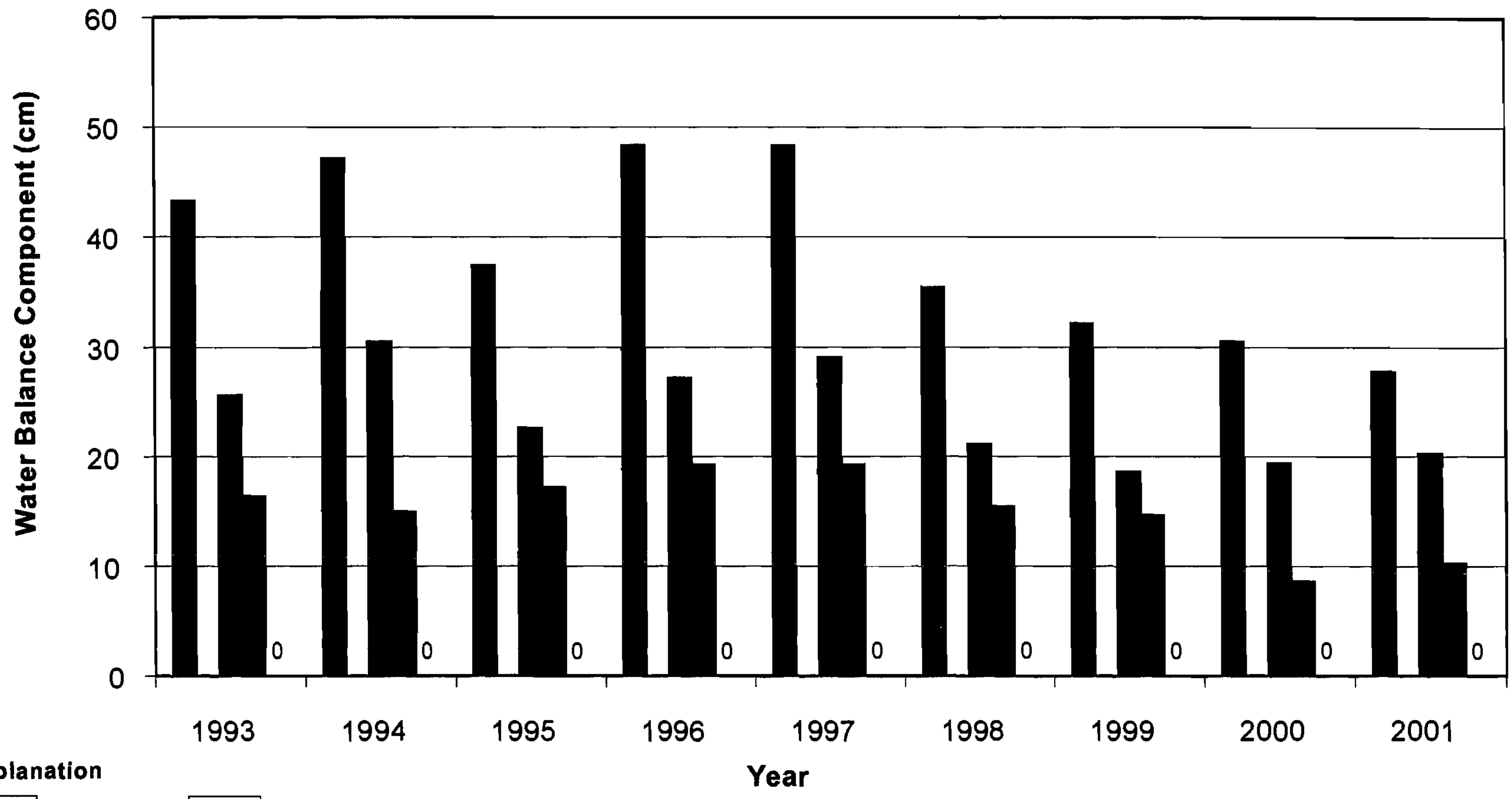

Explanation

- Evaporation
- Transpiration
- Infiltration
- Drainage
- Runoff

TA-73

Vented Soil Cover Performance
(30 cm soil over 15 cm venting layer, roots to 45 cm)
Water Balance for 1993-2001

Figure 8

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3-14-02 JN 9372

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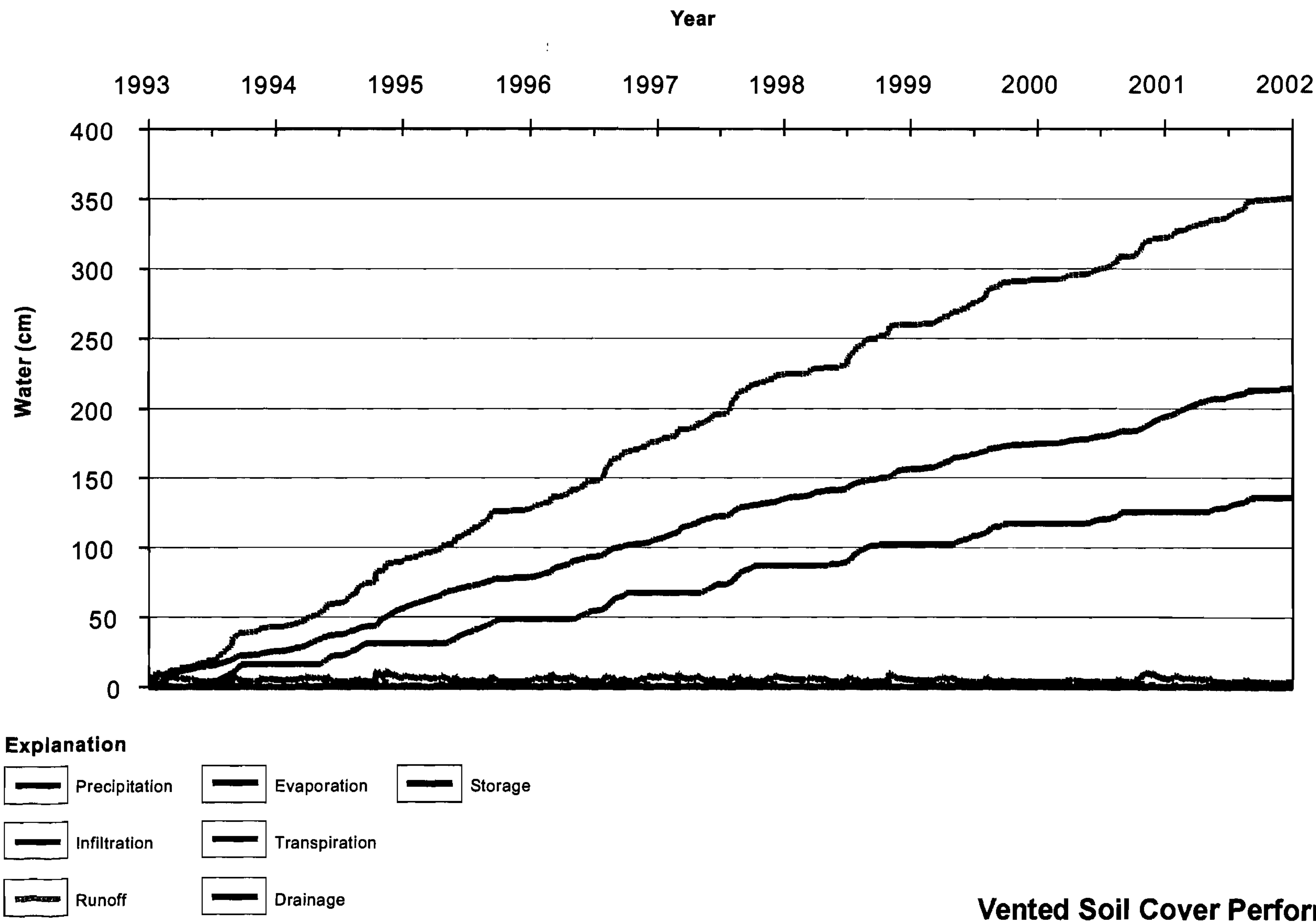


TA-73

Vented Soil Cover Performance
(30 cm soil over 15 cm venting layer, roots to 45 cm)
Water Flow During 1993 to 2001

Daniel B. Stephens & Associates, Inc.
3-14-02 JN 9372

Figure 9

Appendix H

Waste Calculations and Details of Landfill Partitioning,
Methane Generation Potential and
Gas Generation Rate Results,
Active and Dual Active Air Injection Venting System Diagrams

Calculation Cover Sheet

Daniel B. Stephens & Associates, Inc.

Project Name LANL TA-73 Main Landfill   Project Number 9372

Calculation Number 9372-2002-3-001   Discipline Engineering   No. of Sheets 2

PROJECT: LANL

SITE: LANL TA-73 Main Landfill

SUBJECT: Calculate LFG flowrates from Main Landfill and required air injection rate for soil carburetor

SOURCES OF DATA:

1. LANL RFI Report for Airport Landfill, November 20, 1998.

SOURCES OF FORMULAE & REFERENCES:

EPA Landfill Gas Emissions Model (LandGEM) Version 2.07, August 1997.

☐ Preliminary Calculation   ☒ Final Calculation   Supersedes Calculation No. ________

Rev. No.	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
0	--	SJS	3-4-2002	MEM	4/23/02	MEM	4/23/02

Daniel B. Stephens & Associates, Inc.

Calculation Sheet

Project No. 9372 | Date 3-4-2002
Subject LFG Flowrates from TA-73 and required air injection rates | Sheet 2 of 2
By SJS | Checked By MEM 4/25/02 | Calculation No. 9372-2002-4-001

1.0 PURPOSE

Calculate LFG flowrates from Main Landfill and required air injection rate for soil carburetor.

2.0 METHOD

1. Use a site plan map from Reference #1 and divide the landfill into 5 sections of equal area.

2. Use cross-sections from reference #1 to estimate and average waste depth for each section.

3. Multiply average waste depth by area to come up with a waste volume for each section (subtract 20% of volume as daily and intermediate soil cover).

4. Covert waste volumes to waste mass (assume an in-place waste density of 1000 lb/yd^3).

5. Input waste masses into LandGEM for estimation of current landfill gas generation rates (use operating years from Reference #1 (1943-June 30, 1973) and assign approximately 6 years of operation to each section of waste assuming section 1 is the oldest and section 5 is the youngest.

6. Assign methane generation rate constants (k) of 0.02/year to each section (this value is used for areas experiencing less than 25 inches of rainfall per year.

7. Assign ultimate methane generation potential values of 50 m^3/Mg to sections 1 through 3 and values of 100 m^3/Mg. Sections 1 through 3 were assigned a lower number because Reference #1 stated that waste was burned on a regular basis between the years of approximately 1943 through 1965 (sections 1 through 3 were assumed to have operated during those years). Because the waste was burned, it is assumed that the combustion process greatly decreased its methane production potential.

8. LandGEM was run for methane and carbon dioxide for each section and the gases were added together in an Excel spreadsheet to calculate total LFG generation.

9. Methane and total LFG generation rates were then converted to gas fluxes and velocities and the required air to combust the methane in a soil carburetor was calculated.

3.0 SOLUTION

Daniel B. Stephens & Associates, Inc.

Project Name ______ Project Number ______ Date ______

Subject ______ Sheet ______ of ______

By ______ Checked By ______ Calculation No. ______

Waste Volumes

Waste were estimated by dividing the entire landfill area in five individual sections of equal area. Then cross-sections were used to estimate the average waste depth for each of the five sections. Finally, the average depths were multiplied by the section area to get the waste volume for each section.

Section	Section length	Section width	Avg Waste Depth	Waste Volume (ft³)	Waste Volume yd³
Area 1	418 ft	225 ft	10 ft[1]	940500	34,833
Area 2	436 ft	225 ft	15 ft[2]	1471500	54,500
Area 3	445 ft	225 ft	25 ft[3]	2503125	92,708
Area 4	455 ft	225 ft	43 ft[4]	4402125	163,042
Area 5	460 ft	225 ft	50 ft[5]	5175000	191,667
				Total	536,750 yd³

Notes:
1. Waste depth is average depth of Area 1
2. Waste depth is average depth of cross-section A-A'
3. Waste depth is average depth of cross-sections A-A' and B-B'
4. " " B-B' and C-C'
5. " " C-C' and D-D'

Because landfills typically possess about 20% of their volume as daily cover and intermediate cover (old landfills sometimes have even more than 30%); we subtracted 20% of the waste volume from each section.

Calculation Sheet

Daniel B. Stephens & Associates, Inc.

Project Name ______ Project Number ______ Date ______

Subject ______ Sheet ______ of ______

By ______ Checked By ______ Calculation No. ______

Section	Waste Volume yd³	Daily Cover + Intermediate Cover (20%)	Corrected Waste Volume yd³
Area 1	34,833	-6,967	27,866
Area 2	54,500	-10,900	43,600
Area 3	92,708	-18,542	74,166
Area 4	163,042	-32,608	130,434
Area 5	191,667	-38,333	153,334
			Total = 429,400

Next the corrected waste volumes were converted to waste mass by applying an in-place waste density of 1000 lb/yd³ or 0.5 tons/yd³. Then the waste mass values were converted to Mg by applying the following conversion factor:
1 ton = 0.907 Mg

Section	Waste Volume (yd³)	Waste mass (tons)	Waste mass (Mg)
Area 1	27,866	13,933	12,637
Area 2	43,600	21,800	19,773
Area 3	74,166	37,083	33,634
Area 4	130,434	65,217	59,152
Area 5	153,334	76,667	69,537

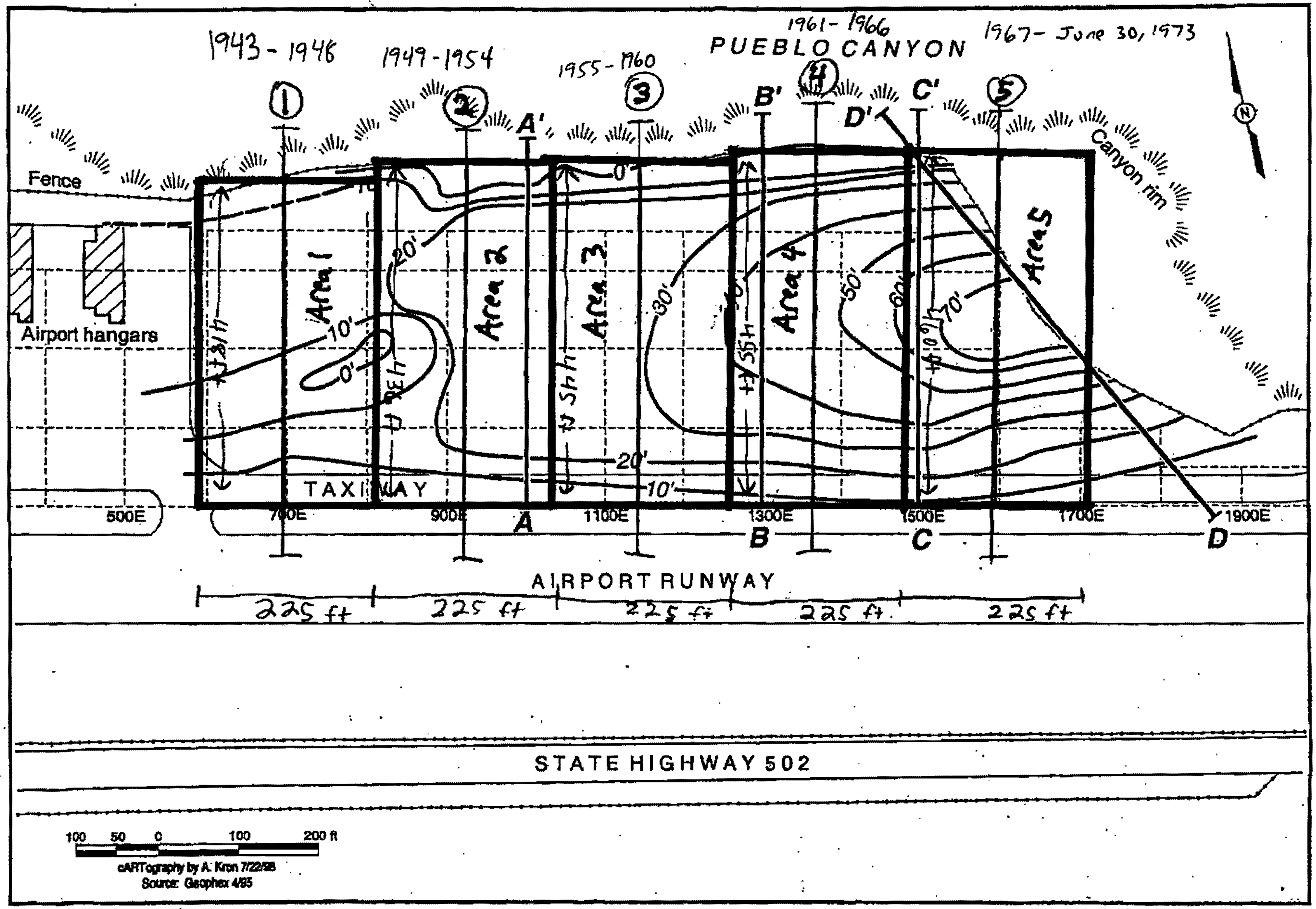


Figure 2.3.4.2-1. Isopachmap of landfill thickness and locations of cross-sections A–A', B–B', C–C', D–D'.

RFI Report

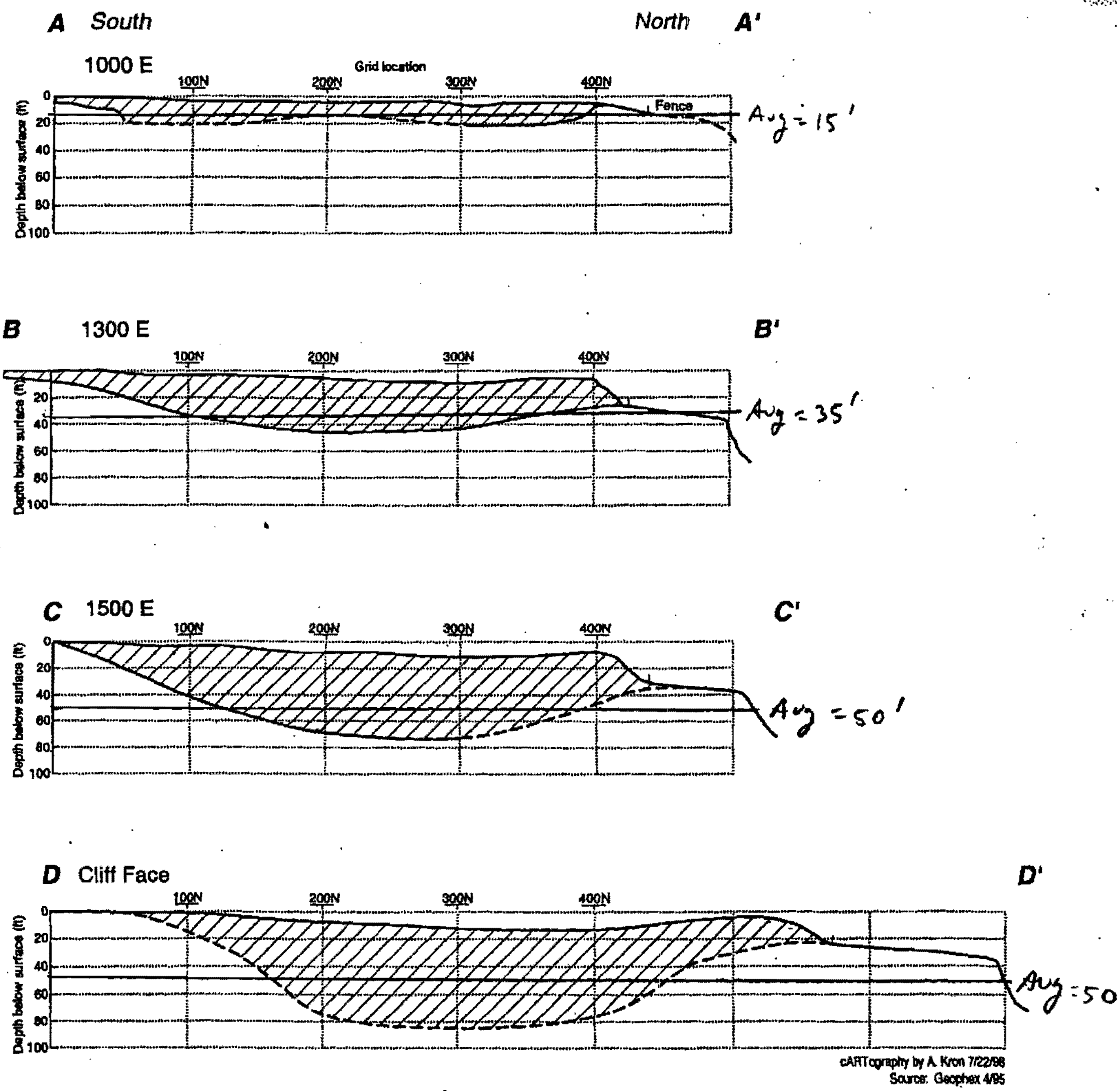


Figure 2.3.4.2-2. Four cross-sections of the landfill structure

Figure 1
Methane Gas Generation at the Main Landfill
Los Alamos National Laboratory TA-73

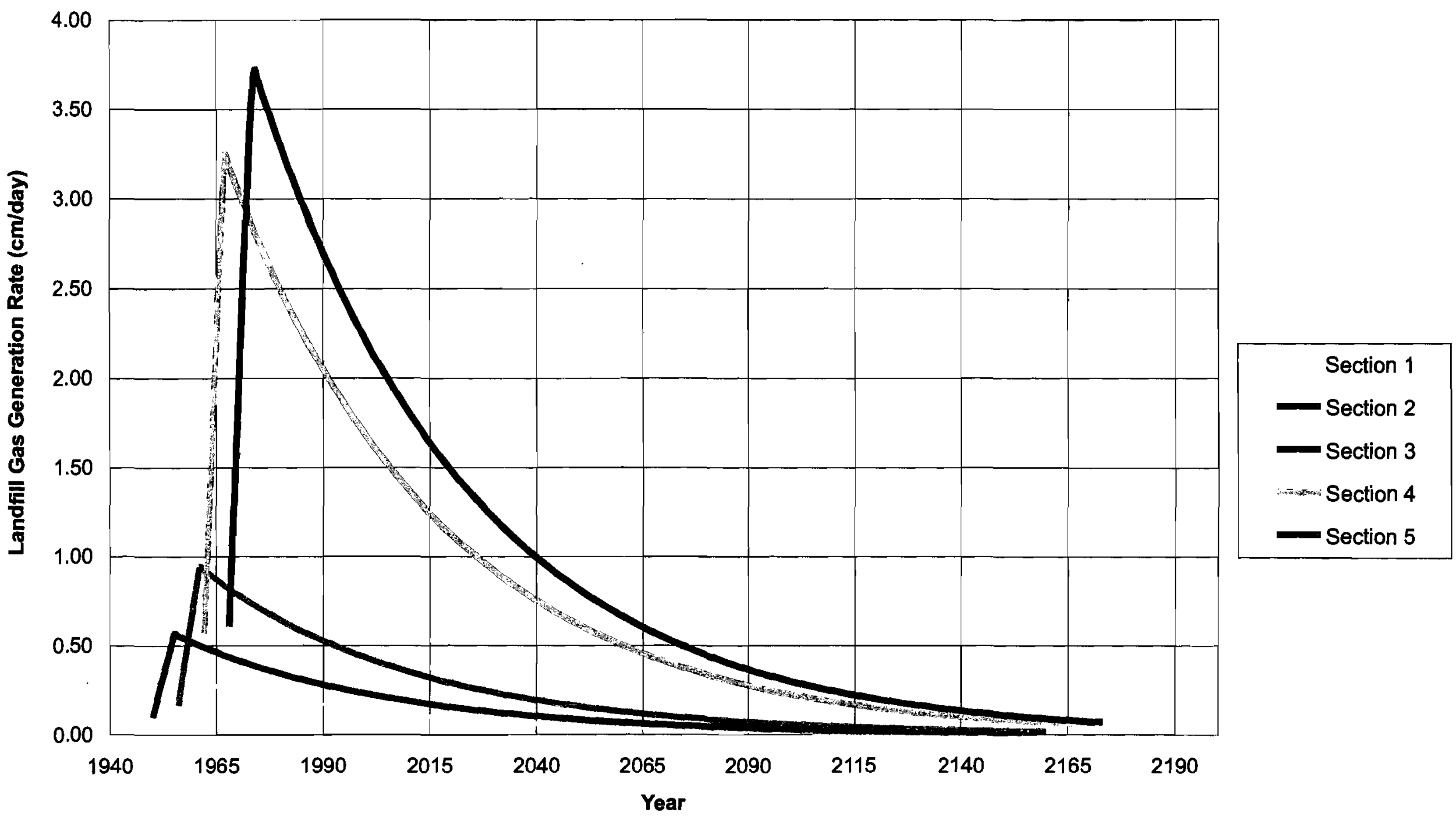


Figure 2
Total Landfill Gas Generation at the Main Landfill
Los Alamos National Laboratory TA-73

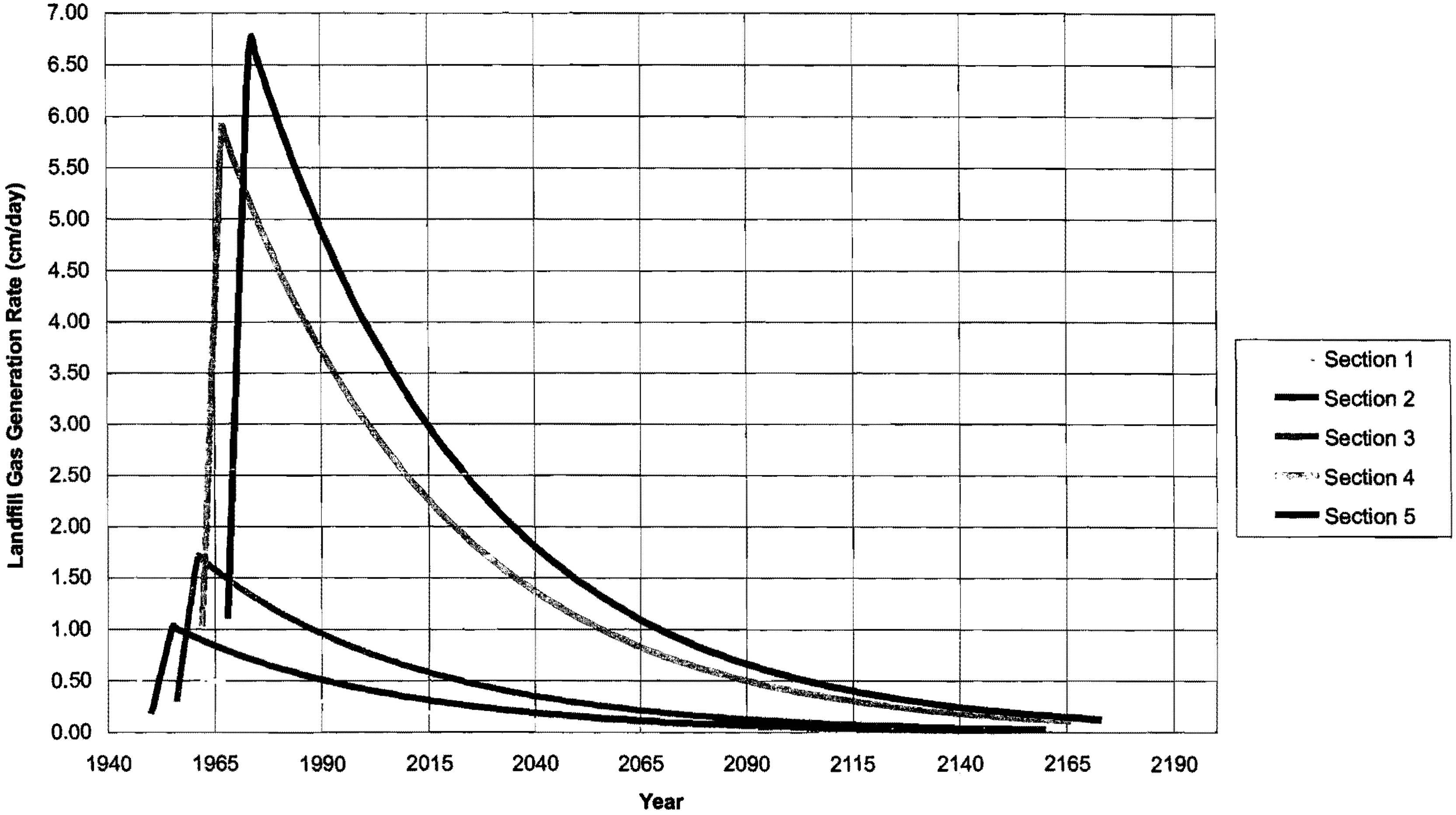
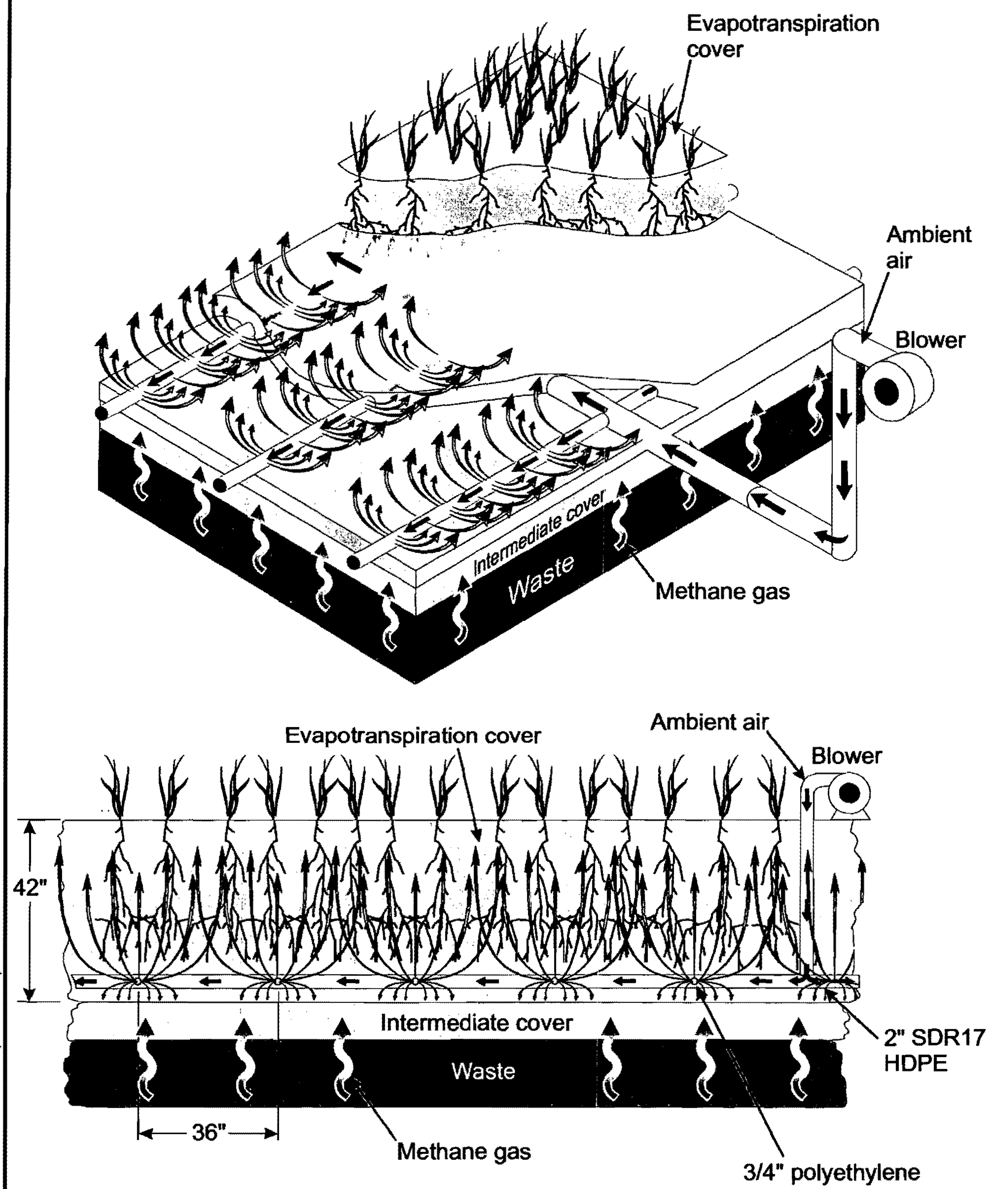


Table 1
2002 Methane Gas Flux/Velocity and Required Air Injection for Combustion
LANL TA-73 Main Landfill

Section	Area (ft)	2002 Methane Generation Rate (ft^3/min)	2002 Methane Gas Flux ($ft^3/min/ft^2$)	2002 Methane Gas Velocity		2002 Total LFG Generation Rate (ft^3/min)	2002 Total LFG Flux ($ft^3/ft^2/min$)	2002 Total LFG Velocity		2002 Required Air Flowrate[1] (ft3/min)	2002 Required Air Flux ($ft^3/ft^2/min$)	2002 Required Air Flux ($l/m^2/day$)
				ft/min	cm/day			ft/min	cm/day			
Section 1	94,050	0.28	2.98E-06	2.98E-06	1.31E-01	0.509	5.41E-06	5.41E-06	2.38E-01	2.8	2.98E-05	0.11
Section 2	98,100	0.494	5.04E-06	5.04E-06	2.21E-01	0.898	9.15E-06	9.15E-06	4.02E-01	4.94	5.04E-05	0.19
Section 3	100,125	0.947	9.46E-06	9.46E-06	4.15E-01	1.723	1.72E-05	1.72E-05	7.55E-01	9.47	9.46E-05	0.36
Section 4	102,375	3.757	3.67E-05	3.67E-05	1.61E+00	6.830	6.67E-05	6.67E-05	2.93E+00	37.57	3.67E-04	1.39
Section 5	103,500	5.006	4.84E-05	4.84E-05	2.12E+00	9.102	8.79E-05	8.79E-05	3.86E+00	50.06	4.84E-04	1.83
Total	**498,150**	**10.484**	--	--	--	**19.062**	--	--	--	**104.84**	--	--

[1]Methane combustion requires two parts oxygen for each part methane, ambient air is 20% oxygen.



LANL TA-73
Active Air Injection System

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2-25-02 JN 9372

Figure 3

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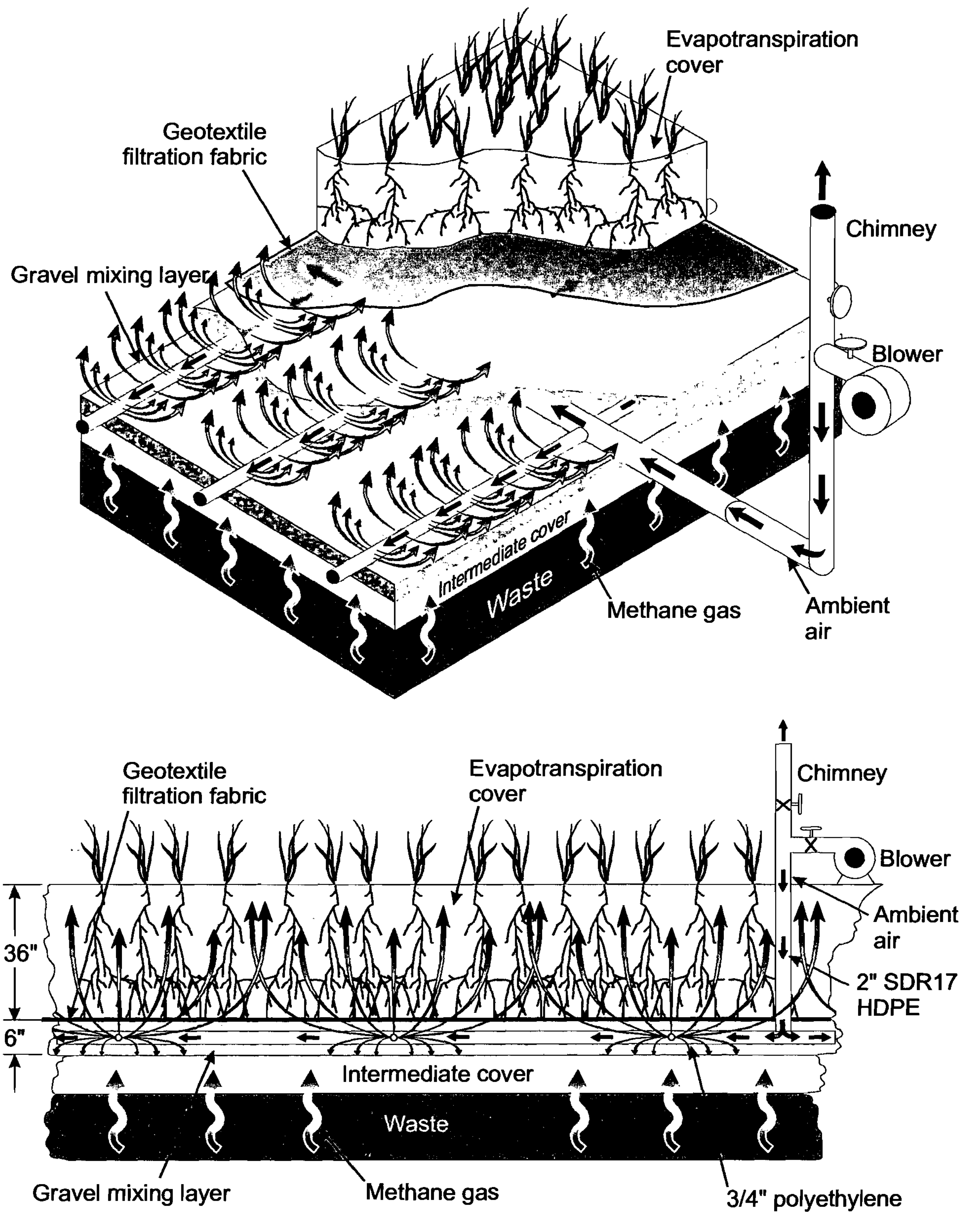

LANL TA-73

Dual Air Injection/Wind Venting System

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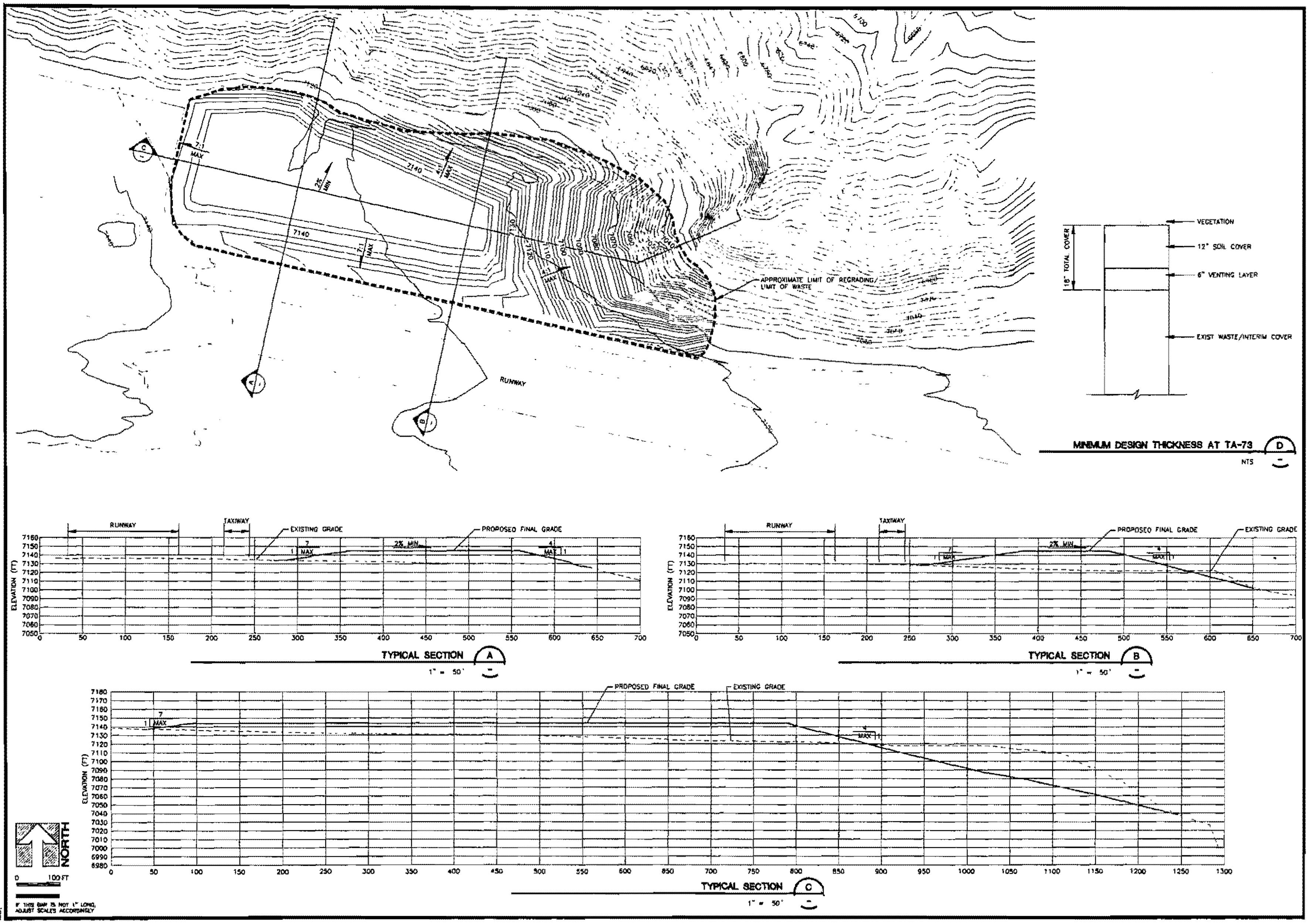
2-25-02 JN 9372

Figure 4

VDR\0-VDR-PROJECTS\9372\937202W.CDR (PAGE 1 OF 2)

Appendix I

Regrading Calculations



LANL TA-73 MAIN LANDFILL
LOS ALAMOS, NEW MEXICO

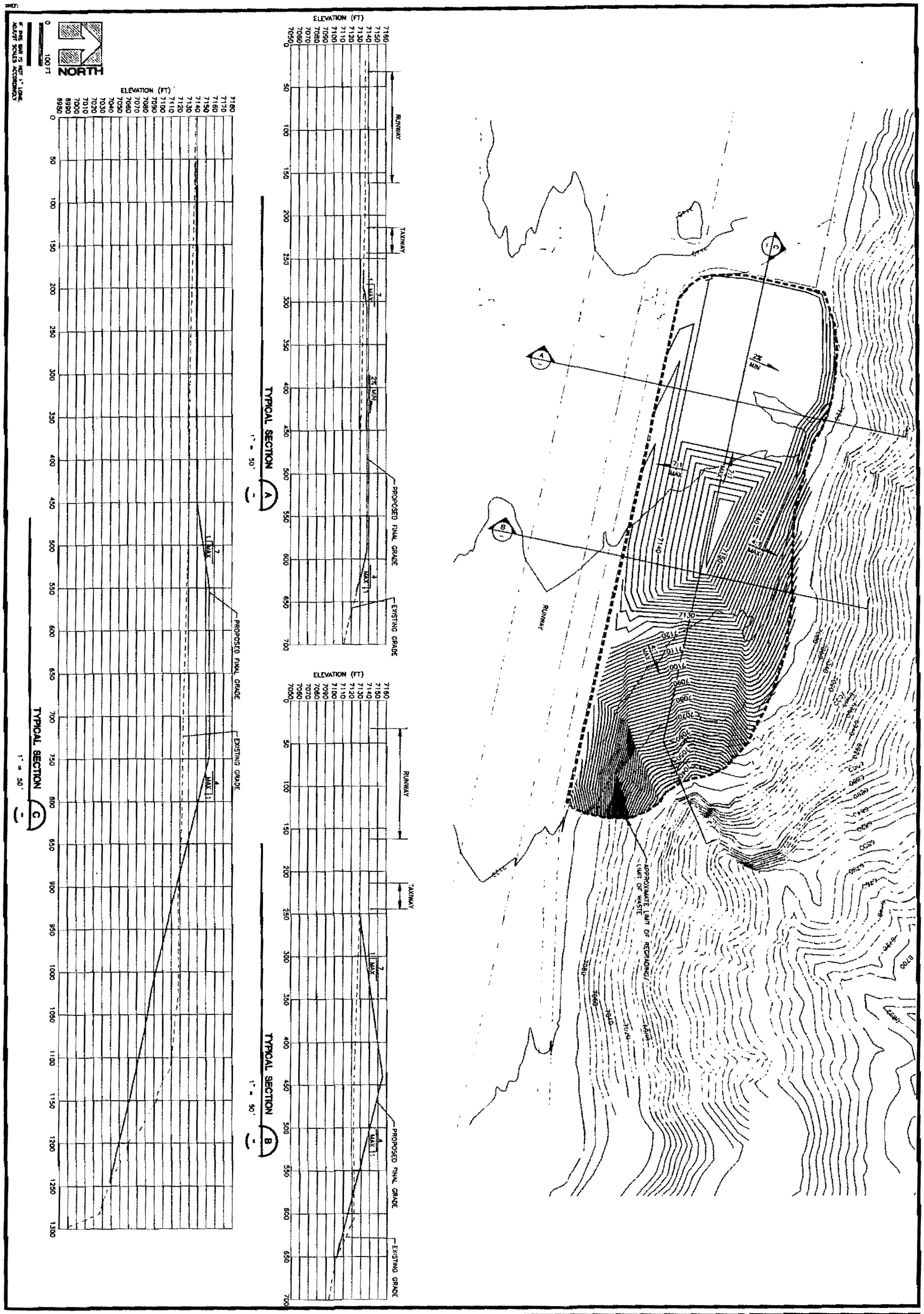
CONCEPTUAL FINAL COVER GRADING PLAN - ALTERNATE 1

Daniel B. Stephens & Associates, Inc.

ENVIRONMENTAL SCIENTISTS & ENGINEERS

JOB NO. 9372

SHEET 1 of 4



SHEET 2 of 4	JOB NO. 9372	LANL TA-73 MAIN LANDFILL LOS ALAMOS, NEW MEXICO **CONCEPTUAL FINAL COVER** **GRADING PLAN - ALTERNATE 2**	DESIGNED BY: CMA DRAWN BY: KDD CHECKED BY: MCM DATE: 3/01/02	*Daniel B. Stephens & Associates, Inc.* ENVIRONMENTAL SCIENTISTS & ENGINEERS 6020 ACADEMY NE, SUITE 100 ALBUQUERQUE, NM 87109 (505) 822-9400	

NO	DATE	BY	REVISION MADE
0	2/20/02	CMA	ISSUED FOR DISCUSSION
1	3/01/02	CMA	DRAFT

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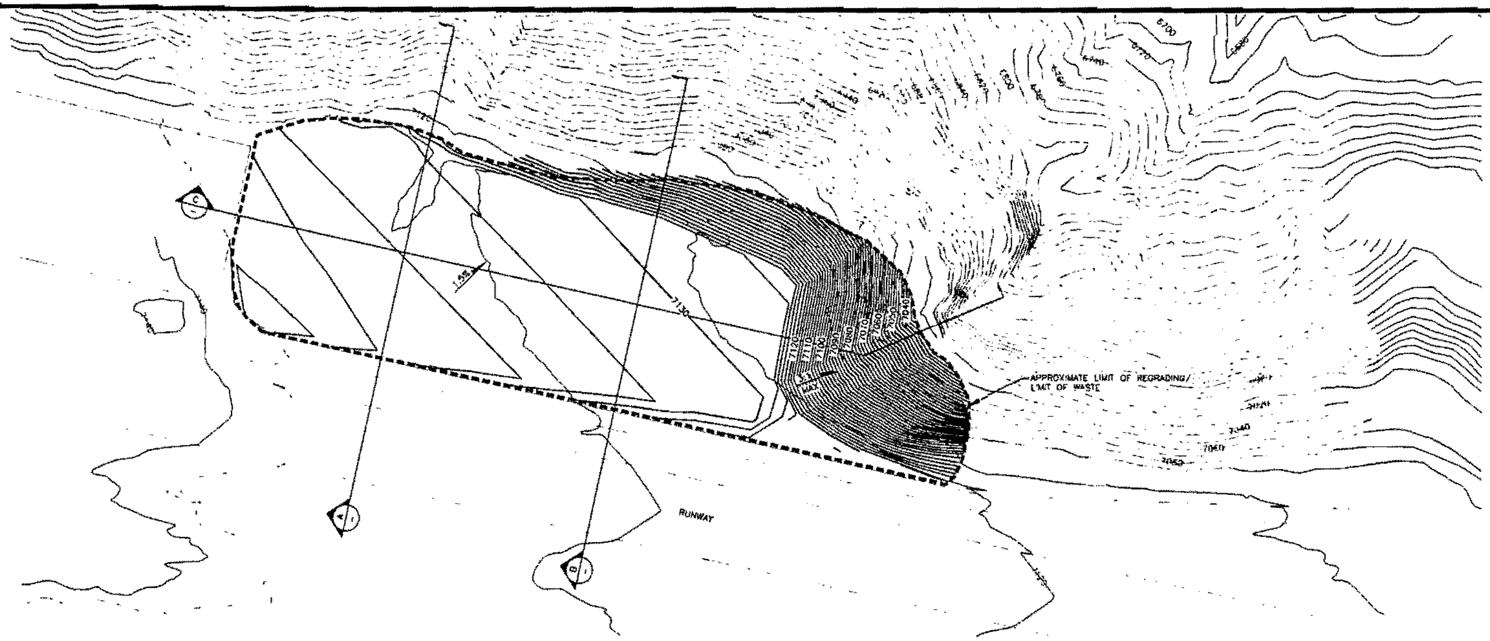

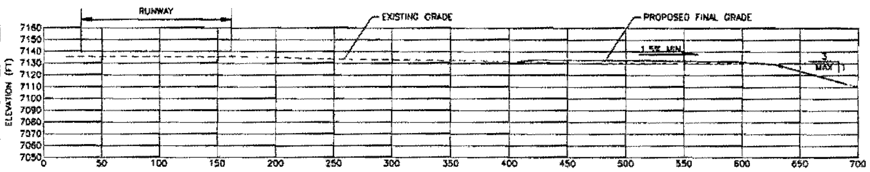

TYPICAL SECTION A

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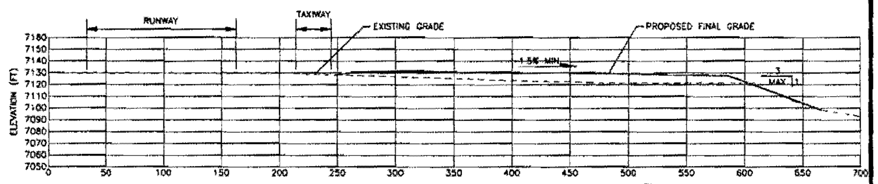

TYPICAL SECTION B

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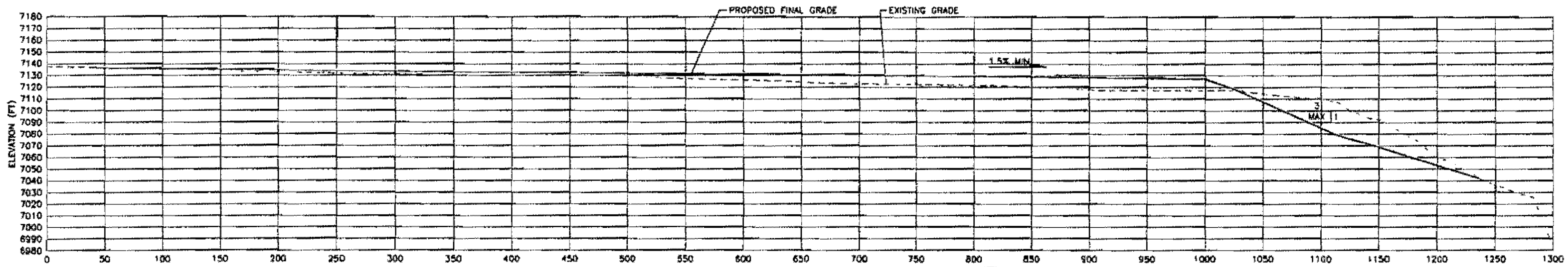

TYPICAL SECTION C

1" = 50'

NORTH

0 100 FT

IF THIS BAR IS NOT 1" LONG, ADJUST SCALES ACCORDINGLY

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1	3/01/02	DWA	DRAFT

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DESIGNED BY: DWA

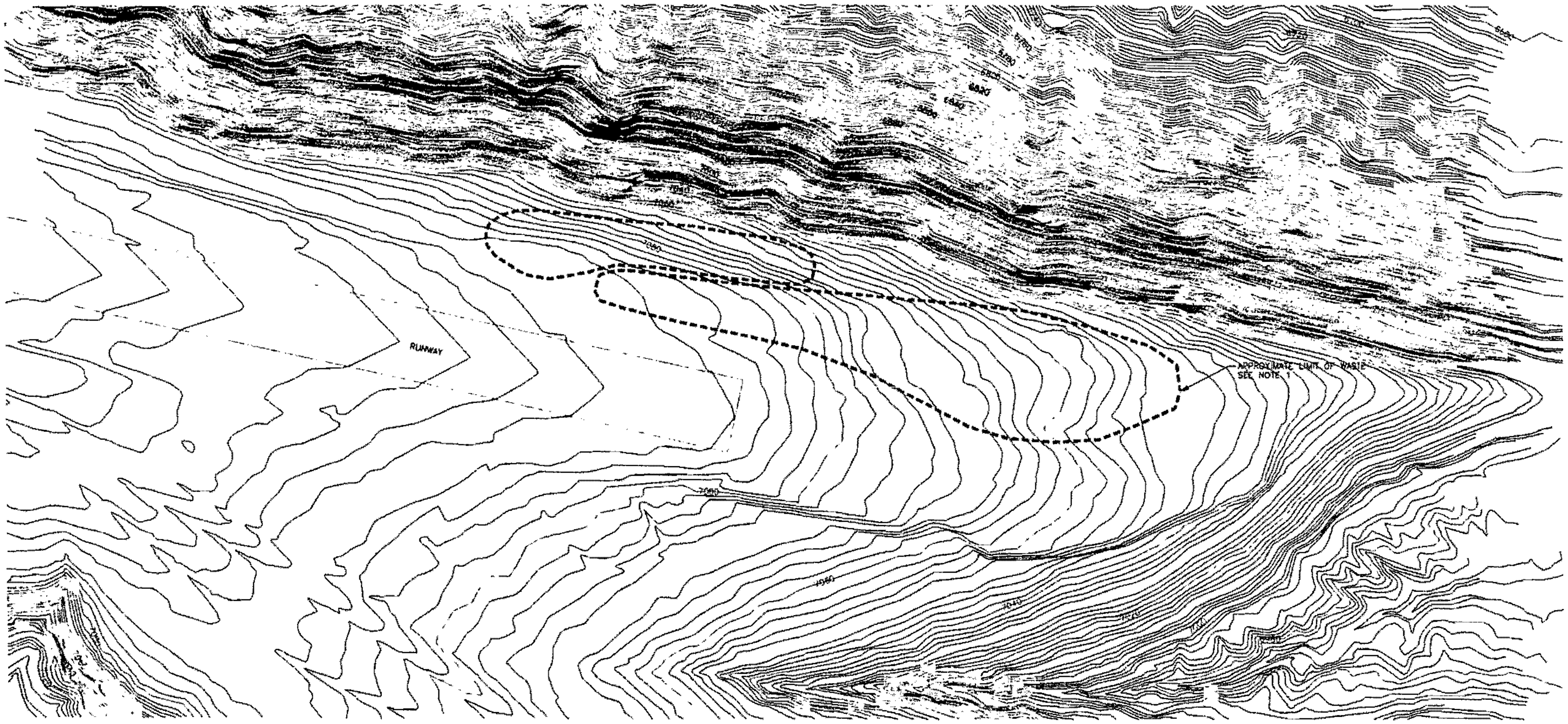
DATE: 3/01/02

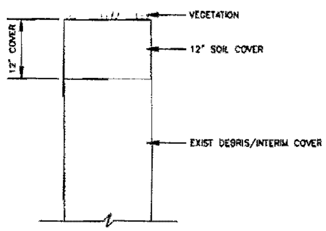
LANL TA-73 MAIN LANDFILL
LOS ALAMOS, NEW MEXICO

CONCEPTUAL FINAL COVER GRADING PLAN - ALTERNATE 3

JOB NO. 9372

SHEET 3 of 4





MINIMUM DESIGN THICKNESS AT DDA (A/1) NTS

NOTES:

1. FINAL GRADE CONTOURS WILL BE VERY SIMILAR TO EXISTING CONTOURS.

NORTH

0 100 FT

IF THIS BAR IS NOT 1" LONG, ADJUST SCALES ACCORDINGLY

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(505) 822-9400

DESIGNED BY: CMA
DRAWN BY: KDB
CHECKED BY: MCM
DATE: 3/01/02

LANL TA-73 DEBRIS DISPOSAL AREA
LOS ALAMOS, NEW MEXICO
CONCEPTUAL FINAL COVER SITE PLAN

JOB NO. 9372

SHEET 4 of 4