TA-73

Department of Energy

National Nuclear Security Administration
Los Alamos Site Office
Los Alamos, New Mexico 87544

JUL 30 2004

RECEIVED
JUL 2004

James Bearzi, Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building I
Santa Fe, NM 87505-6303

Dear Mr. Bearzi:

Subject: Response to Notice of Disapproval of Phase II Work Plan for Los Alamos Site Office TA-73 Airport Landfill; Los Alamos National Laboratory NM0890010515; NMED Task LANL-04-007

Attached are two copies of our response to the subject Notice of Deficiency (NOD). This NOD was received by Department of Energy (DOE)/Los Alamos Site Office (LASO) on July 9, 2004. The response is in two parts. The first is a table containing all 26 comments poised in your NOD letter of July 7, 2004, and our responses to 25 of your comments. The second part is a 30-page response to New Mexico Environment Department (NMED) Comment #2, and contains the HELP modeling documentation that was requested during our phone conversation with Dave Cobrain, Nick Schiavo, and Darlene Goering on July 19, 2004. Once DOE has resolved all 26 questions to the satisfaction of NMED, we will incorporate the 26 responses into the text of the Phase II Work Plan and will re-submit a revised Phase II Work Plan to NMED.

Should you have questions, please contact Bob Enz at (505) 667-7640.

Respectfully,

for

David Gregory
Program Manager

OPM:5BE-002

Enclosures
See Page 2

4913

cc w/enclosures:
R. Enz, OPM, LASO
D. Cobrain, NMED, HWB
N. Schiavo, NMED, HWB
D. Goering, NMED, HWB
E. Hansen, NMED, SWB

North Wind

NMED PHASE II WORK PLAN REVIEW COMMENTS AND PROPOSED RESOLUTIONS

JUL 2003

Project Name: LANL Release Sites 73-001(A)-99 and 73-001(B)-99	Document Owner: DOE-LASO.	Phone Number:	Reviewer's Name/Discipline:	Phone No.:
Comments resolved by: Robert Enz, DOE-LASO	E-Mail Address: renz@doeal.gov		Phone Number: (505) 667-7640	
Doc ID:	Document Title: NOTICE OF DISAPPROVAL OF PHASE II WORK PLAN FOR LOS ALAMOS SITE OFFICE TA-73		Rev. No.: DRAFT	

Item No.	Page No./ Section/Zone	Review Comment	Comment Resolution	Acceptance (Initials/Date)
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			Therefore concentrations at the property boundary are not expected to exceed 25% of the LEL in the future."	
4	Comment #4	The Work Plan states that the collection of water samples was attempted at existing monitoring wells in 2001, but insufficient water was collected from the wells for analysis. The Permittees must indicate if the existing wells will continue to be monitored or if new wells will be installed in an attempt to detect landfill leachate. The Permittees must describe how they will monitor for leachate, including collection methods, frequency, and duration.	Comments noted. Section 2.0 of the Post-Closure Care and Monitoring Plan (PCMP) [Appendix D of the Work Plan] states that "The TA-73 landfill does not have dedicated groundwater monitoring wells because the depth to groundwater is over 1200 feet (ft) This statement is based on the RFI Report Section 2.4.4.2 statement that "Groundwater was not encountered beneath the landfill area during this investigation. The greatest vertical depth penetrated in this investigation was 186 feet beneath the ground surface in perimeter borehole LPS-2, and unsaturated conditions were encountered to this depth. All borings drilled within the landfill area encountered unsaturated conditions to a maximum drilled depth of 82 feet below ground surface. No deeper boreholes exist on the mesa-top site, and thus deeper site-specific groundwater occurrences are undefined. Based on depths to water measured in wells located in Pueblo Canyon to the north, and Los Alamos Canyon to the south, the depth to the regional aquifer beneath TA-73 is estimated to be approximately 1260 ft. Based on the fact that saturated conditions have not been encountered beneath the landfill or near it's perimeter in any previous investigation, existing wells will not be monitored further, and no new wells will be constructed. Regarding leachate monitoring, please see the response to Comment No. 2 re: occurrence of leachate cited in the RFI Report. The RFI Report stated that "relatively small amounts of leachate	

			appear to occur at isolated locations beneath the landfill". This was confirmed by the cone penetrometer survey performed subsequent to the RFI Report and summarized in the Site Characterization Report (to be submitted with the revised Phase 2 Work Plan) which found unsaturated conditions based on pore pressures. Saturated conditions indicative of presence of leachate do not appear to occur except sporadically and therefore no efforts will be made to monitor for leachate in the closed landfill.	
5	Comment #5	Appendix A, Hydraulic Calculations section, sheet 3 of 25 shows that analysis using the TR 55 Model was based upon a two-year 24-hour storm event. 40 CFR Section 258.26(a)2 requires that the model be based on a 24-hour, 25-year storm. The Permittees must clarify the number of years upon which the hydraulic analysis was based and resubmit the analysis with the correct storm event information.	Comment incorporated. A 25-year, 24-hour storm was used in the referenced hydraulic calculations to size drainage structures, i.e., channels and pipes, per 40 CFR. A 2-year, 24-hour storm was used in the calculation of shear force on landfill surface as it relates to estimating the erosion of the cap. As far as we are aware, there are no regulatory requirements governing the calculation of erosive forces on landfill surfaces. However for purposes of consistency the 25-yr 24-hr storm event will be used for both purposes.	
6	Comment #6	The Permittees must describe the measures that will be taken to insure the integrity of the landfill cover is not compromised through intrusion by animals, roots, and other biota.	Comment noted. Section 3.1 of the PCMP addresses inspection and repair of animal burrows. Since a native vegetation mix will be applied, plant roots may eventually penetrate the entire cover profile. Undesired invasion by plants, e.g. cheatgrass, is not expected in the 30-year post-closure period if the native plant mix is successful. However if a fire-prone species like cheatgrass became widespread and if a fire occurred, inspection and repair is addressed under Section 3.1 heading "Condition of Vegetation".	
7	Comment #7	Appendix A, Page 02200-5, Paragraph C Earthquake Quality Control specifies that the landfill cover will have a final compaction	Comment noted. Preliminary testing of cover soils showed that the required permeability could	

		Control specifies that the landfill cover will have a final compaction of 98 percent. Discuss the rationale behind a final compaction rate of 98 percent.	soils showed that the required permeability could be achieved with 95% compaction. To be more conservative, and to account for minor variability in the soil, 98% compaction rate was chosen.	
8	Comment #8	Discuss the location of the borrow source for the landfill cover. Identify if the location is proximal to any SWMUs or AOCs and how it will be determined if the fill material is clean. The Permittees must identify where the low permeability soil for the landfill cover will be obtained.	Comments noted/incorporated. The soil borrow source(s) will be identified in the remedy completion report. The location will not be proximal to any SWMUs or AOCs. As stated in the Construction Specifications Section 02200.2.01.A-C, all borrow soils must be environmentally clean. Requirements for certification will be added to the specification.	
9	Comment #9	Section 5.0 Demonstration of Cover Performance, Page 14: This section must respond to the requirement of the NMED Conditional Approval of Voluntary Corrective Measures (VCM) Plan (Conditional Approval Letter dated April 1, 2003) that the Phase II Work Plan contain a demonstration of the cover performance for the life of the cover. Instead this section only references Appendix D (Post-closure Care and Monitoring Plan). The Permittees must revise the Work Plan to satisfy this requirement.	Comment incorporated. Please see the attached response to Comment #2 and HELP3 modeling results.	
10	Comment #10	Appendix A, Drawing Nos. 2006, 2007 and 2008, Page 5-3: These drawing show an approximate location of the 1962 ground surface. The general notes on these drawing indicate that the 1962 surfaces depicted on this drawing should be considered for information only. It is not clear what information the 1962 ground surface provides, since waste was accepted at the Main Landfill before that date. The Permittees must revise these drawings to either explain the pertinent information that these suface lines provide or remove them from the drawings.	Comment incorporated. Note 1 on each of the referenced drawings will be revised to describe the relevance/significance of the 1962 Ground Surface line. The landfill was filled from west to east. Based on historical documentation, i.e., 1962 aerial survey, it appears that the east portion of the landfill was filled in the period between 1962 and when the landfill ceased operation in 1973. The note will contain the following wording: "*Based on historical data, the 1962 surface at the east end of the landfill is anticipated to be the original ground surface prior to landfilling activities and is provided* ***For Information Only***	
11	Comment #11	Appendix A, Hydraulic Calculations, sheet 1 of 25: Paragraph 4 states that each bench was designed as a 10-ft wide triangular channel with a bed slope of 4%, and side slopes of 2.75% and 10%	Comment incorporated. References to slopes will be presented in both percent slope and as H:V.	

		bench slope. The Permittees must clarify if the slopes indicated are the ratio of horizontal (H) to vertical (V) change and not percent slope. Drawing No. 2005 indicates that the side slope of each bench is 2.75 (i.e. 2.75H:1V). The Permittees must correct all references to H:V ratio as percent slope throughout the Work Plan.		
12	Comment #12	Appendix A, Hydraulic Calculations, Drainage Structures Hydraulic Design, sheet 1 of 25: Paragraph 6 indicates that, at a minimum, R-6 rip rap is required for the trapezoidal downchute based on the shear stress level, resulting from the steep slope. However in the supporting documentation provided in Tables 6 and 9, and Figure 3 and 21, a R-5 rip rap is selected for the downchute. The Permittees must reconcile this discrepancy and revise the text, table, and figures, accordingly.	Comment incorporated. The calculations will be reviewed and discrepancies will be resolved.	
13	Comment #13	Appendix A, Hydraulic Calculations, Drainage Structures Hydraulic Design, sheet 7 of 25: For the inlet/outlet control check a design discharge of 5.2 cubic feet per second (cfs) is used. However, the hydraulic calculations conducted for pipe segments 1 and 2 resulted in a maximum discharge of 5.5 cfs in pipe segment 1. The Permittees must clarify why this discharge was not used as the design discharge for the inlet/outlet control check computations.	Comment incorporated. The calculations will be reviewed and revised as needed.	
14	Comment #14	Appendix A, Hydraulic Calculations, Landfill Top Erosion Forces Estimate, sheet 1 of 8: It is indicated that to determine velocities and shear forces generated by the sheet flow atop of the landfill, sheet flow was examined for a 300-ft length of a 3% slope. Using the top of cap grading plan elevations and the scale provided on Drawing No. 2002, the slope atop the landfill appears to be in range of 6% to 8%. The Permittees must reconcile this discrepancy and revise the calculations.	Comment noted. NMED clarified that the comment was generated based on review of reduced-scale drawings. Full-scale drawings were reviewed and the 3% slope inclination confirmed.	
15	Comment #15	Appendix A, Settlement Evaluations, Differential Settlement Evaluation, sheet 2 of 8: The first paragraph states, settlement due to dewatering will also be negligible as no dewatering of the waste mass has been proposed. Furthermore, there is no evidence of a perched water table or leachate mound within the landfill. The Permittees must revise the Work Plan to provide data to support this contention or provide a reference for this determination.	Comment incorporated/noted. The RFI Report for the Airport Landfill (1998) states that no perched water was encountered in the landfill area during the RFI and perched waters are not known with certainty to occur directly beneath the landfill (Section B-4.3.2). Suction lysimeters sampling was performed during the RFI, but limited samples were collected. Additionally, no free water was encountered during the drilling of	

			RFI perimeter boreholes. The RFI Report states that "Relatively small amounts of leachate appear to occur at isolated locations beneath the landfill". This was confirmed by the cone penetrometer survey performed subsequent to the RFI Report and summarized in the Site Characterization Report (to be submitted with the revised Phase 2 Work Plan) which found unsaturated conditions based on pore pressures. Saturated conditions indicative of presence of leachate do not appear to occur except sporadically.	
16	Comment #16	Appendix A, Settlement Evaluations, Differential Settlement Evaluation, sheet 4 of 8: In Table 1, at the bottom of this sheet, the interim cover thickness is given as one foot. The engineering drawings (e.g., Drawing No. 2005) indicate the interim cover thickness as a minimum of 6 inches. The Permittees must clarify if the thickness used in the settlement calculations is the maximum expected or the average thickness of the interim cover.	Comment noted. The thickness of interim cover indicated on the drawings (6 inches) is the minimum required/acceptable thickness of interim cover. A 1-foot interim cover thickness was utilized in the calculation to account for variability in the actual thickness of interim cover that will be placed. In areas that are undisturbed, the interim cover will be comprised of the existing cover soil, which has a thickness in excess of 6 inches. It is anticipated that there will be some variation in the thickness of the interim cover but the impact on settlement or differential settlement will be negligible.	
17	Comment #17	Appendix A, Settlement Evaluations, Differential Settlement Evaluation, sheet 5 of 8: It is indicated on this page that with respect to grid point B5, the existing ground surface elevation is 7132 feet and Figure 1 is referenced for this information. However, the closest elevation point that can be used to approximate the elevation at point B5 is given as 7143 feet on Figure 1. None of the drawings and figures provided clearly depict labeled contour elevations of the existing grade. The Permittees must revise the Work Plan to provide a drawing or a figure that clearly provides the existing ground surface.	Comment incorporated/noted. The calculation will be reviewed and revised as necessary. Please refer to Drawing 2001 in the Work Plan to confirm contour labels. Full-size drawings were also provided as part of the submittal.	

18	Comment #18	Under Conclusions, Sheet 8 of 8: It is stated that due to the anticipated rate of settlement of the landfill and consolidation of the relocated waste due to compaction by construction equipment, it is likely that the final grades shown on the project drawing will not be achieved. The Permittees must revise the Work Plan to provide acceptance criteria for what grades will be acceptable and procedures to follow in the event final grades shown on the drawings are not achieved, or provide in the final work plan submittal an achievable grading plan. The Permittees must provide clear instructions on compaction requirements and permeability specifications of the infiltration barrier layer to the construction contractor.	Comment noted. Due to the nature of this project, i.e., the volume of material to be relocated, the degree of shrinkage or swell of the relocated material and the rate of settlement of the relocated material cannot be precisely determined, therefore it is likely that the final elevations shown on the drawings as "Top of Cap" will not be achieved without the importation of additional fill materials. The intent of the project is the construction to slopes and not to elevations. Grading requirements will be reviewed and the technical specifications revised as necessary to clarify the requirements. Slope requirements will be specified as no flatter than 3% on the flat top area and no steeper than 33% (3H:1V) composite on the sideslopes.	
19	Comment #19	Appendix A, Slope Stability, Global Slope Stability, sheet 5 of 5: The last sentence on this page states that the stability of slopes during construction was addressed in a separate memo. The Permittees must clarify if the content of this memo is incorporated in this Work Plan (in one of the Plans); if so provide the memo.	Comment incorporated. A separate slope stability analysis was completed for the purpose of determining the means and methods to be employed by the contractor. Results of the analysis will be included in the discussion of slope stability in the revised Phase 2 WP.	
20	Comment #20	Appendix A, Landfill Gas Assumptions, Section 3.2, Factors Affecting LFG Generation, Page 2: In the equation used to estimate total tonnage of waste, the total waste is estimated as 429,400 cubic yards (cy) or 214,700 tons. However, in Section 2.0 (page 1), the estimated in-place tonnage of the waste is given as 268,400 tons. The maximum LFG calculated using this tonnage would be 102 standard cubic feet per minute (scfm) as compared to 82 scfm that is presented as the maximum LFG generation rate. The smaller waste tonnage (214,700 tons) was used throughout to determine LFG generation rates. The Permittees must reconcile these discrepancies and revise the discussions and conclusions presented as necessary. In addition, since gas venting is not incorporated in the cover design, the Permittees must revise the Work Plan to evaluate the effect of the impervious layer of the cover on the LFG generated during the 30-year post-closure period, and if	Comment incorporated. Appendix H of the VCM Plan presents the waste calculations. The total volume of the landfill is estimated to be 536,800 cy. It was assumed that 20% of the total volume was daily cover/intermediate daily cover. Therefore, the corrected waste volume is 429,400 cy. This information will be added to the discussion. Based on data obtained and presented in the VCM Plan (October 2002), the 2002 total landfill gas (LFG) generation rate is approximately 19 cf/min. This number is based on modeling the landfill using an average methane generation rate, a methane generation potential, and 55%	

		perimeter monitoring will be necessary. In addition, since gas venting is not incorporated in the cover design, the Permittees must revise the Work Plan to evaluate the effect of the impervious layer of the cover on the LFG generated during the 30-year post-closure period, and if perimeter monitoring will be necessary.	methane/45% carbon dioxide ratio. Data collected at the landfill showed that of the 30 soil gas locations sampled, only 10 of the 30 locations showed methane gas in excess of 1%. These data demonstrate that gas generation in the landfill is limited to small pockets of trash that has had infiltration to start the decomposition process, and two-thirds of the landfill has little to no gas generation. Using the data from the VCM Plan (Table 1), the average flux is 3.83×10^{-5} cf/min/sf. Using an average waste depth of 23.3 ft, the landfill produces a gas generation rate of 8.3×10^{-7} cm/sec/cf. The saturated permeability of the proposed landfill cover is 1×10^{-5} cm/sec. Gas diffusion is on the order of 10-100 times slower than the saturated permeability of soil and since the predicted gas generation rate is 12 times slower than the Ksat, the gas will have time to diffuse through the soil and will not build up under the cover. In addition, regarding the comment that "...the Permittees must revise the Work Plan to evaluate the effect of the impervious layer of the cover on the LFG generated..." , please see comment response to Comment #3.	
21	Comment #21	Appendix B, Construction Plan, Section 5.7.3, Install Topsoil, page 15: This section states, in most cases, topsoil delivery will involve the belly dump trucks driving on the previous cover soil and not the top soil. It is not clear how this would be possible when the infiltration layer has already been installed. The Permittees must clarify this statement and revise this section accordingly.	Comment noted. The intent here is to keep the delivery trucks off the final 6" topsoil cover to prevent excessive compaction of that topsoil. The 18" infiltration soil cover (exclusive of topsoil) will be in-place and compacted before topsoil is placed. The final layer to be placed is	

			the 6" topsoil cover for vegetative growth media.	
22	Comment #22	Appendix B, Construction Plan, Section 5.9.1, Debris Disposal Area (DDA), page 16: This section states that work areas within the DDA will be constructed as shown on design drawings. The Permittees must revise this section to identify and include these drawings.	Comment noted. The work areas are shown on Design Drawing sheets 2009 and 2010. These plan views depict the work areas to be graded and covered.	
23	Comment #23	Appendix B, Construction Plan, Section 9.6, Dust Control, page 19: The dust control procedures are deficient. The Permittees must revise the documents to indicate that no work will be conducted when dust obscures visibility by 25%. The Permittees must revise the specifications to indicate that dust will be continuously monitored (visually). The Permittees must indicate that all dust-creating operations will be stopped when visibility is obscured by 25% and that operations will not recommence until at least two hours have passed in which visibility has not been obscured by 25%. As is mentioned above, in the event that ash to be moved at the landfill is determined to contain hazardous levels of dioxins/furans or metals, enhanced dust control procedures will be required. Propose contingency dust control procedures in the work plan for the case that contaminated ash must be relocated during this project.	Comment incorporated. The Construction Plan and Specifications will be revised to include real-time monitoring to discern a 25% reduction in visibility due to dust. Action levels for dust emissions, above background levels, will be established to reflect a 25% visual obscurity. Using water and/or tacking compounds will mitigate dust emissions. Dust emissions will be monitored at a minimum of three perimeter locations: background area (upwind from the disturbance areas), down wind near the runway, and near the canyon edge. If visible dust emissions occur, more noticeable than the background dust, and emissions exceed the action level, or the dust emissions peak even instantaneously over a prescribed level, the construction will stop until dust control is reestablished. Water will be primarily used on access routes and during placement of cover soils over the debris. In the event that fine ash materials are exposed during the debris excavation, a tacking agent will be readily available to apply as needed. In the event of extremely dry fine ash materials, water may be needed during the excavation process rather than a tacking agent. Water will be applied with a hose in a manner which prevents free draining excess water.	
24	Comment #24	Appendix B, Construction Plan, Section 9.10, Housekeeping, page 21: The litter control procedures presented in the Work Plan are not present and are therefore deficient. Litter screens at least 20 feet high must be installed down wind of any waste excavation or	Comment incorporated/noted. The specifications will be modified to include the litter control procedures. Placement of a 20' high litter fence may not be allowed in the airport/runway setting.	

		placement operations. The entire site must be inspected at the end of every work shift, and as needed any litter present on site must be collected for proper disposal. The Permittees must revise the design to incorporate litter screens and site inspections to control litter. The Permittees must propose in the Work Plan a sustained wind velocity above which no operations involving exposed waste will take place.	The proposed litter controls include the placement of an interim cover (salvaged existing cover soil) on debris embankment immediately after compaction of the debris. Areas of exposed debris during excavation activities will be covered with a woven geotextile or a plastic mesh material and anchored at the end of the workday. Prior to excavation activities resuming, the cover fabric will be rolled up and stored for later use. Large debris that is not susceptible to being airborne will not require temporary cover (i.e. concrete rubble, asphalt, heavy metals). Once the excavation area is to subgrade elevation, the interim soil cover will be applied.	
25	Comment #25	Appendix C, Construction Quality Control Plan, Table 5.3.1-1, As-Delivered Testing Requirements for Infiltration Layer Material, page 11: The Permittees must add testing requirements for Atterberg Limits to the Work Plan. The Permittees must require that the soil have a Liquid Limit in excess of at least 25 and a Plasticity Index of at least 10. In addition, tests must be conducted at any significant visual change in material.	Comments noted/incorporated. Atterberg limits will be determined for samples collected prior to construction as described in Specification 02200.1.04. "The frequency of conformance testing of each approved soil material shall be in accordance with Table 02200-1 or at any time that a significant change in physical properties of the proposed fill materials is observed by the geotechnical laboratory or the Engineer. The results of this on-going conformance testing shall be reviewed and approved by the Engineer prior to use of that material for which the testing was completed." The CQCP will be revised to clarify that conformance testing will be performed upon a significant change in physical properties as described in the Specification.	
26	Comment #26	Appendix C, Construction Quality Control Plan, Table 5.4.1-1, As-Delivered Testing Requirements for Topsoil, Page 12: Kjeldahl nitrogen is unavailable to plants. The Permittees should consider testing for nitrate and ammonia instead.	Comment incorporated. Since topsoil will likely be produced by addition of organic supplements, i.e. compost or wood chips, plant-available nitrogen will be determined using TKN to determine total organic nitrogen, i.e. the fraction that is slowly released to soil upon	

			decomposition; and also separate analysis for nitrate and ammonia to determine water-soluble nitrogen immediately available at the time of application.	

North Wind

NMED PHASE II WORK PLAN REVIEW COMMENTS AND PROPOSED RESOLUTIONS

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Comments resolved by: Robert Enz, DOE-LASO	E-Mail Address: renz@doeal.gov		Phone Number: (505) 667-7640	
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3	Comment #3	The Permittees must submit all Land Fill Gas (LFG) monitoring results to the HWB. The proposed Work Plan states that "engineering calculations indicated that gas concentrations will not exceed 25 percent of the LEL for methane." The Permittees must provide any engineering calculations used to the project concentrations of LFG.	Comment incorporated. The referenced text will be revised to state that "Soil gas and air measurements reported in the RFI Report and summarized in the attached Engineering Calculations indicate that methane concentrations currently do not exceed 25% of the LEL at the property boundary. Methane concentrations should continue to decline over time based on current calculated generation rates, which are low relative to the reported range for municipal solid waste methane generation rates, and to the age of the waste.	

			Therefore concentrations at the property boundary are not expected to exceed 25% of the LEL in the future."	
4	Comment #4	The Work Plan states that the collection of water samples was attempted at existing monitoring wells in 2001, but insufficient water was collected from the wells for analysis. The Permittees must indicate if the existing wells will continue to be monitored or if new wells will be installed in an attempt to detect landfill leachate. The Permittees must describe how they will monitor for leachate, including collection methods, frequency, and duration.	Comments noted. Section 2.0 of the Post-Closure Care and Monitoring Plan (PCMP) [Appendix D of the Work Plan] states that "The TA-73 landfill does not have dedicated groundwater monitoring wells because the depth to groundwater is over 1200 feet (ft) This statement is based on the RFI Report Section 2.4.4.2 statement that "Groundwater was not encountered beneath the landfill area during this investigation. The greatest vertical depth penetrated in this investigation was 186 feet beneath the ground surface in perimeter borehole LPS-2, and unsaturated conditions were encountered to this depth. All borings drilled within the landfill area encountered unsaturated conditions to a maximum drilled depth of 82 feet below ground surface. No deeper boreholes exist on the mesa-top site, and thus deeper site-specific groundwater occurrences are undefined. Based on depths to water measured in wells located in Pueblo Canyon to the north, and Los Alamos Canyon to the south, the depth to the regional aquifer beneath TA-73 is estimated to be approximately 1260 ft. Based on the fact that saturated conditions have not been encountered beneath the landfill or near it's perimeter in any previous investigation, existing wells will not be monitored further, and no new wells will be constructed. Regarding leachate monitoring, please see the response to Comment No. 2 re: occurrence of leachate cited in the RFI Report. The RFI Report stated that "relatively small amounts of leachate	

			appear to occur at isolated locations beneath the landfill". This was confirmed by the cone penetrometer survey performed subsequent to the RFI Report and summarized in the Site Characterization Report (to be submitted with the revised Phase 2 Work Plan) which found unsaturated conditions based on pore pressures. Saturated conditions indicative of presence of leachate do not appear to occur except sporadically and therefore no efforts will be made to monitor for leachate in the closed landfill.	
5	Comment #5	Appendix A, Hydraulic Calculations section, sheet 3 of 25 shows that analysis using the TR 55 Model was based upon a two-year 24-hour storm event. 40 CFR Section 258.26(a)2 requires that the model be based on a 24-hour, 25-year storm. The Permittees must clarify the number of years upon which the hydraulic analysis was based and resubmit the analysis with the correct storm event information.	Comment incorporated. A 25-year, 24-hour storm was used in the referenced hydraulic calculations to size drainage structures, i.e., channels and pipes, per 40 CFR. A 2-year, 24-hour storm was used in the calculation of shear force on landfill surface as it relates to estimating the erosion of the cap. As far as we are aware, there are no regulatory requirements governing the calculation of erosive forces on landfill surfaces. However for purposes of consistency the 25-yr 24-hr storm event will be used for both purposes.	
6	Comment #6	The Permittees must describe the measures that will be taken to insure the integrity of the landfill cover is not compromised through intrusion by animals, roots, and other biota.	Comment noted. Section 3.1 of the PCMP addresses inspection and repair of animal burrows. Since a native vegetation mix will be applied, plant roots may eventually penetrate the entire cover profile. Undesired invasion by plants, e.g. cheatgrass, is not expected in the 30-year post-closure period if the native plant mix is successful. However if a fire-prone species like cheatgrass became widespread and if a fire occurred, inspection and repair is addressed under Section 3.1 heading "Condition of Vegetation".	
7	Comment #7	Appendix A, Page 02200-5, Paragraph C Earthquake Quality Control specifies that the landfill cover will have a final compaction	Comment noted. Preliminary testing of cover soils showed that the required permeability could	

		Control specifies that the landfill cover will have a final compaction of 98 percent. Discuss the rationale behind a final compaction rate of 98 percent.	soils showed that the required permeability could be achieved with 95% compaction. To be more conservative, and to account for minor variability in the soil, 98% compaction rate was chosen.	
8	Comment #8	Discuss the location of the borrow source for the landfill cover. Identify if the location is proximal to any SWMUs or AOCs and how it will be determined if the fill material is clean. The Permittees must identify where the low permeability soil for the landfill cover will be obtained.	Comments noted/incorporated. The soil borrow source(s) will be identified in the remedy completion report. The location will not be proximal to any SWMUs or AOCs. As stated in the Construction Specifications Section 02200.2.01.A-C, all borrow soils must be environmentally clean. Requirements for certification will be added to the specification.	
9	Comment #9	Section 5.0 Demonstration of Cover Performance, Page 14: This section must respond to the requirement of the NMED Conditional Approval of Voluntary Corrective Measures (VCM) Plan (Conditional Approval Letter dated April 1, 2003) that the Phase II Work Plan contain a demonstration of the cover performance for the life of the cover. Instead this section only references Appendix D (Post-closure Care and Monitoring Plan). The Permittees must revise the Work Plan to satisfy this requirement.	Comment incorporated. Please see the attached response to Comment #2 and HELP3 modeling results.	
10	Comment #10	Appendix A, Drawing Nos. 2006, 2007 and 2008, Page 5-3: These drawing show an approximate location of the 1962 ground surface. The general notes on these drawing indicate that the 1962 surfaces depicted on this drawing should be considered for information only. It is not clear what information the 1962 ground surface provides, since waste was accepted at the Main Landfill before that date. The Permittees must revise these drawings to either explain the pertinent information that these suface lines provide or remove them from the drawings.	Comment incorporated. Note 1 on each of the referenced drawings will be revised to describe the relevance/significance of the 1962 Ground Surface line. The landfill was filled from west to east. Based on historical documentation, i.e., 1962 aerial survey, it appears that the east portion of the landfill was filled in the period between 1962 and when the landfill ceased operation in 1973. The note will contain the following wording: "*Based on historical data, the 1962 surface at the east end of the landfill is anticipated to be the original ground surface prior to landfilling activities and is provided* ***For Information Only***	
11	Comment #11	Appendix A, Hydraulic Calculations, sheet 1 of 25: Paragraph 4 states that each bench was designed as a 10-ft wide triangular channel with a bed slope of 4%, and side slopes of 2.75% and 10%	Comment incorporated. References to slopes will be presented in both percent slope and as H:V.	

		bench slope. The Permittees must clarify if the slopes indicated are the ratio of horizontal (H) to vertical (V) change and not percent slope. Drawing No. 2005 indicates that the side slope of each bench is 2.75 (i.e. 2.75H:1V). The Permittees must correct all references to H:V ratio as percent slope throughout the Work Plan.		
12	Comment #12	Appendix A, Hydraulic Calculations, Drainage Structures Hydraulic Design, sheet 1 of 25: Paragraph 6 indicates that, at a minimum, R-6 rip rap is required for the trapezoidal downchute based on the shear stress level, resulting from the steep slope. However in the supporting documentation provided in Tables 6 and 9, and Figure 3 and 21, a R-5 rip rap is selected for the downchute. The Permittees must reconcile this discrepancy and revise the text, table, and figures, accordingly.	Comment incorporated. The calculations will be reviewed and discrepancies will be resolved.	
13	Comment #13	Appendix A, Hydraulic Calculations, Drainage Structures Hydraulic Design, sheet 7 of 25: For the inlet/outlet control check a design discharge of 5.2 cubic feet per second (cfs) is used. However, the hydraulic calculations conducted for pipe segments 1 and 2 resulted in a maximum discharge of 5.5 cfs in pipe segment 1. The Permittees must clarify why this discharge was not used as the design discharge for the inlet/outlet control check computations.	Comment incorporated. The calculations will be reviewed and revised as needed.	
14	Comment #14	Appendix A, Hydraulic Calculations, Landfill Top Erosion Forces Estimate, sheet 1 of 8: It is indicated that to determine velocities and shear forces generated by the sheet flow atop of the landfill, sheet flow was examined for a 300-ft length of a 3% slope. Using the top of cap grading plan elevations and the scale provided on Drawing No. 2002, the slope atop the landfill appears to be in range of 6% to 8%. The Permittees must reconcile this discrepancy and revise the calculations.	Comment noted. NMED clarified that the comment was generated based on review of reduced-scale drawings. Full-scale drawings were reviewed and the 3% slope inclination confirmed.	
15	Comment #15	Appendix A, Settlement Evaluations, Differential Settlement Evaluation, sheet 2 of 8: The first paragraph states, settlement due to dewatering will also be negligible as no dewatering of the waste mass has been proposed. Furthermore, there is no evidence of a perched water table or leachate mound within the landfill. The Permittees must revise the Work Plan to provide data to support this contention or provide a reference for this determination.	Comment incorporated/noted. The RFI Report for the Airport Landfill (1998) states that no perched water was encountered in the landfill area during the RFI and perched waters are not known with certainty to occur directly beneath the landfill (Section B-4.3.2). Suction lysimeters sampling was performed during the RFI, but limited samples were collected. Additionally, no free water was encountered during the drilling of	

			RFI perimeter boreholes. The RFI Report states that "Relatively small amounts of leachate appear to occur at isolated locations beneath the landfill". This was confirmed by the cone penetrometer survey performed subsequent to the RFI Report and summarized in the Site Characterization Report (to be submitted with the revised Phase 2 Work Plan) which found unsaturated conditions based on pore pressures. Saturated conditions indicative of presence of leachate do not appear to occur except sporadically.	
16	Comment #16	Appendix A, Settlement Evaluations, Differential Settlement Evaluation, sheet 4 of 8: In Table 1, at the bottom of this sheet, the interim cover thickness is given as one foot. The engineering drawings (e.g., Drawing No. 2005) indicate the interim cover thickness as a minimum of 6 inches. The Permittees must clarify if the thickness used in the settlement calculations is the maximum expected or the average thickness of the interim cover.	Comment noted. The thickness of interim cover indicated on the drawings (6 inches) is the minimum required/acceptable thickness of interim cover. A 1-foot interim cover thickness was utilized in the calculation to account for variability in the actual thickness of interim cover that will be placed. In areas that are undisturbed, the interim cover will be comprised of the existing cover soil, which has a thickness in excess of 6 inches. It is anticipated that there will be some variation in the thickness of the interim cover but the impact on settlement or differential settlement will be negligible.	
17	Comment #17	Appendix A, Settlement Evaluations, Differential Settlement Evaluation, sheet 5 of 8: It is indicated on this page that with respect to grid point B5, the existing ground surface elevation is 7132 feet and Figure 1 is referenced for this information. However, the closest elevation point that can be used to approximate the elevation at point B5 is given as 7143 feet on Figure 1. None of the drawings and figures provided clearly depict labeled contour elevations of the existing grade. The Permittees must revise the Work Plan to provide a drawing or a figure that clearly provides the existing ground surface.	Comment incorporated/noted. The calculation will be reviewed and revised as necessary. Please refer to Drawing 2001 in the Work Plan to confirm contour labels. Full-size drawings were also provided as part of the submittal.	

18	Comment #18	Under Conclusions, Sheet 8 of 8: It is stated that due to the anticipated rate of settlement of the landfill and consolidation of the relocated waste due to compaction by construction equipment, it is likely that the final grades shown on the project drawing will not be achieved. The Permittees must revise the Work Plan to provide acceptance criteria for what grades will be acceptable and procedures to follow in the event final grades shown on the drawings are not achieved, or provide in the final work plan submittal an achievable grading plan. The Permittees must provide clear instructions on compaction requirements and permeability specifications of the infiltration barrier layer to the construction contractor.	Comment noted. Due to the nature of this project, i.e., the volume of material to be relocated, the degree of shrinkage or swell of the relocated material and the rate of settlement of the relocated material cannot be precisely determined, therefore it is likely that the final elevations shown on the drawings as "Top of Cap" will not be achieved without the importation of additional fill materials. The intent of the project is the construction to slopes and not to elevations. Grading requirements will be reviewed and the technical specifications revised as necessary to clarify the requirements. Slope requirements will be specified as no flatter than 3% on the flat top area and no steeper than 33% (3H:1V) composite on the sideslopes.	
19	Comment #19	Appendix A, Slope Stability, Global Slope Stability, sheet 5 of 5: The last sentence on this page states that the stability of slopes during construction was addressed in a separate memo. The Permittees must clarify if the content of this memo is incorporated in this Work Plan (in one of the Plans); if so provide the memo.	Comment incorporated. A separate slope stability analysis was completed for the purpose of determining the means and methods to be employed by the contractor. Results of the analysis will be included in the discussion of slope stability in the revised Phase 2 WP.	
20	Comment #20	Appendix A, Landfill Gas Assumptions, Section 3.2, Factors Affecting LFG Generation, Page 2: In the equation used to estimate total tonnage of waste, the total waste is estimated as 429,400 cubic yards (cy) or 214,700 tons. However, in Section 2.0 (page 1), the estimated in-place tonnage of the waste is given as 268,400 tons. The maximum LFG calculated using this tonnage would be 102 standard cubic feet per minute (scfm) as compared to 82 scfm that is presented as the maximum LFG generation rate. The smaller waste tonnage (214,700 tons) was used throughout to determine LFG generation rates. The Permittees must reconcile these discrepancies and revise the discussions and conclusions presented as necessary. In addition, since gas venting is not incorporated in the cover design, the Permittees must revise the Work Plan to evaluate the effect of the impervious layer of the cover on the LFG generated during the 30-year post-closure period, and if	Comment incorporated. Appendix H of the VCM Plan presents the waste calculations. The total volume of the landfill is estimated to be 536,800 cy. It was assumed that 20% of the total volume was daily cover/intermediate daily cover. Therefore, the corrected waste volume is 429,400 cy. This information will be added to the discussion. Based on data obtained and presented in the VCM Plan (October 2002), the 2002 total landfill gas (LFG) generation rate is approximately 19 cf/min. This number is based on modeling the landfill using an average methane generation rate, a methane generation potential, and 55%	

		perimeter monitoring will be necessary. In addition, since gas venting is not incorporated in the cover design, the Permittees must revise the Work Plan to evaluate the effect of the impervious layer of the cover on the LFG generated during the 30-year post-closure period, and if perimeter monitoring will be necessary.	methane/45% carbon dioxide ratio. Data collected at the landfill showed that of the 30 soil gas locations sampled, only 10 of the 30 locations showed methane gas in excess of 1%. These data demonstrate that gas generation in the landfill is limited to small pockets of trash that has had infiltration to start the decomposition process, and two-thirds of the landfill has little to no gas generation. Using the data from the VCM Plan (Table 1), the average flux is 3.83×10^{-5} cf/min/sf. Using an average waste depth of 23.3 ft, the landfill produces a gas generation rate of 8.3×10^{-7} cm/sec/cf. The saturated permeability of the proposed landfill cover is 1×10^{-5} cm/sec. Gas diffusion is on the order of 10-100 times slower than the saturated permeability of soil and since the predicted gas generation rate is 12 times slower than the Ksat, the gas will have time to diffuse through the soil and will not build up under the cover. In addition, regarding the comment that "...the Permittees must revise the Work Plan to evaluate the effect of the impervious layer of the cover on the LFG generated..." , please see comment response to Comment #3.	
21	Comment #21	Appendix B, Construction Plan, Section 5.7.3, Install Topsoil, page 15: This section states, in most cases, topsoil delivery will involve the belly dump trucks driving on the previous cover soil and not the top soil. It is not clear how this would be possible when the infiltration layer has already been installed. The Permittees must clarify this statement and revise this section accordingly.	Comment noted. The intent here is to keep the delivery trucks off the final 6" topsoil cover to prevent excessive compaction of that topsoil. The 18" infiltration soil cover (exclusive of topsoil) will be in-place and compacted before topsoil is placed. The final layer to be placed is	

			the 6" topsoil cover for vegetative growth media.	
22	Comment #22	Appendix B, Construction Plan, Section 5.9.1, Debris Disposal Area (DDA), page 16: This section states that work areas within the DDA will be constructed as shown on design drawings. The Permittees must revise this section to identify and include these drawings.	Comment noted. The work areas are shown on Design Drawing sheets 2009 and 2010. These plan views depict the work areas to be graded and covered.	
23	Comment #23	Appendix B, Construction Plan, Section 9.6, Dust Control, page 19: The dust control procedures are deficient. The Permittees must revise the documents to indicate that no work will be conducted when dust obscures visibility by 25%. The Permittees must revise the specifications to indicate that dust will be continuously monitored (visually). The Permittees must indicate that all dust-creating operations will be stopped when visibility is obscured by 25% and that operations will not recommence until at least two hours have passed in which visibility has not been obscured by 25%. As is mentioned above, in the event that ash to be moved at the landfill is determined to contain hazardous levels of dioxins/furans or metals, enhanced dust control procedures will be required. Propose contingency dust control procedures in the work plan for the case that contaminated ash must be relocated during this project.	Comment incorporated. The Construction Plan and Specifications will be revised to include real-time monitoring to discern a 25% reduction in visibility due to dust. Action levels for dust emissions, above background levels, will be established to reflect a 25% visual obscurity. Using water and/or tacking compounds will mitigate dust emissions. Dust emissions will be monitored at a minimum of three perimeter locations: background area (upwind from the disturbance areas), down wind near the runway, and near the canyon edge. If visible dust emissions occur, more noticeable than the background dust, and emissions exceed the action level, or the dust emissions peak even instantaneously over a prescribed level, the construction will stop until dust control is reestablished. Water will be primarily used on access routes and during placement of cover soils over the debris. In the event that fine ash materials are exposed during the debris excavation, a tacking agent will be readily available to apply as needed. In the event of extremely dry fine ash materials, water may be needed during the excavation process rather than a tacking agent. Water will be applied with a hose in a manner which prevents free draining excess water.	
24	Comment #24	Appendix B, Construction Plan, Section 9.10, Housekeeping, page 21: The litter control procedures presented in the Work Plan are not present and are therefore deficient. Litter screens at least 20 feet high must be installed down wind of any waste excavation or	Comment incorporated/noted. The specifications will be modified to include the litter control procedures. Placement of a 20' high litter fence may not be allowed in the airport/runway setting.	

		placement operations. The entire site must be inspected at the end of every work shift, and as needed any litter present on site must be collected for proper disposal. The Permittees must revise the design to incorporate litter screens and site inspections to control litter. The Permittees must propose in the Work Plan a sustained wind velocity above which no operations involving exposed waste will take place.	The proposed litter controls include the placement of an interim cover (salvaged existing cover soil) on debris embankment immediately after compaction of the debris. Areas of exposed debris during excavation activities will be covered with a woven geotextile or a plastic mesh material and anchored at the end of the workday. Prior to excavation activities resuming, the cover fabric will be rolled up and stored for later use. Large debris that is not susceptible to being airborne will not require temporary cover (i.e. concrete rubble, asphalt, heavy metals). Once the excavation area is to subgrade elevation, the interim soil cover will be applied.	
25	Comment #25	Appendix C, Construction Quality Control Plan, Table 5.3.1-1, As-Delivered Testing Requirements for Infiltration Layer Material, page 11: The Permittees must add testing requirements for Atterberg Limits to the Work Plan. The Permittees must require that the soil have a Liquid Limit in excess of at least 25 and a Plasticity Index of at least 10. In addition, tests must be conducted at any significant visual change in material.	Comments noted/incorporated. Atterberg limits will be determined for samples collected prior to construction as described in Specification 02200.1.04. "The frequency of conformance testing of each approved soil material shall be in accordance with Table 02200-1 or at any time that a significant change in physical properties of the proposed fill materials is observed by the geotechnical laboratory or the Engineer. The results of this on-going conformance testing shall be reviewed and approved by the Engineer prior to use of that material for which the testing was completed." The CQCP will be revised to clarify that conformance testing will be performed upon a significant change in physical properties as described in the Specification.	
26	Comment #26	Appendix C, Construction Quality Control Plan, Table 5.4.1-1, As-Delivered Testing Requirements for Topsoil, Page 12: Kjeldahl nitrogen is unavailable to plants. The Permittees should consider testing for nitrate and ammonia instead.	Comment incorporated. Since topsoil will likely be produced by addition of organic supplements, i.e. compost or wood chips, plant-available nitrogen will be determined using TKN to determine total organic nitrogen, i.e. the fraction that is slowly released to soil upon	

			decomposition; and also separate analysis for nitrate and ammonia to determine water-soluble nitrogen immediately available at the time of application.	

Comment #2. Section 2.0 Detailed Engineering Design, page 3: The Work Plan calls for a RCRA Subtitle D municipal landfill cover as described by NMAC regulations. The permittees incorrectly state that the selected remedy was prescribed by NMED. The prescribed remedy outlined in the April 1, 2003 letter to LANL explains that the final remedy for the Airport Landfill shall be equivalent to applicable RCRA Subtitle C requirements. The Permittees must provide the basis for the change in design.

Response: Comments incorporated. The following text will be added to the revised Phase 2 Work Plan in a new Section titled "Development of Design Basis".

1. BACKGROUND.

The VCM Plan (LANL 2003) presented three cover design alternatives for the TA-73 landfill. The three alternatives were comprised from a single cap conceptual design option (30-cm soil layer over a 15-cm gravel layer) and three grading plan options. The April 1, 2003 letter from NMED to LANL granting conditional approval for the VCM Plan (NMED 2003) stated that "The RFI Report recommended the final remedy for the Airport Landfill be consistent with RCRA Subtitle D regulations. Upon review of the RFI Report, NMED required the final remedy for the Airport Landfill be equivalent to applicable RCRA Subtitle C requirements. The VCM proposes the use of an engineered alternative earthen final cover. NMED approves the use of an engineered alternative earthen cover (cap) or RCRA Subtitle C equivalent cover, as long as the cover constructed will perform equivalent to or better than a standard RCRA Subtitle C prescriptive cover outlined in 40 CFR 265 subpart N, incorporated by 20.4.1.600 NMAC. The alternative cover must function efficiently and in accordance with the design parameters for the duration of the 30-year post closure care period."

On 12/15/03 Mr. Robert Enz of DOE-LASO met with Mr. Edward Hansen and Ms. Darlene Goering of NMED to discuss the TA-73 closure. At that time Mr. Hansen stated his preference that the TA-73 closure be modeled after the LANL TA-54 Area J closure, with 18 inches of engineered fill with a hydraulic conductivity of 1E-05 cm/sec overlain by 6 inches of soil to sustain native plant growth. This is the conceptual design of a RCRA Subtitle D landfill cover as prescribed in 40 CFR 258.60(a)(1-3) and in NMAC 20.9.1.500.B(1). Mr. Hansen stated that this design would provide for good venting for landfill gases, with some lateral migration although most of the methane has already been produced by this landfill.

Mr. Hansen provided the Hydrologic Evaluation of Landfill Performance (HELP) code modeling results for the TA-54 closure, including the weather data used; and the "Guidance Document for Performance Demonstration for an Alternate Cover Design under Section 502.A.2 of the New Mexico Solid Waste Management Regulations (20 NMAC 9.1) Using HELP Modeling" (NMED 1998).

Mr. Hansen also stated that the NMED Solid Waste Bureau would technically approve the design, and that the Hazardous Waste Bureau would give final approval.

Given that the direction provided by NMED on 12/15/03 appeared to supercede the NMED (2003) requirement for a Subtitle C-equivalent design, the approach used in the TA-73 conceptual design was to use the guidance document and weather data provided to assess equivalence, with respect to percolation of infiltration through the bottom of the cap, of the VCM Plan design relative to the RCRA Subtitle D design, which prescribes an 18-in soil layer with a saturated hydraulic conductivity (Ksat) of 1E-05 cm/sec overlain by 6-in topsoil (40 CFR 258.60(a)(1-3); NMAC 20.9.1.500.B(1)).

Modeling results are provided in Attachment 1 and are summarized in Table 1-1 below. Percolation through the bottom of the cap was calculated at 0.01 in/yr for the Subtitle D cap, vs. 0.71 in/yr for the VCM Plan design. NMED (1998) states that "If the two average annual percolation values are within 0.00001 in of each other, then the demonstration is successful since these values are practically equal (the definition of equivalent) and well within the modeling uncertainty." Based on this criterion the VCM Plan design would allow more infiltration than the NMED Subtitle D design.

Due to the way the HELP3 code is formulated (the code does not rigorously calculate the effects of a capillary barrier under unsaturated conditions), as well as the NMED-prescribed approach for modeling (using HELP and LANL weather data for the five wettest years on record), it appeared that the VCM Plan design would not meet the equivalency criterion. Note that the VCM Plan design coarse sand Layer 2 functioned as a capillary barrier; and that the VCM Plan modeling used UNSAT-H to calculate infiltration, which is a Richards equation-based code that more rigorously addresses the effects of capillary barriers than the water balance-based HELP3 code. Much more earthen material would have to be added to provide enough soil moisture storage capacity to approach the NMED-prescribed Subtitle D infiltration performance, as determined using the HELP3 code.

Table 1-1. Summary of HELP3 results for RCRA Subtitle D cover and VCM Plan conceptual design.

Parameters	**Design**	
	RCRA Subtitle D cover	**VCM Plan design**
Layer 1	6-in topsoil layer -- Soil Texture No. 8	12-in topsoil layer -- K= 2.84E-04
Layer 2	18-in soil layer -- K=1E-05-- Soil Texture No. 23	6-in coarse sand layer -- K=8.25E-03
Layer 3	No drainage layer	No drainage layer
Grass stand	Poor	Poor
CN Number	85.6	85.6
Top slope	3%	3%
Average drainage length	500 ft	500 ft
Evaporative Depth	18 inches	18 inches
Precipitation	23.39	23.39
Runoff	0.886	0.91
Evaporation	22.488	21.776
Percolation Thru Layer 2/3	0.01065	0.7132
Change in Storage	0.002	-0.011

2. COMPARISON OF PROPOSED COVER TO RCRA SUBTITLE C REQUIREMENTS.

Based on these results, the VCM Plan alternative cover conceptual design was abandoned and the prescribed Subtitle D cover was advanced as the more cost-efficient approach. To satisfy the VCM Plan Approval letter requirement that "the final remedy for the Airport Landfill be equivalent to applicable RCRA Subtitle C requirements", as outlined in 40 CFR 265 subpart N, these requirements were compared to the prescribed features and the modeled hydrologic performance of the Subtitle D cover. Table 2-1 below shows the results of this comparison.

Table 2-1. Comparison of proposed cover performance to RCRA Subtitle C requirements (40 CFR 265.310).

Number	RCRA Subtitle C Closure Cover Requirement	Extent to which the proposed cover does or does not meet the requirement
1	Provide long-term minimization of migration of liquids through the closed landfill	*Meets the requirement.* Modeled average annual infiltration rate using weather data for the 5 wettest years on record is only 0.01 in/year.
2	Function with minimum maintenance	*Meets the requirement.* The proposed cover consists almost entirely of earthen materials and vegetation, with minimal maintenance needs as discussed in the O&M Plan. No compacted clay layers or geosynthetic membranes are included, which typically require more expensive maintenance when breached by subsidence, excavation or other disturbance to the cover.
3	Promote drainage and minimize erosion or abrasion of the cover	*Meets the requirement.* The surface cover will provide erosion control using a vegetated topsoil surface and 3% maximum slope; with durable rock armor side slope surfaces. Supporting calculations are provided in the design.
4	Accommodate settling and subsidence so that the cover's integrity is maintained	*Meets the requirement.* The proposed cover consists almost entirely of earthen materials and vegetation. Earthen materials are self-healing and easily repaired, compared to geosynthetic membranes which can tear under the stress of bridging voids beneath the liner resulting from subsidences.
5	Have a permeability less than or equal to the permeability of any bottom liner or natural subsoils present	*Meets the requirement.* The landfill is not lined and is entirely underlain by the Bandelier Tuff. D.B. Stephens & Associates, Inc. (1993) report in "Preliminary Geologic and Hydrologic Conceptual Model of the TA-73 Area, Los Alamos, New Mexico", states that "Saturated hydraulic conductivity ranges over approximately two orders of magnitude in the Bandelier Tuff, from approximately 1E-03 cm/s to 1E-05 cm/s." The prescribed RCRA Subtitle D Ksat of 1E-05 cm/sec therefore meets this requirement (see discussion below).

The permeability of the natural subsoils present is addressed in D.B. Stephens & Associates, Inc. (1993), which discusses the geology and hydrogeology of the vadose zone under TA-73-001(a). The report describes the stratigraphy as (top to bottom):

1. The Quaternary Bandelier Tuff of the Tewa Group, consisting of sequences of non-welded to welded rhyolitic ash flows and pumice. Three members are identified (top to bottom):

    a. The Tshirege Member, consisting of alternating beds of ash-fall pumice. The extent of welding in the Tshirege member underlying TA-73 is not described.

    b. The Otowi Member, described as a crystal-rich rhyolitic tuff that is non-welded and vitric throughout.

    c. The Guaje Member, consisting of a bedded ash-fall pumice.

2. the Tertiary/Quaternary Puye conglomerate of the Santa Fe Group, consisting of:

    a. The upper fanglomerate which consists of poorly consolidated, silty, sandy conglomerate, with interbedded lapilli tuff and volcanic mudflow deposits.

    b. The lower Totavi Lentil, consisting of well rounded pebbles, cobbles, and boulders in a matrix of coarse, arkosic sandstone.

3. The Miocene Tesuque Formation of the Santa Fe Group, consisting mainly of tuffaceous sand and silt, gravels, and possibly some interbedded basalts.

D.B. Stephens & Associates, Inc. (1993) reported in situ and laboratory-determined hydrologic information for the geologic units underlying TA-73. Data were obtained from an earlier D.B. Stephens & Associates (1991) report for the Bandelier Tuff in Mortandad Canyon and from the TA-21 Draft RFI Work Plan. Results are summarized in Table 2-2 below.

Table 2-2. Hydrologic properties of geologic units underlying TA-73 (D.B. Stephens & Associates, Inc. (1993))

Geologic Unit	Ksat, cm/sec	Notes
Bandelier Tuff		
Tshirege member	3.0E-03 to 4.7E-05	a
	1.0E-03 to 9.7E-05	b
Tsankawi Pumice[c]	2.0E-03 to 5.8E-05	a
	4.8E-04	b
Otowi member	4.3E-03 to 7.9E-04	a
	9.6E-04	b
Guaje Member	4.8E-04	b
Puye Conglomerate		
Fanglomerate member	4.8E-03	b

Geologic Unit	Ksat, cm/sec	Notes
Interbedded basalts	9.6E-04	b
Totavi Lentil[d]	3.9E-01	b

a: Laboratory data for samples from Mortandad Canyon

b: Field and laboratory data from USGS work in the 1950s and 1960s, and air/waste injection tests conducted by Bendix Corp. in the mid 1980s.

c: Tsankawi Pumice and Cerro Toledo were extrapolated to TA-73 from the TA-21 work plan schematic cross section.

d: Totavi Lentil hydraulic conductivity was estimated from pump tests in TW-2 and TW-3.

The D.B. Stephens & Associates, Inc. (1993) report states that overall the calculated hydraulic conductivities obtained from the different tests show generally good correlation. The report cites structural characteristics, including joints and fractures, and textural characteristics (induration or welding) as the principal factors affecting hydraulic properties of the Bandelier Tuff, while noting that correlation between observed geology and calculated hydraulic parameters has not been established. Ksat values for moderately to densely welded units of the Bandelier Tuff would be expected to differ significantly from those for non-welded tuff. Samples of Bandelier Tuff obtained by D.B. Stephens & Associates, Inc. from Mortandad Canyon ranged from no welding to slightly welded. The report concludes that "Without new data, it must be assumed that the hydraulic parameters determined for similar geologic units in the Los Alamos area are representative of site conditions."

A later report by Rogers and Gallagher (1995) referenced in the VCM Plan cites a Ksat value of 2.84E-04 cm/sec for the Tshirege Member of the Bandelier Tuff. This report was not available and it is unknown how this value was obtained. However, it is within the range reported in D.B. Stephens & Associates (1993).

The Ksat range reported in D.B. Stephens & Associates (1993) appears to be supported by soil gas and lysimeter sampling results from the RFI Report, and by inspection of the landfill and it's surroundings. Even in the current condition, i.e. with a thin interim soil cover that has subsided about 6 ft overall, the landfill shows no evidence of "bathtubbing" or other accumulation or discharge of leachate.

The RFI Report Executive Summary further states that "Measurements of the soil water potentials confirm relatively wet, but unsaturated, conditions within the refuse and within the tuff immediately surrounding the refuse." "Samples collected from the tuff bordering the landfill indicate increasingly dry conditions, demonstrating a decreasing trend in the potential for migration. A reduction in available moisture, from implementing surface water run-on controls, will further reduce the potential for contaminant migration".

These findings are further corroborated by the results of the cone penetrometer survey performed in January 2004 which found pore pressures indicative of unsaturated conditions throughout the landfill. These results are provided in the Site Characterization Report, to be provided with the revised Phase 2 Work Plan.

A large Ksat difference between the waste and the tuff would be expected to create saturated conditions in the waste at the interface. The average Ksat for municipal solid waste cited in the HELP3 code documentation is 1E-03 cm/sec. Given these lines of evidence for the

current unclosed condition, i.e. unsaturated conditions in the waste, low soil moisture contents in the tuff underlying the landfill, no evidence of perching of leachate at the tuff-waste contact, and no discharge of leachate observed into Pueblo Canyon; then the Ksat range for the Bandelier Tuff under TA-73 reported by D. B. Stephens, Inc. (1993) of 1E-03 to 1E-05 cm/sec appears reasonable.

The RFI Report Section 2.3.5 states "The potential transport to groundwater was not included in the preliminary site conceptual model due to the considerable depth to the regional aquifer" (about 1200 ft), "and the results of the site investigation activities support this premise. The results show that VOC concentrations in soil gas attenuate significantly with distance away from the landfill. In addition, relatively small amounts of leachate appear to occur at isolated locations beneath the landfill. The leachate contains very low levels of organics and somewhat higher levels of some inorganics; however the potential for transport of these constituents is expected to be limited." Concentrations of VOCs and inorganics detected in TA-73 pore water reported in RFI Report Tables 2.3.5.1-2 and 2.3.5.1-3 corroborate this assessment. Four VOCs and four inorganics were detected above the EPA Drinking Water MCLs. The magnitudes of the exceedences are low enough that sorption and dispersion, and degradation of organics, would be expected to reduce concentrations to allowable levels well before reaching groundwater receptors.

3. COMPARISON OF PROPOSED COVER TO RCRA SUBTITLE C GUIDANCE.

The proposed TA-73 cover is compared to current EPA guidance for Subtitle C landfill covers in this section. EPA developed a series of guidance documents to help owner/operators meet the Subtitle C requirements including "Technical Guidance Document, Final Covers on Hazardous Waste Landfills and Surface Impoundments" (EPA 1989). EPA 1989 describes the recommended RCRA Subtitle C design as depicted in Figure 3-1 below, hereafter referred to as the RCRA Subtitle C Minimum Technology Guidance (MTG) cover. The features of RCRA Subtitle C MTG and Subtitle D prescribed covers are compared in Table 3-1. The primary differences between Subtitle C and D designs are a lack of a lateral drainage layer, geosynthetic membrane and gas collection layer for the Subtitle D design; as well as a less thick upper vegetated layer, and a less thick, higher permeability soil barrier layer.

The lateral drainage layer has no function if the cap does not have a geosynthetic membrane and therefore the Subtitle D design does not require this layer. Similarly, the gas collection layer has no function if the cap does not have a geosynthetic membrane, and if the landfill does not have structures built on it, or if methane concentrations do not exceed 25% of the LEL at the property boundary. As discussed in Section 2.3.5.1(b) of the RFI Report the methane plume is entirely confined within the property boundary and concentrations of methane are below the LEL everywhere along the property boundary. Figure 2.3.5.1-5 shows the approximate lateral extent of methane in soil gas at the main landfill. The eastern extent of methane is bounded by monitoring well LP-2, and the western extent by LP-5 and LP-9, neither of which has shown detectable methane concentrations during multiple sampling events. The northern extent of the landfill gas plume is bounded by LPS-1 and LP-8, which contain little or no methane.

Additionally, RFI Report Section 2.3.4.3(d) describes a field screening survey performed along the south wall of Pueblo Canyon to determine if landfill gas (LFG) including methane could be detected. LFG was not detected in animal burrows, fissures or joints along the wall of Pueblo Canyon north of the boundary fence along the northern perimeter of the TA-73 main landfill.

The South boundary of the methane plume shown in Figure 2.3.5.1-5 is inferred as extending under the runway. No soil gas monitoring locations were installed under the runway or between the runway and the property boundary. However the property boundary is over 100 ft from the inferred southern extent of the methane plume and therefore concentrations at the property boundary are expected to be well below the LEL.

The TA-73 landfill does not have structures built on it and methane concentrations are near or below detection limits everywhere along the property boundary. Therefore a gas collection layer is not required as a functional element of the proposed design.

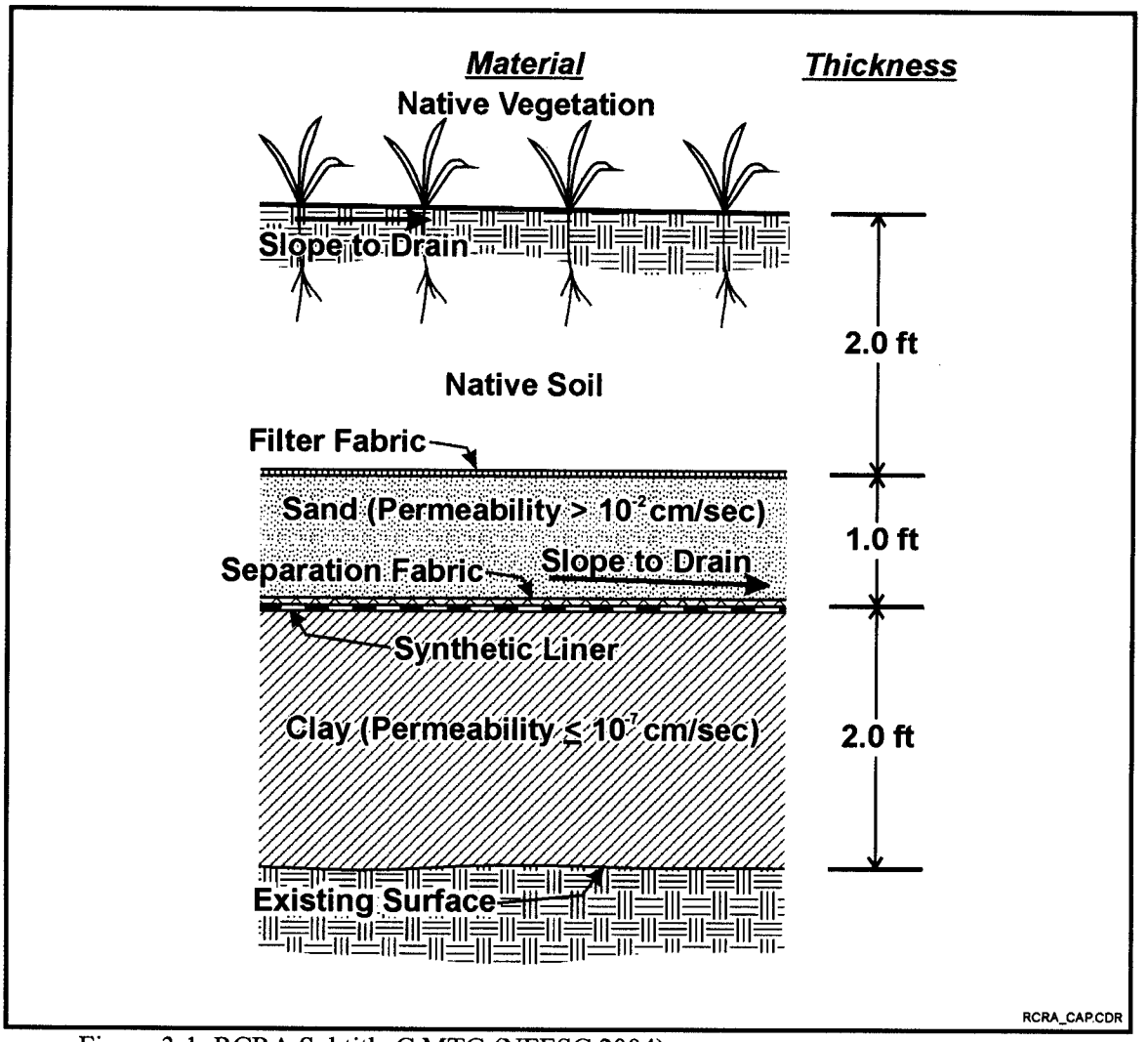

Figure 3-1. RCRA Subtitle C MTG (NFESC 2004)

Table 3-1. Comparison of RCRA Subtitle C MTG and Subtitle D covers.

Cap Element	Function	Subtitle C	Subtitle D
Upper vegetated layer	Support vegetation to control erosion	24 in	6 in
Drainage layer	Reduce hydraulic head on the geosynthetic membrane	12 in	Not required since no geosynthetic liner for water to accumulate on.
Geosynthetic membrane	Prevent infiltration	> 20 mil HDPE or other geosynthetic	None
Soil barrier layer	Prevent infiltration	24 in clay, compacted to 1E-07 cm/sec Ksat	12-in, compacted to 1E-05 cm/sec
Gas collection layer	Prevent accumulation of LFG which can rupture geosynthetic membrane	12 in sand/gravel w/PVC manifolded to blower	Not required unless structures are built on landfill or if methane concentrations exceed 25% LEL at property boundary

The Subtitle C MTG design was developed by EPA to meet the requirements listed in 40 CFR 264.310 and 265.310 cited previously. EPA (1989) states that "Landfill closure requirements are based on a two-part liquids management strategy of (1) minimizing the leachate generation by keeping liquids out of the unit, and (2) detecting, collecting, and removing leachate with the unit". The RCRA MTG design has been widely critiqued by State and Federal agencies (ITRC 2004) as inappropriate for closure of arid sites primarily because 1) the design relies on the installed condition (wet) for the compacted clay layer, which typically rapidly dessicates and cracks after (or even during) construction, thereby impairing performance; and 2) evapotranspiration demand in arid climates can effectively control the water balance, reducing infiltration to very small amounts, without reliance on compacted clay or geosynthetic membranes. The RCRA Subtitle D design is more consistent with current alternative cover design guidance (ITRC 2004), in that no geosynthetic membranes or compacted clay are used, resulting in a more permeable cover which also allows for diffusion of methane gas.

Over the long-term plant roots will eventually intrude into the barrier soil layer, increasing the bulk density and thereby increasing the Ksat, however the relatively high compaction of the layer will resist root intrusion for some time. As the rooting depth increases, the depth affected by plant transpiration also increases, thereby effectively controlling infiltration as evidenced by the HELP3 code modeling results summarized previously and presented in Appendix A.

4. SUMMARY

Overall, for the specific application at the LANL TA-73 Airport Landfill, the proposed design effectively meets all RCRA Subtitle C requirements. The average annual infiltration rate through the proposed cover of 0.01 in/yr calculated using HELP3 code, the NMED (1998)

guidance, and the five wettest years on record for LANL equate to an effective Ksat for the cover of 8.58E-10 cm/sec. These results demonstrate that the proposed design will effectively minimize infiltration and the migration of leachate.

The proposed design also contains the RCRA Subtitle C MTG cover design functional elements necessary for application to the TA-73 closure. Those functional elements not required are not present (e.g., no lateral drainage layer, no gas collection layer) and others are reduced in scale and performance requirements accordingly (e.g., low-permeability layer less thick and Ksat <1E-05). Given that contaminant transport to groundwater is not considered a threat to human health and the environment, as stated in the RFI Report Section 2.3.5 and discussed previously; and since "bathtubbing" is not an issue for this unlined landfill for reasons stated previously; the proposed design appears to effectively correlate to the recommended functional elements present in a Subtitle C MTG design cover for the TA-73 closure.

5. REFERENCES

D.B. Stephens & Associates, Inc. 1993, "Preliminary Geologic and Hydrologic Conceptual Model of the TA-73 Area, Los Alamos, New Mexico", January 1993.

EPA 1989, "Technical Guidance Document, Final Covers on Hazardous Waste Landfills and Surface Impoundments, EPA/530-SW-89-047, July 1989.

LANL 1998, "RFI Report for Potential Release Sites 73-001(a,b,c,d), 73-004(d), Airport Landfill Areas, LA-UR-98-3824, November 1998.

LANL 2002, "Voluntary Corrective Measure Plan for Potential Release Sites 73-001(a)-99 and 73-001(b)-99, LA-UR-02-4433, October 2002.

NFESC 2004, Naval Facilities Engineering Services Center, http://enviro.nfesc.navy.mil/erb/restoration/technologies/remed/contain_remove/cr-06.asp

ITRC 2003, "Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers, Interstate Technology & Regulatory Council, http://www.itrcweb.org/ALT-2.pdf, December 2003.

NMED 1998, "Guidance Document for Performance Demonstration for an Alternate Cover Design under Section 502.A.2 of the New Mexico Solid Waste Management Regulations (20 NMAC 9.1) Using HELP Modeling", April 1, 1998.

NMED 2003, "Conditional Approval of Voluntary Corrective Measures (VCM) Plan for Potential Release Sites (PRSs) 73-001(a)-99 and 73-001(b)-99, Los Alamos National Laboratory", April 1, 2003.

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

Appendix A: HELP3 Code Modeling Results

SIMULATION 1 — HELP OUTPUT FILE — RCRA SUBTITLE D

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:      C:\HELP3\LANM5.D4
TEMPERATURE DATA FILE:        C:\HELP3\LANM5.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\LANM5.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\LANM.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\SIM11.D10
OUTPUT DATA FILE:             C:\HELP3\sim11out.OUT


TIME:  16:55     DATE:   1/ 6/2004


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

     TITLE:  Los Alamos Landfill

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   8
        THICKNESS                    =      6.00   INCHES
        POROSITY                     =      0.4630 VOL/VOL
        FIELD CAPACITY               =      0.2320 VOL/VOL
        WILTING POINT                =      0.1160 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.1450 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.13
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2400	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.750	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.310	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.132	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.190	INCHES
TOTAL INITIAL WATER	=	5.190	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LOS ALAMOS NEW MEXICO

STATION LATITUDE	=	35.52	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.30	
START OF GROWING SEASON (JULIAN DATE)	=	135	
END OF GROWING SEASON (JULIAN DATE)	=	285	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.30	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.30	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	53.30	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 55.30 %

NOTE: PRECIPITATION DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: TEMPERATURE DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBUQUERQUE NEW MEXICO
AND STATION LATITUDE = 35.52 DEGREES

****

ANNUAL TOTALS FOR YEAR 1984

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.36	702768.187	100.00
RUNOFF	1.200	43551.582	6.20
EVAPOTRANSPIRATION	16.425	596225.812	84.84
PERC./LEAKAGE THROUGH LAYER 2	0.000211	7.671	0.00
CHANGE IN WATER STORAGE	1.735	62982.945	8.96
SOIL WATER AT START OF YEAR	5.190	188395.250	
SOIL WATER AT END OF YEAR	6.608	239866.094	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.317	11512.097	1.64
ANNUAL WATER BUDGET BALANCE	0.0000	0.155	0.00

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ANNUAL TOTALS FOR YEAR 1985

	INCHES	CU. FEET	PERCENT

PRECIPITATION	25.57	928191.062	100.00
RUNOFF	0.464	16826.957	1.81
EVAPOTRANSPIRATION	26.579	964805.687	103.94
PERC./LEAKAGE THROUGH LAYER 2	0.000347	12.588	0.00
CHANGE IN WATER STORAGE	-1.473	-53454.184	-5.76
SOIL WATER AT START OF YEAR	6.608	239866.094	
SOIL WATER AT END OF YEAR	5.452	197924.016	
SNOW WATER AT START OF YEAR	0.317	11512.097	1.24
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

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ANNUAL TOTALS FOR YEAR 1986

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.12	875556.187	100.00
RUNOFF	0.168	6103.321	0.70
EVAPOTRANSPIRATION	22.999	834860.625	95.35
PERC./LEAKAGE THROUGH LAYER 2	0.001335	48.445	0.01
CHANGE IN WATER STORAGE	0.952	34543.809	3.95
SOIL WATER AT START OF YEAR	5.452	197924.016	
SOIL WATER AT END OF YEAR	6.404	232467.828	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.011	0.00

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ANNUAL TOTALS FOR YEAR 1987

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.56	855228.000	100.00
RUNOFF	2.016	73167.516	8.56
EVAPOTRANSPIRATION	20.920	759404.812	88.80
PERC./LEAKAGE THROUGH LAYER 2	0.035379	1284.249	0.15
CHANGE IN WATER STORAGE	0.589	21371.484	2.50
SOIL WATER AT START OF YEAR	6.404	232467.828	
SOIL WATER AT END OF YEAR	6.095	221236.344	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.898	32602.967	3.81
ANNUAL WATER BUDGET BALANCE	0.0000	-0.065	0.00

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ANNUAL TOTALS FOR YEAR 1988

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.33	883179.312	100.00
RUNOFF	0.585	21243.098	2.41
EVAPOTRANSPIRATION	25.519	926356.625	104.89
PERC./LEAKAGE THROUGH LAYER 2	0.015982	580.148	0.07
CHANGE IN WATER STORAGE	-1.791	-65000.434	-7.36
SOIL WATER AT START OF YEAR	6.095	221236.344	
SOIL WATER AT END OF YEAR	5.202	188838.875	
SNOW WATER AT START OF YEAR	0.898	32602.967	3.69
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.095	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1984 THROUGH 1988

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.92	1.00	1.59	1.65	1.88	3.07
	2.74	4.00	2.30	2.00	1.04	1.20
STD. DEVIATIONS	0.91	1.07	1.01	0.98	0.79	1.96
	1.25	0.47	0.71	1.35	0.79	1.24
RUNOFF						
TOTALS	0.149	0.027	0.241	0.042	0.000	0.145
	0.000	0.035	0.008	0.003	0.000	0.237
STD. DEVIATIONS	0.242	0.038	0.501	0.070	0.000	0.141
	0.000	0.065	0.012	0.006	0.000	0.530
EVAPOTRANSPIRATION						
TOTALS	0.768	0.922	1.390	1.864	2.058	2.918
	3.016	3.903	2.189	1.572	1.165	0.723
STD. DEVIATIONS	0.235	0.413	0.863	0.323	1.146	1.542
	1.143	0.886	0.919	0.732	0.341	0.260
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0001	0.0001	0.0003	0.0004	0.0001
	0.0017	0.0026	0.0002	0.0034	0.0017	0.0001
STD. DEVIATIONS	0.0000	0.0001	0.0002	0.0007	0.0006	0.0002
	0.0023	0.0036	0.0003	0.0071	0.0027	0.0002

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1984 THROUGH 1988

	INCHES		CU. FEET	PERCENT
PRECIPITATION	23.39	(2.368)	848984.6	100.00

RUNOFF	0.886	(0.7346)	32178.50	3.790
EVAPOTRANSPIRATION	22.488	(4.0436)	816330.69	96.154
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.01065	(0.01534)	386.620	0.04554
CHANGE IN WATER STORAGE	0.002	(1.5522)	88.72	0.010

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PEAK DAILY VALUES FOR YEARS 1984 THROUGH 1988

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	78408.000
RUNOFF	0.870	31578.1309
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.003569	129.53833
SNOW WATER	2.38	86375.2578

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3339
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1740

****

****

FINAL WATER STORAGE AT END OF YEAR 1988

LAYER	(INCHES)	(VOL/VOL)
1	0.8332	0.1389
2	4.3690	0.2427
SNOW WATER	0.000	

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SIMULATION 2 — HELP OUTPUT FILE — VCMPLAN

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**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
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PRECIPITATION DATA FILE:     C:\HELP3\LANM5.D4
TEMPERATURE DATA FILE:       C:\HELP3\LANM5.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\LANM5.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\LANM.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\vcmplan.D10
OUTPUT DATA FILE:            C:\HELP3\vcmout.OUT


TIME:  17:20     DATE:   1/ 6/2004


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

     TITLE:  Los Alamos Landfill

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     12.00   INCHES
          POROSITY                     =      0.4630 VOL/VOL
          FIELD CAPACITY               =      0.2320 VOL/VOL
          WILTING POINT                =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1450 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.284000009000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0335	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.824999996000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.941	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.178	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.536	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1.941	INCHES
TOTAL INITIAL WATER	=	1.941	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LOS ALAMOS NEW MEXICO

STATION LATITUDE	=	35.52	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.30	
START OF GROWING SEASON (JULIAN DATE)	=	135	
END OF GROWING SEASON (JULIAN DATE)	=	285	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.30	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.30	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	53.30	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	55.30	%

NOTE: PRECIPITATION DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: TEMPERATURE DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBUQUERQUE NEW MEXICO
AND STATION LATITUDE = 35.52 DEGREES

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ANNUAL TOTALS FOR YEAR 1984

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.36	702768.187	100.00
RUNOFF	1.205	43735.566	6.22
EVAPOTRANSPIRATION	15.872	576146.437	81.98
PERC./LEAKAGE THROUGH LAYER 2	0.393408	14280.705	2.03
CHANGE IN WATER STORAGE	1.890	68605.008	9.76
SOIL WATER AT START OF YEAR	1.941	70458.297	
SOIL WATER AT END OF YEAR	3.514	127551.203	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.317	11512.097	1.64
ANNUAL WATER BUDGET BALANCE	0.0000	0.429	0.00

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ANNUAL TOTALS FOR YEAR 1985

	INCHES	CU. FEET	PERCENT

PRECIPITATION	25.57	928191.062	100.00
RUNOFF	0.527	19130.445	2.06
EVAPOTRANSPIRATION	25.246	916427.250	98.73
PERC./LEAKAGE THROUGH LAYER 2	1.249735	45365.367	4.89
CHANGE IN WATER STORAGE	-1.453	-52731.871	-5.68
SOIL WATER AT START OF YEAR	3.514	127551.203	
SOIL WATER AT END OF YEAR	2.378	86331.430	
SNOW WATER AT START OF YEAR	0.317	11512.097	1.24
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.130	0.00

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ANNUAL TOTALS FOR YEAR 1986

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.12	875556.187	100.00
RUNOFF	0.173	6281.281	0.72
EVAPOTRANSPIRATION	22.905	831462.562	94.96
PERC./LEAKAGE THROUGH LAYER 2	0.786285	28542.158	3.26
CHANGE IN WATER STORAGE	0.255	9270.083	1.06
SOIL WATER AT START OF YEAR	2.378	86331.430	
SOIL WATER AT END OF YEAR	2.634	95601.516	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.113	0.00

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ANNUAL TOTALS FOR YEAR 1987

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.56	855228.000	100.00
RUNOFF	2.033	73803.164	8.63
EVAPOTRANSPIRATION	20.462	742754.062	86.85
PERC./LEAKAGE THROUGH LAYER 2	0.518649	18826.955	2.20
CHANGE IN WATER STORAGE	0.547	19844.121	2.32
SOIL WATER AT START OF YEAR	2.634	95601.516	
SOIL WATER AT END OF YEAR	2.282	82842.672	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.898	32602.967	3.81
ANNUAL WATER BUDGET BALANCE	0.0000	-0.307	0.00

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ANNUAL TOTALS FOR YEAR 1988

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.33	883179.312	100.00
RUNOFF	0.610	22140.525	2.51
EVAPOTRANSPIRATION	24.397	885613.875	100.28
PERC./LEAKAGE THROUGH LAYER 2	0.617902	22429.842	2.54
CHANGE IN WATER STORAGE	-1.295	-47005.285	-5.32
SOIL WATER AT START OF YEAR	2.282	82842.672	
SOIL WATER AT END OF YEAR	1.885	68440.352	
SNOW WATER AT START OF YEAR	0.898	32602.967	3.69
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.411	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1984 THROUGH 1988

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.92	1.00	1.59	1.65	1.88	3.07
	2.74	4.00	2.30	2.00	1.04	1.20
STD. DEVIATIONS	0.91	1.07	1.01	0.98	0.79	1.96
	1.25	0.47	0.71	1.35	0.79	1.24
RUNOFF						
TOTALS	0.147	0.027	0.245	0.054	0.000	0.150
	0.000	0.038	0.009	0.003	0.000	0.238
STD. DEVIATIONS	0.241	0.037	0.502	0.088	0.000	0.146
	0.000	0.066	0.012	0.007	0.000	0.532
EVAPOTRANSPIRATION						
TOTALS	0.747	0.848	1.381	1.724	1.916	2.693
	3.210	3.774	2.180	1.471	1.133	0.701
STD. DEVIATIONS	0.265	0.482	0.736	0.212	1.154	1.534
	1.193	0.841	0.810	0.701	0.300	0.256
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0060	0.0177	0.0290	0.0777	0.1387	0.0281
	0.0507	0.0583	0.0718	0.0642	0.1327	0.0383
STD. DEVIATIONS	0.0086	0.0169	0.0209	0.0723	0.2039	0.0236
	0.0315	0.0464	0.0875	0.0831	0.1883	0.0475

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1984 THROUGH 1988

	INCHES		CU. FEET	PERCENT
PRECIPITATION	23.39	(2.368)	848984.6	100.00

RUNOFF	0.910	(0.7294)	33018.20	3.889
EVAPOTRANSPIRATION	21.776	(3.7674)	790480.87	93.109
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.71320	(0.33257)	25889.006	3.04941
CHANGE IN WATER STORAGE	-0.011	(1.3895)	-403.59	-0.048

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                PEAK DAILY VALUES FOR YEARS 1984 THROUGH 1988
   ------------------------------------------------------------------------
                                                (INCHES)       (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              2.16          78408.000

      RUNOFF                                     0.871         31612.1855

      PERCOLATION/LEAKAGE THROUGH LAYER  2       0.067321       2443.75073

      SNOW WATER                                 2.38          86375.2578

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2540

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0853

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FINAL WATER STORAGE AT END OF YEAR 1988

LAYER	(INCHES)	(VOL/VOL)
1	1.6759	0.1397
2	0.2095	0.0349
SNOW WATER	0.000	

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Comment #2. Section 2.0 Detailed Engineering Design, page 3: The Work Plan calls for a RCRA Subtitle D municipal landfill cover as described by NMAC regulations. The permittees incorrectly state that the selected remedy was prescribed by NMED. The prescribed remedy outlined in the April 1, 2003 letter to LANL explains that the final remedy for the Airport Landfill shall be equivalent to applicable RCRA Subtitle C requirements. The Permittees must provide the basis for the change in design.

Response: Comments incorporated. The following text will be added to the revised Phase 2 Work Plan in a new Section titled "Development of Design Basis".

1. BACKGROUND.

The VCM Plan (LANL 2003) presented three cover design alternatives for the TA-73 landfill. The three alternatives were comprised from a single cap conceptual design option (30-cm soil layer over a 15-cm gravel layer) and three grading plan options. The April 1, 2003 letter from NMED to LANL granting conditional approval for the VCM Plan (NMED 2003) stated that "The RFI Report recommended the final remedy for the Airport Landfill be consistent with RCRA Subtitle D regulations. Upon review of the RFI Report, NMED required the final remedy for the Airport Landfill be equivalent to applicable RCRA Subtitle C requirements. The VCM proposes the use of an engineered alternative earthen final cover. NMED approves the use of an engineered alternative earthen cover (cap) or RCRA Subtitle C equivalent cover, as long as the cover constructed will perform equivalent to or better than a standard RCRA Subtitle C prescriptive cover outlined in 40 CFR 265 subpart N, incorporated by 20.4.1.600 NMAC. The alternative cover must function efficiently and in accordance with the design parameters for the duration of the 30-year post closure care period."

On 12/15/03 Mr. Robert Enz of DOE-LASO met with Mr. Edward Hansen and Ms. Darlene Goering of NMED to discuss the TA-73 closure. At that time Mr. Hansen stated his preference that the TA-73 closure be modeled after the LANL TA-54 Area J closure, with 18 inches of engineered fill with a hydraulic conductivity of 1E-05 cm/sec overlain by 6 inches of soil to sustain native plant growth. This is the conceptual design of a RCRA Subtitle D landfill cover as prescribed in 40 CFR 258.60(a)(1-3) and in NMAC 20.9.1.500.B(1). Mr. Hansen stated that this design would provide for good venting for landfill gases, with some lateral migration although most of the methane has already been produced by this landfill.

Mr. Hansen provided the Hydrologic Evaluation of Landfill Performance (HELP) code modeling results for the TA-54 closure, including the weather data used; and the "Guidance Document for Performance Demonstration for an Alternate Cover Design under Section 502.A.2 of the New Mexico Solid Waste Management Regulations (20 NMAC 9.1) Using HELP Modeling" (NMED 1998).

Mr. Hansen also stated that the NMED Solid Waste Bureau would technically approve the design, and that the Hazardous Waste Bureau would give final approval.

Given that the direction provided by NMED on 12/15/03 appeared to supercede the NMED (2003) requirement for a Subtitle C-equivalent design, the approach used in the TA-73 conceptual design was to use the guidance document and weather data provided to assess equivalence, with respect to percolation of infiltration through the bottom of the cap, of the VCM Plan design relative to the RCRA Subtitle D design, which prescribes an 18-in soil layer with a saturated hydraulic conductivity (Ksat) of 1E-05 cm/sec overlain by 6-in topsoil (40 CFR 258.60(a)(1-3); NMAC 20.9.1.500.B(1)).

Modeling results are provided in Attachment 1 and are summarized in Table 1-1 below. Percolation through the bottom of the cap was calculated at 0.01 in/yr for the Subtitle D cap, vs. 0.71 in/yr for the VCM Plan design. NMED (1998) states that "If the two average annual percolation values are within 0.00001 in of each other, then the demonstration is successful since these values are practically equal (the definition of equivalent) and well within the modeling uncertainty." Based on this criterion the VCM Plan design would allow more infiltration than the NMED Subtitle D design.

Due to the way the HELP3 code is formulated (the code does not rigorously calculate the effects of a capillary barrier under unsaturated conditions), as well as the NMED-prescribed approach for modeling (using HELP and LANL weather data for the five wettest years on record), it appeared that the VCM Plan design would not meet the equivalency criterion. Note that the VCM Plan design coarse sand Layer 2 functioned as a capillary barrier; and that the VCM Plan modeling used UNSAT-H to calculate infiltration, which is a Richards equation-based code that more rigorously addresses the effects of capillary barriers than the water balance-based HELP3 code. Much more earthen material would have to be added to provide enough soil moisture storage capacity to approach the NMED-prescribed Subtitle D infiltration performance, as determined using the HELP3 code.

Table 1-1. Summary of HELP3 results for RCRA Subtitle D cover and VCM Plan conceptual design.

Parameters	**Design**	
	RCRA Subtitle D cover	**VCM Plan design**
Layer 1	6-in topsoil layer -- Soil Texture No. 8	12-in topsoil layer -- K= 2.84E-04
Layer 2	18-in soil layer -- K=1E-05-- Soil Texture No. 23	6-in coarse sand layer -- K=8.25E-03
Layer 3	No drainage layer	No drainage layer
Grass stand	Poor	Poor
CN Number	85.6	85.6
Top slope	3%	3%
Average drainage length	500 ft	500 ft
Evaporative Depth	18 inches	18 inches
Precipitation	23.39	23.39
Runoff	0.886	0.91
Evaporation	22.488	21.776
Percolation Thru Layer 2/3	0.01065	0.7132
Change in Storage	0.002	-0.011

2. COMPARISON OF PROPOSED COVER TO RCRA SUBTITLE C REQUIREMENTS.

Based on these results, the VCM Plan alternative cover conceptual design was abandoned and the prescribed Subtitle D cover was advanced as the more cost-efficient approach. To satisfy the VCM Plan Approval letter requirement that "the final remedy for the Airport Landfill be equivalent to applicable RCRA Subtitle C requirements", as outlined in 40 CFR 265 subpart N, these requirements were compared to the prescribed features and the modeled hydrologic performance of the Subtitle D cover. Table 2-1 below shows the results of this comparison.

Table 2-1. Comparison of proposed cover performance to RCRA Subtitle C requirements (40 CFR 265.310).

Number	RCRA Subtitle C Closure Cover Requirement	Extent to which the proposed cover does or does not meet the requirement
1	Provide long-term minimization of migration of liquids through the closed landfill	*Meets the requirement.* Modeled average annual infiltration rate using weather data for the 5 wettest years on record is only 0.01 in/year.
2	Function with minimum maintenance	*Meets the requirement.* The proposed cover consists almost entirely of earthen materials and vegetation, with minimal maintenance needs as discussed in the O&M Plan. No compacted clay layers or geosynthetic membranes are included, which typically require more expensive maintenance when breached by subsidence, excavation or other disturbance to the cover.
3	Promote drainage and minimize erosion or abrasion of the cover	*Meets the requirement.* The surface cover will provide erosion control using a vegetated topsoil surface and 3% maximum slope; with durable rock armor side slope surfaces. Supporting calculations are provided in the design.
4	Accommodate settling and subsidence so that the cover's integrity is maintained	*Meets the requirement.* The proposed cover consists almost entirely of earthen materials and vegetation. Earthen materials are self-healing and easily repaired, compared to geosynthetic membranes which can tear under the stress of bridging voids beneath the liner resulting from subsidences.
5	Have a permeability less than or equal to the permeability of any bottom liner or natural subsoils present	*Meets the requirement.* The landfill is not lined and is entirely underlain by the Bandelier Tuff. D.B. Stephens & Associates, Inc. (1993) report in "Preliminary Geologic and Hydrologic Conceptual Model of the TA-73 Area, Los Alamos, New Mexico", states that "Saturated hydraulic conductivity ranges over approximately two orders of magnitude in the Bandelier Tuff, from approximately 1E-03 cm/s to 1E-05 cm/s." The prescribed RCRA Subtitle D Ksat of 1E-05 cm/sec therefore meets this requirement (see discussion below).

The permeability of the natural subsoils present is addressed in D.B. Stephens & Associates, Inc. (1993), which discusses the geology and hydrogeology of the vadose zone under TA-73-001(a). The report describes the stratigraphy as (top to bottom):

1. The Quaternary Bandelier Tuff of the Tewa Group, consisting of sequences of non-welded to welded rhyolitic ash flows and pumice. Three members are identified (top to bottom):

    a. The Tshirege Member, consisting of alternating beds of ash-fall pumice. The extent of welding in the Tshirege member underlying TA-73 is not described.

    b. The Otowi Member, described as a crystal-rich rhyolitic tuff that is non-welded and vitric throughout.

    c. The Guaje Member, consisting of a bedded ash-fall pumice.

2. the Tertiary/Quaternary Puye conglomerate of the Santa Fe Group, consisting of:

    a. The upper fanglomerate which consists of poorly consolidated, silty, sandy conglomerate, with interbedded lapilli tuff and volcanic mudflow deposits.

    b. The lower Totavi Lentil, consisting of well rounded pebbles, cobbles, and boulders in a matrix of coarse, arkosic sandstone.

3. The Miocene Tesuque Formation of the Santa Fe Group, consisting mainly of tuffaceous sand and silt, gravels, and possibly some interbedded basalts.

D.B. Stephens & Associates, Inc. (1993) reported in situ and laboratory-determined hydrologic information for the geologic units underlying TA-73. Data were obtained from an earlier D.B. Stephens & Associates (1991) report for the Bandelier Tuff in Mortandad Canyon and from the TA-21 Draft RFI Work Plan. Results are summarized in Table 2-2 below.

Table 2-2. Hydrologic properties of geologic units underlying TA-73 (D.B. Stephens & Associates, Inc. (1993))

Geologic Unit	Ksat, cm/sec	Notes
Bandelier Tuff		
Tshirege member	3.0E-03 to 4.7E-05	a
	1.0E-03 to 9.7E-05	b
Tsankawi Pumice[c]	2.0E-03 to 5.8E-05	a
	4.8E-04	b
Otowi member	4.3E-03 to 7.9E-04	a
	9.6E-04	b
Guaje Member	4.8E-04	b
Puye Conglomerate		
Fanglomerate member	4.8E-03	b

Geologic Unit	Ksat, cm/sec	Notes
Interbedded basalts	9.6E-04	b
Totavi Lentil[d]	3.9E-01	b

a: Laboratory data for samples from Mortandad Canyon

b: Field and laboratory data from USGS work in the 1950s and 1960s, and air/waste injection tests conducted by Bendix Corp. in the mid 1980s.

c: Tsankawi Pumice and Cerro Toledo were extrapolated to TA-73 from the TA-21 work plan schematic cross section.

d: Totavi Lentil hydraulic conductivity was estimated from pump tests in TW-2 and TW-3.

The D.B. Stephens & Associates, Inc. (1993) report states that overall the calculated hydraulic conductivities obtained from the different tests show generally good correlation. The report cites structural characteristics, including joints and fractures, and textural characteristics (induration or welding) as the principal factors affecting hydraulic properties of the Bandelier Tuff, while noting that correlation between observed geology and calculated hydraulic parameters has not been established. Ksat values for moderately to densely welded units of the Bandelier Tuff would be expected to differ significantly from those for non-welded tuff. Samples of Bandelier Tuff obtained by D.B. Stephens & Associates, Inc. from Mortandad Canyon ranged from no welding to slightly welded. The report concludes that "Without new data, it must be assumed that the hydraulic parameters determined for similar geologic units in the Los Alamos area are representative of site conditions."

A later report by Rogers and Gallagher (1995) referenced in the VCM Plan cites a Ksat value of 2.84E-04 cm/sec for the Tshirege Member of the Bandelier Tuff. This report was not available and it is unknown how this value was obtained. However, it is within the range reported in D.B. Stephens & Associates (1993).

The Ksat range reported in D.B. Stephens & Associates (1993) appears to be supported by soil gas and lysimeter sampling results from the RFI Report, and by inspection of the landfill and it's surroundings. Even in the current condition, i.e. with a thin interim soil cover that has subsided about 6 ft overall, the landfill shows no evidence of "bathtubbing" or other accumulation or discharge of leachate.

The RFI Report Executive Summary further states that "Measurements of the soil water potentials confirm relatively wet, but unsaturated, conditions within the refuse and within the tuff immediately surrounding the refuse." "Samples collected from the tuff bordering the landfill indicate increasingly dry conditions, demonstrating a decreasing trend in the potential for migration. A reduction in available moisture, from implementing surface water run-on controls, will further reduce the potential for contaminant migration".

These findings are further corroborated by the results of the cone penetrometer survey performed in January 2004 which found pore pressures indicative of unsaturated conditions throughout the landfill. These results are provided in the Site Characterization Report, to be provided with the revised Phase 2 Work Plan.

A large Ksat difference between the waste and the tuff would be expected to create saturated conditions in the waste at the interface. The average Ksat for municipal solid waste cited in the HELP3 code documentation is 1E-03 cm/sec. Given these lines of evidence for the

current unclosed condition, i.e. unsaturated conditions in the waste, low soil moisture contents in the tuff underlying the landfill, no evidence of perching of leachate at the tuff-waste contact, and no discharge of leachate observed into Pueblo Canyon; then the Ksat range for the Bandelier Tuff under TA-73 reported by D. B. Stephens, Inc. (1993) of 1E-03 to 1E-05 cm/sec appears reasonable.

The RFI Report Section 2.3.5 states "The potential transport to groundwater was not included in the preliminary site conceptual model due to the considerable depth to the regional aquifer" (about 1200 ft), "and the results of the site investigation activities support this premise. The results show that VOC concentrations in soil gas attenuate significantly with distance away from the landfill. In addition, relatively small amounts of leachate appear to occur at isolated locations beneath the landfill. The leachate contains very low levels of organics and somewhat higher levels of some inorganics; however the potential for transport of these constituents is expected to be limited." Concentrations of VOCs and inorganics detected in TA-73 pore water reported in RFI Report Tables 2.3.5.1-2 and 2.3.5.1-3 corroborate this assessment. Four VOCs and four inorganics were detected above the EPA Drinking Water MCLs. The magnitudes of the exceedences are low enough that sorption and dispersion, and degradation of organics, would be expected to reduce concentrations to allowable levels well before reaching groundwater receptors.

3. COMPARISON OF PROPOSED COVER TO RCRA SUBTITLE C GUIDANCE.

The proposed TA-73 cover is compared to current EPA guidance for Subtitle C landfill covers in this section. EPA developed a series of guidance documents to help owner/operators meet the Subtitle C requirements including "Technical Guidance Document, Final Covers on Hazardous Waste Landfills and Surface Impoundments" (EPA 1989). EPA 1989 describes the recommended RCRA Subtitle C design as depicted in Figure 3-1 below, hereafter referred to as the RCRA Subtitle C Minimum Technology Guidance (MTG) cover. The features of RCRA Subtitle C MTG and Subtitle D prescribed covers are compared in Table 3-1. The primary differences between Subtitle C and D designs are a lack of a lateral drainage layer, geosynthetic membrane and gas collection layer for the Subtitle D design; as well as a less thick upper vegetated layer, and a less thick, higher permeability soil barrier layer.

The lateral drainage layer has no function if the cap does not have a geosynthetic membrane and therefore the Subtitle D design does not require this layer. Similarly, the gas collection layer has no function if the cap does not have a geosynthetic membrane, and if the landfill does not have structures built on it, or if methane concentrations do not exceed 25% of the LEL at the property boundary. As discussed in Section 2.3.5.1(b) of the RFI Report the methane plume is entirely confined within the property boundary and concentrations of methane are below the LEL everywhere along the property boundary. Figure 2.3.5.1-5 shows the approximate lateral extent of methane in soil gas at the main landfill. The eastern extent of methane is bounded by monitoring well LP-2, and the western extent by LP-5 and LP-9, neither of which has shown detectable methane concentrations during multiple sampling events. The northern extent of the landfill gas plume is bounded by LPS-1 and LP-8, which contain little or no methane.

Additionally, RFI Report Section 2.3.4.3(d) describes a field screening survey performed along the south wall of Pueblo Canyon to determine if landfill gas (LFG) including methane could be detected. LFG was not detected in animal burrows, fissures or joints along the wall of Pueblo Canyon north of the boundary fence along the northern perimeter of the TA-73 main landfill.

The South boundary of the methane plume shown in Figure 2.3.5.1-5 is inferred as extending under the runway. No soil gas monitoring locations were installed under the runway or between the runway and the property boundary. However the property boundary is over 100 ft from the inferred southern extent of the methane plume and therefore concentrations at the property boundary are expected to be well below the LEL.

The TA-73 landfill does not have structures built on it and methane concentrations are near or below detection limits everywhere along the property boundary. Therefore a gas collection layer is not required as a functional element of the proposed design.

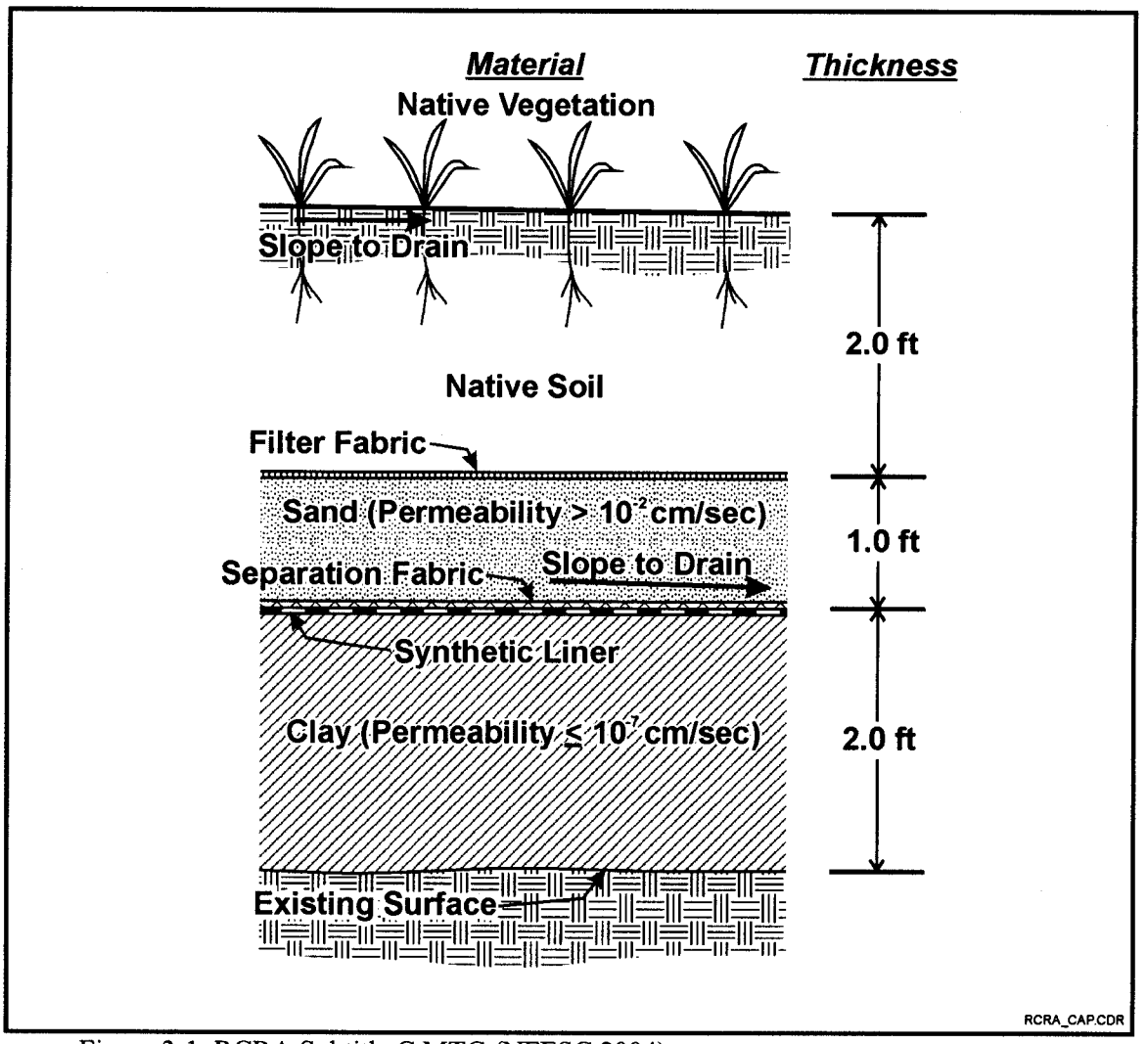

Figure 3-1. RCRA Subtitle C MTG (NFESC 2004)

Table 3-1. Comparison of RCRA Subtitle C MTG and Subtitle D covers.

Cap Element	Function	Subtitle C	Subtitle D
Upper vegetated layer	Support vegetation to control erosion	24 in	6 in
Drainage layer	Reduce hydraulic head on the geosynthetic membrane	12 in	Not required since no geosynthetic liner for water to accumulate on.
Geosynthetic membrane	Prevent infiltration	> 20 mil HDPE or other geosynthetic	None
Soil barrier layer	Prevent infiltration	24 in clay, compacted to 1E-07 cm/sec Ksat	12-in, compacted to 1E-05 cm/sec
Gas collection layer	Prevent accumulation of LFG which can rupture geosynthetic membrane	12 in sand/gravel w/PVC manifolded to blower	Not required unless structures are built on landfill or if methane concentrations exceed 25% LEL at property boundary

The Subtitle C MTG design was developed by EPA to meet the requirements listed in 40 CFR 264.310 and 265.310 cited previously. EPA (1989) states that "Landfill closure requirements are based on a two-part liquids management strategy of (1) minimizing the leachate generation by keeping liquids out of the unit, and (2) detecting, collecting, and removing leachate with the unit". The RCRA MTG design has been widely critiqued by State and Federal agencies (ITRC 2004) as inappropriate for closure of arid sites primarily because 1) the design relies on the installed condition (wet) for the compacted clay layer, which typically rapidly dessicates and cracks after (or even during) construction, thereby impairing performance; and 2) evapotranspiration demand in arid climates can effectively control the water balance, reducing infiltration to very small amounts, without reliance on compacted clay or geosynthetic membranes. The RCRA Subtitle D design is more consistent with current alternative cover design guidance (ITRC 2004), in that no geosynthetic membranes or compacted clay are used, resulting in a more permeable cover which also allows for diffusion of methane gas.

Over the long-term plant roots will eventually intrude into the barrier soil layer, increasing the bulk density and thereby increasing the Ksat, however the relatively high compaction of the layer will resist root intrusion for some time. As the rooting depth increases, the depth affected by plant transpiration also increases, thereby effectively controlling infiltration as evidenced by the HELP3 code modeling results summarized previously and presented in Appendix A.

4. SUMMARY

Overall, for the specific application at the LANL TA-73 Airport Landfill, the proposed design effectively meets all RCRA Subtitle C requirements. The average annual infiltration rate through the proposed cover of 0.01 in/yr calculated using HELP3 code, the NMED (1998)

guidance, and the five wettest years on record for LANL equate to an effective Ksat for the cover of 8.58E-10 cm/sec. These results demonstrate that the proposed design will effectively minimize infiltration and the migration of leachate.

The proposed design also contains the RCRA Subtitle C MTG cover design functional elements necessary for application to the TA-73 closure. Those functional elements not required are not present (e.g., no lateral drainage layer, no gas collection layer) and others are reduced in scale and performance requirements accordingly (e.g., low-permeability layer less thick and Ksat <1E-05). Given that contaminant transport to groundwater is not considered a threat to human health and the environment, as stated in the RFI Report Section 2.3.5 and discussed previously; and since "bathtubbing" is not an issue for this unlined landfill for reasons stated previously; the proposed design appears to effectively correlate to the recommended functional elements present in a Subtitle C MTG design cover for the TA-73 closure.

5. REFERENCES

D.B. Stephens & Associates, Inc. 1993, "Preliminary Geologic and Hydrologic Conceptual Model of the TA-73 Area, Los Alamos, New Mexico", January 1993.

EPA 1989, "Technical Guidance Document, Final Covers on Hazardous Waste Landfills and Surface Impoundments, EPA/530-SW-89-047, July 1989.

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Appendix A: HELP3 Code Modeling Results

SIMULATION 1 — HELP OUTPUT FILE — RCRA SUBTITLE D

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


PRECIPITATION DATA FILE:     C:\HELP3\LANM5.D4
TEMPERATURE DATA FILE:       C:\HELP3\LANM5.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\LANM5.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\LANM.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\SIM11.D10
OUTPUT DATA FILE:            C:\HELP3\sim11out.OUT


TIME:  16:55     DATE:   1/ 6/2004


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

     TITLE:  Los Alamos Landfill

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   8
          THICKNESS                   =      6.00   INCHES
          POROSITY                    =      0.4630 VOL/VOL
          FIELD CAPACITY              =      0.2320 VOL/VOL
          WILTING POINT               =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT  =      0.1450 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  2.13
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	18.00	INCHES
POROSITY	=	0.4610	VOL/VOL
FIELD CAPACITY	=	0.3600	VOL/VOL
WILTING POINT	=	0.2030	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2400	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999999975000E-05	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.750	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.310	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.132	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	5.190	INCHES
TOTAL INITIAL WATER	=	5.190	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LOS ALAMOS NEW MEXICO

STATION LATITUDE	=	35.52	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.30	
START OF GROWING SEASON (JULIAN DATE)	=	135	
END OF GROWING SEASON (JULIAN DATE)	=	285	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.30	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.30	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	53.30	%

AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 55.30 %

NOTE: PRECIPITATION DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: TEMPERATURE DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBUQUERQUE NEW MEXICO
AND STATION LATITUDE = 35.52 DEGREES

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ANNUAL TOTALS FOR YEAR 1984

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.36	702768.187	100.00
RUNOFF	1.200	43551.582	6.20
EVAPOTRANSPIRATION	16.425	596225.812	84.84
PERC./LEAKAGE THROUGH LAYER 2	0.000211	7.671	0.00
CHANGE IN WATER STORAGE	1.735	62982.945	8.96
SOIL WATER AT START OF YEAR	5.190	188395.250	
SOIL WATER AT END OF YEAR	6.608	239866.094	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.317	11512.097	1.64
ANNUAL WATER BUDGET BALANCE	0.0000	0.155	0.00

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ANNUAL TOTALS FOR YEAR 1985

	INCHES	CU. FEET	PERCENT

PRECIPITATION	25.57	928191.062	100.00
RUNOFF	0.464	16826.957	1.81
EVAPOTRANSPIRATION	26.579	964805.687	103.94
PERC./LEAKAGE THROUGH LAYER 2	0.000347	12.588	0.00
CHANGE IN WATER STORAGE	-1.473	-53454.184	-5.76
SOIL WATER AT START OF YEAR	6.608	239866.094	
SOIL WATER AT END OF YEAR	5.452	197924.016	
SNOW WATER AT START OF YEAR	0.317	11512.097	1.24
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

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ANNUAL TOTALS FOR YEAR 1986

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.12	875556.187	100.00
RUNOFF	0.168	6103.321	0.70
EVAPOTRANSPIRATION	22.999	834860.625	95.35
PERC./LEAKAGE THROUGH LAYER 2	0.001335	48.445	0.01
CHANGE IN WATER STORAGE	0.952	34543.809	3.95
SOIL WATER AT START OF YEAR	5.452	197924.016	
SOIL WATER AT END OF YEAR	6.404	232467.828	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.011	0.00

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ANNUAL TOTALS FOR YEAR 1987

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.56	855228.000	100.00
RUNOFF	2.016	73167.516	8.56
EVAPOTRANSPIRATION	20.920	759404.812	88.80
PERC./LEAKAGE THROUGH LAYER 2	0.035379	1284.249	0.15
CHANGE IN WATER STORAGE	0.589	21371.484	2.50
SOIL WATER AT START OF YEAR	6.404	232467.828	
SOIL WATER AT END OF YEAR	6.095	221236.344	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.898	32602.967	3.81
ANNUAL WATER BUDGET BALANCE	0.0000	-0.065	0.00

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ANNUAL TOTALS FOR YEAR 1988

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.33	883179.312	100.00
RUNOFF	0.585	21243.098	2.41
EVAPOTRANSPIRATION	25.519	926356.625	104.89
PERC./LEAKAGE THROUGH LAYER 2	0.015982	580.148	0.07
CHANGE IN WATER STORAGE	-1.791	-65000.434	-7.36
SOIL WATER AT START OF YEAR	6.095	221236.344	
SOIL WATER AT END OF YEAR	5.202	188838.875	
SNOW WATER AT START OF YEAR	0.898	32602.967	3.69
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.095	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1984 THROUGH 1988

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.92	1.00	1.59	1.65	1.88	3.07
	2.74	4.00	2.30	2.00	1.04	1.20
STD. DEVIATIONS	0.91	1.07	1.01	0.98	0.79	1.96
	1.25	0.47	0.71	1.35	0.79	1.24
RUNOFF						
TOTALS	0.149	0.027	0.241	0.042	0.000	0.145
	0.000	0.035	0.008	0.003	0.000	0.237
STD. DEVIATIONS	0.242	0.038	0.501	0.070	0.000	0.141
	0.000	0.065	0.012	0.006	0.000	0.530
EVAPOTRANSPIRATION						
TOTALS	0.768	0.922	1.390	1.864	2.058	2.918
	3.016	3.903	2.189	1.572	1.165	0.723
STD. DEVIATIONS	0.235	0.413	0.863	0.323	1.146	1.542
	1.143	0.886	0.919	0.732	0.341	0.260
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0000	0.0001	0.0001	0.0003	0.0004	0.0001
	0.0017	0.0026	0.0002	0.0034	0.0017	0.0001
STD. DEVIATIONS	0.0000	0.0001	0.0002	0.0007	0.0006	0.0002
	0.0023	0.0036	0.0003	0.0071	0.0027	0.0002

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1984 THROUGH 1988

	INCHES		CU. FEET	PERCENT
PRECIPITATION	23.39	(2.368)	848984.6	100.00

RUNOFF	0.886	(0.7346)	32178.50	3.790
EVAPOTRANSPIRATION	22.488	(4.0436)	816330.69	96.154
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.01065	(0.01534)	386.620	0.04554
CHANGE IN WATER STORAGE	0.002	(1.5522)	88.72	0.010

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PEAK DAILY VALUES FOR YEARS 1984 THROUGH 1988

	(INCHES)	(CU. FT.)
PRECIPITATION	2.16	78408.000
RUNOFF	0.870	31578.1309
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.003569	129.53833
SNOW WATER	2.38	86375.2578

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3339
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1740

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FINAL WATER STORAGE AT END OF YEAR 1988

LAYER	(INCHES)	(VOL/VOL)
1	0.8332	0.1389
2	4.3690	0.2427
SNOW WATER	0.000	

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SIMULATION 2 — HELP OUTPUT FILE — VCMPLAN

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


PRECIPITATION DATA FILE:      C:\HELP3\LANM5.D4
TEMPERATURE DATA FILE:        C:\HELP3\LANM5.D7
SOLAR RADIATION DATA FILE:    C:\HELP3\LANM5.D13
EVAPOTRANSPIRATION DATA:      C:\HELP3\LANM.D11
SOIL AND DESIGN DATA FILE:    C:\HELP3\vcmplan.D10
OUTPUT DATA FILE:             C:\HELP3\vcmout.OUT


TIME:  17:20     DATE:   1/ 6/2004


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

     TITLE:  Los Alamos Landfill

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


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                  LAYER  1
                                  --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      12.00   INCHES
          POROSITY                     =       0.4630 VOL/VOL
          FIELD CAPACITY               =       0.2320 VOL/VOL
          WILTING POINT                =       0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT   =       0.1450 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.284000009000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	6.00	INCHES
POROSITY	=	0.4370	VOL/VOL
FIELD CAPACITY	=	0.0620	VOL/VOL
WILTING POINT	=	0.0240	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0335	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.824999996000E-02	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A POOR STAND OF GRASS, A SURFACE SLOPE OF 3.% AND A SLOPE LENGTH OF 500. FEET.

SCS RUNOFF CURVE NUMBER	=	85.60	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.000	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.941	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.178	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.536	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1.941	INCHES
TOTAL INITIAL WATER	=	1.941	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LOS ALAMOS NEW MEXICO

STATION LATITUDE	=	35.52	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.30	
START OF GROWING SEASON (JULIAN DATE)	=	135	
END OF GROWING SEASON (JULIAN DATE)	=	285	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	6.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	54.30	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	41.30	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	53.30	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	55.30	%

NOTE: PRECIPITATION DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: TEMPERATURE DATA FOR LOS ALAMOS NEW MEXICO
WAS ENTERED FROM A NOAA DATA FILE.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR ALBUQUERQUE NEW MEXICO
AND STATION LATITUDE = 35.52 DEGREES

****

ANNUAL TOTALS FOR YEAR 1984

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.36	702768.187	100.00
RUNOFF	1.205	43735.566	6.22
EVAPOTRANSPIRATION	15.872	576146.437	81.98
PERC./LEAKAGE THROUGH LAYER 2	0.393408	14280.705	2.03
CHANGE IN WATER STORAGE	1.890	68605.008	9.76
SOIL WATER AT START OF YEAR	1.941	70458.297	
SOIL WATER AT END OF YEAR	3.514	127551.203	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.317	11512.097	1.64
ANNUAL WATER BUDGET BALANCE	0.0000	0.429	0.00

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ANNUAL TOTALS FOR YEAR 1985

	INCHES	CU. FEET	PERCENT

PRECIPITATION	25.57	928191.062	100.00
RUNOFF	0.527	19130.445	2.06
EVAPOTRANSPIRATION	25.246	916427.250	98.73
PERC./LEAKAGE THROUGH LAYER 2	1.249735	45365.367	4.89
CHANGE IN WATER STORAGE	-1.453	-52731.871	-5.68
SOIL WATER AT START OF YEAR	3.514	127551.203	
SOIL WATER AT END OF YEAR	2.378	86331.430	
SNOW WATER AT START OF YEAR	0.317	11512.097	1.24
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.130	0.00

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ANNUAL TOTALS FOR YEAR 1986

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.12	875556.187	100.00
RUNOFF	0.173	6281.281	0.72
EVAPOTRANSPIRATION	22.905	831462.562	94.96
PERC./LEAKAGE THROUGH LAYER 2	0.786285	28542.158	3.26
CHANGE IN WATER STORAGE	0.255	9270.083	1.06
SOIL WATER AT START OF YEAR	2.378	86331.430	
SOIL WATER AT END OF YEAR	2.634	95601.516	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.113	0.00

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ANNUAL TOTALS FOR YEAR 1987

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.56	855228.000	100.00
RUNOFF	2.033	73803.164	8.63
EVAPOTRANSPIRATION	20.462	742754.062	86.85
PERC./LEAKAGE THROUGH LAYER 2	0.518649	18826.955	2.20
CHANGE IN WATER STORAGE	0.547	19844.121	2.32
SOIL WATER AT START OF YEAR	2.634	95601.516	
SOIL WATER AT END OF YEAR	2.282	82842.672	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.898	32602.967	3.81
ANNUAL WATER BUDGET BALANCE	0.0000	-0.307	0.00

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ANNUAL TOTALS FOR YEAR 1988

	INCHES	CU. FEET	PERCENT
PRECIPITATION	24.33	883179.312	100.00
RUNOFF	0.610	22140.525	2.51
EVAPOTRANSPIRATION	24.397	885613.875	100.28
PERC./LEAKAGE THROUGH LAYER 2	0.617902	22429.842	2.54
CHANGE IN WATER STORAGE	-1.295	-47005.285	-5.32
SOIL WATER AT START OF YEAR	2.282	82842.672	
SOIL WATER AT END OF YEAR	1.885	68440.352	
SNOW WATER AT START OF YEAR	0.898	32602.967	3.69
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.411	0.00

****

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1984 THROUGH 1988

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.92	1.00	1.59	1.65	1.88	3.07
	2.74	4.00	2.30	2.00	1.04	1.20
STD. DEVIATIONS	0.91	1.07	1.01	0.98	0.79	1.96
	1.25	0.47	0.71	1.35	0.79	1.24
RUNOFF						
TOTALS	0.147	0.027	0.245	0.054	0.000	0.150
	0.000	0.038	0.009	0.003	0.000	0.238
STD. DEVIATIONS	0.241	0.037	0.502	0.088	0.000	0.146
	0.000	0.066	0.012	0.007	0.000	0.532
EVAPOTRANSPIRATION						
TOTALS	0.747	0.848	1.381	1.724	1.916	2.693
	3.210	3.774	2.180	1.471	1.133	0.701
STD. DEVIATIONS	0.265	0.482	0.736	0.212	1.154	1.534
	1.193	0.841	0.810	0.701	0.300	0.256
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0060	0.0177	0.0290	0.0777	0.1387	0.0281
	0.0507	0.0583	0.0718	0.0642	0.1327	0.0383
STD. DEVIATIONS	0.0086	0.0169	0.0209	0.0723	0.2039	0.0236
	0.0315	0.0464	0.0875	0.0831	0.1883	0.0475

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1984 THROUGH 1988

	INCHES		CU. FEET	PERCENT
PRECIPITATION	23.39	(2.368)	848984.6	100.00

RUNOFF	0.910	(0.7294)	33018.20	3.889
EVAPOTRANSPIRATION	21.776	(3.7674)	790480.87	93.109
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.71320	(0.33257)	25889.006	3.04941
CHANGE IN WATER STORAGE	-0.011	(1.3895)	-403.59	-0.048

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                PEAK DAILY VALUES FOR YEARS 1984 THROUGH 1988
   ----------------------------------------------------------------------
                                                (INCHES)       (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              2.16          78408.000

      RUNOFF                                     0.871         31612.1855

      PERCOLATION/LEAKAGE THROUGH LAYER  2       0.067321       2443.75073

      SNOW WATER                                 2.38          86375.2578

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2540

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0853

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FINAL WATER STORAGE AT END OF YEAR 1988

LAYER	(INCHES)	(VOL/VOL)
1	1.6759	0.1397
2	0.2095	0.0349
SNOW WATER	0.000	

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