Section 3. Engineering Design

The remedy for OU-1 was selected in accordance with CERCLA, Title 42 United States Code (U.S.C.) § 9601 et seq., as amended, and the NCP, Title 40 Code of Federal Regulations (CFR) Part 300. The selected remedy is consistent with the EPA's presumptive remedy guidance for CERCLA municipal landfill sites (EPA, 1993a and 1993b) and the NCP.

The selected remedy for OU-1 addresses on-site control of COCs through:

- Containment of the waste mass through installation of an impermeable landfill cover system
- Control of surface water runoff and erosion
- Control and passive extraction of LFG
- Long-term monitoring and maintenance
- Implementation of institutional controls (ICs) to limit land and resource use

To support the RD, ERRG conducted a pre-design investigation to evaluate existing site conditions and subsurface geotechnical conditions in support of relocation of waste, design of the multilayer cap and cover system, and site regrading. Results of the geotechnical tests performed during the pre-design investigation are presented in Subsection 1.7. The detailed summary of the pre-design investigation is provided in Appendix B.

Using the pre-design investigation information, calculations were performed to appropriately size the area where excavated waste will be placed, assign the slope of the cover, identify the properties of the products to be used to construct the multilayer cap, and to evaluate the stability of the cap. The calculations are provided in Appendix C.

The design included an analysis of available geotechnical data for the site (Appendix D) and was further developed, refined, and evaluated using computer modeling tools. Information derived from the pre-design investigations was used to assign input parameters to the slope stability analysis (XSTABL) (Sharma, 2003) model and the Hydrologic Evaluation of Landfill Performance (HELP) (EPA, 1994) model (Appendix D).

The following sections discuss the basis of design and design details associated with relocation of waste and construction of the landfill cover components.

3.1. BASIS OF DESIGN

The basis of design for the RD is based on the RAOs for OU-1 and the ARARs provided in the ROD (Forest Service, 2007). The design also adheres to the specific guidelines described in the ROD (Forest

Service, 2007) and the scope of work for this project. This section describes each of the design requirements and identifies the design element(s) selected for this remedy to specifically address the design requirements. Table 3 summarizes the basis of design evaluation.

3.1.1. Remedial Action Objectives

The RAOs for OU-1 (see Section 2) were aligned with the typical RAOs for the CERCLA presumptive remedy for municipal landfills (EPA, 1993a and 1993b), as shown in the following table.

RAOs for OU-1 (Forest Service, 2007)	Typical RAOs for the CERCLA Presumptive Remedy (EPA, 1993a and 1993b)
Landfill area: Protect humans and wildlife from exposure to landfill refuse and soil contamination by eliminating exposure pathways and contaminant migration.	Prevent direct contact with landfill contents
Source area groundwater: Minimize the effects of landfill refuse and soil contaminants on groundwater quality (e.g., rainwater infiltration) and rainwater runon.	Minimize infiltration and any resulting contaminant leaching to groundwater and control surface water runoff and erosion
LFG: Protect humans and wildlife by minimizing exposure pathways and gas migration.	Control and, if necessary, treat LFG

The specific design elements achieve each of the RAOs, as discussed in the following subsections. The presumptive remedy also identifies collection and treatment of contaminated leachate as a typical RAO; this RAO will be addressed by the OU-2 remedy.

3.1.1.1. Landfill Area: Protect Humans and Wildlife from Exposure to Landfill Refuse and Soil Contamination

This RAO requires that the remedial action protect humans and wildlife from exposure to landfill refuse and soil contamination by eliminating exposure pathways and contaminant migration. In accordance with the CERCLA presumptive remedy (EPA, 1993a and 1993b), this RAO is achieved by preventing direct contact with the landfill contents. Exposure depths for humans and wildlife are up to 3 feet bgs. To eliminate exposure pathways and contaminant migration, the design incorporates a multilayer cap system to contain the waste. The multilayer cap includes a 2-foot foundation layer, a low hydraulic conductivity layer, a drainage layer, and a 3-foot erosion-resistant vegetative layer over the landfill waste to protect humans and wildlife from direct contact with waste materials. The total thickness of the multilayer cap exceeds the required thickness of this RAO due to the need to prevent frost-related damage to the liner (per 27 CCR), as discussed in Subsection 3.1.2.3.

3.1.1.2. Source Area Groundwater: Minimize the Effects of Landfill Refuse and Soil Contaminants on Groundwater Quality and Rainwater Runon

This RAO requires that the effects of landfill refuse and soil contaminants on groundwater be minimized. In accordance with the CERCLA presumptive remedy (EPA, 1993a and 1993b), this RAO is achieved by minimizing infiltration and any resulting contaminant leaching to groundwater and by controlling surface water runoff and erosion. The design includes a 60-mil linear low-density polyethylene (LLDPE) geomembrane liner within the multilayer cover system to address infiltration and leaching of landfill contaminants into groundwater. A geomembrane liner was selected instead of a low-permeability clay layer identified in the prescriptive cap and cover system (27 CCR) because it is more resilient through freeze-thaw cycles.

The design includes surface water controls for all precipitation and snowmelt and on-site infiltration, so that migration pathways for COCs from the landfill to groundwater and surface water are controlled. The design controls surface water runoff through construction of a surface water system that routes flow to infiltration areas located outside the extent of waste. Groundwater flow from perched groundwater into the waste is controlled by extending the existing French drain system on the west side of the landfill. An erosion-resistant vegetative cover will be put in place using grasses and other shallow-rooted plants native to the South Lake Tahoe area. The vegetative cover will protect the multilayer cover system from in-place erosion.

3.1.1.3. LFG: Protect Humans and Wildlife by Minimizing Exposure Pathways and Gas Migration

This RAO requires that the design protect humans and wildlife by minimizing LFG exposure pathways and gas migration. In accordance with the CERCLA presumptive remedy (EPA, 1993a and 1993b), this RAO is achieved by controlling and treating LFG (if necessary). Based on a preliminary LFG characterization study presented in the Supplemental RI/FS Report (Weston, 2007), current LFG generation rates are low and are expected to be reduced in the future, following installation of the multilayer cover system. Also, elevated concentrations of VOCs have not been detected in air above the landfill during trenching and drilling operations during any of the previous investigations (Weston, 2007) or during ERRG's predesign field investigation (presented in Appendix B). As a result, to achieve this RAO, the design includes a passive LFG system designed to control and monitor the release of potentially harmful gases from the landfill. If future LFG sampling results indicate elevated concentrations of vinyl chloride or other hazardous substances, treatment measures may be required. If future LFG sampling results indicate concentrations of LFG exceed regulatory limits, additional LFG controls may be required, up to including an active LFG extraction system. However, neither of these scenarios is anticipated based on currently available data and historic information for the site.

3.1.2. Applicable or Relevant and Appropriate Requirements

The design elements of the RD were selected to address each of the chemical-specific, location-specific, and action-specific ARARs specified in the ROD (Forest Service, 2007). A summary of the basis of design evaluation is presented in Table 3. The following subsections summarize the ARARs from the ROD and how the RD addresses each ARAR.

3.1.2.1. Chemical-Specific ARARs

Requirements for control of LFG at solid waste landfills under 27 CCR § 20921, et seq. are relevant and appropriate to the design, construction, and operation and maintenance of the final cover system. The following LFG standards of 27 CCR are chemical-specific ARARs for the OU-1 response action related to LFG:

- § 20921(a)(2), which requires that LFG be monitored to ensure that methane gas concentrations at site boundaries do not exceed the lower explosive limit for methane (5 percent methane by volume).
- § 20921(a)(3), which requires that trace gases be controlled to prevent adverse acute and chronic exposure to toxic or carcinogenic chemicals.

To comply with chemical-specific ARARs dictated by 27 CCR, the design includes a LFG system and monitoring plan to control and monitor the migration of methane beyond site boundaries at concentrations that exceed the lower explosive limit (5 percent methane by volume) and to prevent acute and chronic exposure to toxic or carcinogenic chemicals from other trace gases.

Landfill gas at the site contains vinyl chloride. The following standard of California Clean Air Act (17 CCR) is a chemical-specific ARAR for the OU-1 response action related to vinyl chloride in air:

- § 70200.5, which requires that discharges of vinyl chloride to air, as listed in the Ambient Air Quality Standards for Hazardous Substances, be monitored.

To monitor discharges of vinyl chloride to air, the design includes a LFG monitoring program.

There is periodic surface water runoff to Saxon Creek. Surface water runoff and soil and sediment erosion must be controlled to prevent surface water contamination. The following standards are chemical-specific ARARs for the OU-1 response action related to surface water:

- National Ambient Water Quality Criteria[2]: Discharges to waters of the United States [Clean Water Act, as Amended, 33 U.S.C., Chapter 26, §§ 1251–1387, and 40 CFR § 131.36(b)].

[2] The "National Ambient Water Quality Criteria" have been revised and are now called "National Recommended Water Quality Criteria" (EPA, 2008). The original term for these criteria was retained here for consistency with the ROD (Forest Service, 2007).

- Porter-Cologne Water Quality Control Act, California Water Code, Division 7, §§ 13241, 13243, 13263(a), 13269, and 13360. The substantive provisions of §§ 13241, 13243, 13263(a), 13269, and 13360 of the Porter-Cologne Act enabling legislation, as implemented through waste discharge requirements, and promulgated policies of the Basin Plan, are ARARs. The Basin Plan establishes water quality objectives (WQOs), describes waste discharge prohibitions, and designates the beneficial uses for waters in this watershed basin. The substantive requirements are applicable to implementation and maintenance of the response action.

The following surface WQOs are pertinent to construction and maintenance of the OU-1 remedy:

- Sediment: The suspended sediment load and suspended sediment discharge rate of surface waters will not be altered so as to cause nuisance or adversely affect beneficial uses.
- Settleable Material: Waters will not contain substances at concentrations that result in the deposition of material that causes nuisance or adversely affects beneficial uses.
- Suspended Material: Waters will not contain suspended material at concentrations that cause nuisance or adversely affect beneficial uses.
- Suspended Sediment: Suspended sediment concentrations in streams tributary to Lake Tahoe will not exceed a 90th percentile value of 60 milligrams per liter.
- Biostimulatory Substances: Waters will not contain biostimulatory substances at concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect the water for beneficial uses.
- Floating Materials: Waters will not contain floating material, including solids, liquids, foams, and scum, at concentrations that cause nuisance or adversely affect the water for beneficial uses.
- Toxic Substances: Water will be maintained free of toxic substances at concentrations that produce harmful physiological responses in human, plant, animal, or aquatic life.

To comply with chemical-specific ARARs dictated by the Clean Water Act and the California Water Code requirements for surface water protection, the design includes surface water runoff and erosion controls to minimize discharges of sediments and toxic substances that might adversely affect surface water quality. To protect surface water quality, design of the landfill cover includes drainage and erosion control features to control surface water runoff and erosion. Also, stormwater best management practices (BMPs) to control off-site migration of suspended sediment were included in the construction plans.

Federal and state Safe Drinking Water Act MCLs are relevant and appropriate for the OU-1 response action. Groundwater at the site is not currently being used as a drinking water source. However, it is a potential drinking water source. The site is located in a groundwater basin whose beneficial uses include municipal and domestic water supply. Vinyl chloride concentrations in the groundwater plume exceed applicable California MCLs. The OU-1 response action is a source control remedy in accordance with EPA presumptive remedy guidance (EPA, 1993a and 1993b), and addresses only the landfill waste. Further response action(s) for the purpose of achieving groundwater MCLs are being evaluated separately as part of the RI/FS for OU-2.

To comply with chemical-specific ARARs dictated by the Federal and State Drinking Water Acts' requirements for groundwater protection, the design includes a 27 CCR multilayer cover system and drainage control structures to minimize water percolation through the waste to limit migration of COCs (primarily vinyl chloride) from the waste to underlying groundwater. The anticipated future rate of percolation through the proposed multilayer cover and into the waste was verified using the HELP3 model (see Appendix D).

3.1.2.2. Location-Specific ARARs

Migratory Bird Treaty Act (MBTA) of 1972 (16 U.S.C. §§ 703 to 712): The MBTA makes it unlawful to pursue, capture, hunt, or take actions adversely affecting a broad range of migratory birds. The MBTA and its implementing regulations are applicable to remedial activities that could affect any protected migratory birds. No migratory birds have been observed at the site, but no site-specific migratory bird studies have been conducted. The MBTA is relevant and appropriate. To comply with the MBTA, construction will be performed in a manner that avoids harming protected migratory bird species, including individual birds or their nests.

Protection of Floodplains, Executive Order 11988 (40 CFR Part 6, Appendix A): This executive order mandates that response actions taken by federal agencies must be designed to avoid adverse effects to floodplains. Specifically, if response activities are located within a 100-year floodplain, the activities must be designed to avoid or minimize adversely affecting floodplains. As discussed in the ROD, "if response activities take place in a floodplain, these requirements will be applicable" (Forest Service, 2007). According to the Federal Emergency Management Agency Flood Insurance Rate Map for El Dorado County (Panel 388 of 1125), the OU-1 site is not designated as an area subject to a 1 percent annual chance of flood (100-year flood). Consequently, the requirements for design within a floodplain are not an ARAR for the OU-1 response action.

National Forest Management Act (NFMA) of 1976 (16 U.S.C. §§ 1600-1614): The NFMA requires that the Forest Service develop coordinated land and resource management plans to govern the management and use of National Forest System lands. Because OU-1 is located on National Forest System lands, long-term future use of the site is governed by the LTBMU Forest Plan. CERCLA response actions have to address "reasonably anticipated future land use" as part of the remedy evaluation and selection process, and the final remedy must be compatible with the "reasonably anticipated future land use." The landfill area is currently closed to public access, subsequent to an area closure order placed in 1999 by the Forest Service to implement removal actions under CERCLA. The Forest Service expects to maintain closure status on the property; however, it is understood that without significant additional enforcement resources, the area will likely remain popular for unauthorized OHV recreational use. For this reason, the multilayer cover system was designed to accommodate OHV traffic, while maintaining the integrity of the cover system. Also, on-site structures, such as monitoring wells and gas vents, were designed to minimize vandalism and damage by trespassers.

3.1.2.3. Action-Specific ARARs

The solid waste disposal requirements of 27 CCR, Division 2, are not applicable because the landfill became inactive prior to the effective date of the regulations and did not receive waste after November 27, 1984. However, many of the closure and post-closure maintenance standards of Title 27, Division 2, Subdivision 1, Chapter 3, Subchapter 5, are relevant and appropriate to this remedial action, as discussed in the ROD (Forest Service, 2007).

27 CCR, Division 2, § 20950 sets forth general standards for closure of all solid waste management units, including performance goals for closing such units. Closure includes minimizing the infiltration of water into the waste, thereby minimizing the production of leachate and gas. The proposed multilayer cover design and associated drainage and LFG control systems are meant to satisfy these closure requirements.

27 CCR, § 21090 establishes final cover requirements of the State Water Resources Control Board, including a prescriptive multilayer cap design. The design must include:

- A dense 2-foot foundation layer
- A low hydraulic conductivity layer (with a conductivity 1 foot per year or less)
- An erosion-resistant layer that is:
  - not less than 1 foot thick
  - free of waste (including leachate)
  - placed above the low hydraulic conductivity layer
  - capable of sustaining native, or other suitable plant growth
  - resistant to erosion

These requirements are met by the proposed multilayer cover design.

27 CCR, §§ 20310 and 20320 set forth general construction and containment criteria, which include the following:

- Design will prevent migration of wastes from the landfill to adjacent geologic materials, groundwater, or surface water
- Design will meet seismic design criteria (to withstand the maximum credible earthquake [MCE] without damage)
- The containment structures will be designed and certified by a registered civil engineer or a certified engineering geologist
- A stability analysis will be performed in accordance with 27 CCR, §21750(f)(5)
- The materials used will have appropriate chemical and physical properties to ensure that the containment structures do not fail

The proposed multilayer cover and its containment systems were designed by a registered civil engineer, and will prevent migration of wastes from the landfill to adjacent media. The cover and containment systems were designed to withstand the peak ground acceleration associated with the MCE. Stability analyses were performed (Appendix D) and meet the stability analysis requirements. These analyses include slope failure calculation for the designed cover slopes and loading calculations that account for future unauthorized use of the landfill by site visitors, including motorized dirt bikes and OHV traffic. All materials specified in the design were tested (Appendix D) to verify that they possess the chemical and physical properties required to ensure that the containment structures will not fail.

27 CCR § 21100 et seq. contain California Integrated Waste Management Board (CIWMB) requirements for closed and inactive sites. In particular, CIWMB closure and postclosure maintenance requirements are specified at 27 CCR §§ 21140(a)(b), 21142(a), 21145(a), and 21150(a) and (b). These four sections provide relevant and appropriate narrative standards that duplicate many of the requirements discussed above from 27 CCR § 21090. These narrative standards are as follows:

- Function with minimum maintenance
- Provide waste containment to protect public health and safety
- Achieve compatibility with postclosure land use
- Provide equivalent protection from wind and surface water soil erosion with an erosion layer that contains a minimum of 6 inches of earthen material capable of sustaining native plant growth

The proposed design meets all of the aforementioned requirements by (1) integrating components that require no active operation, (2) substantially reducing or eliminating the risk of exposure, (3) being compatible with the postclosure land use and unauthorized land uses by OHVs, and (4) containing the waste with a cover system that includes a vegetative cover layer, which protects against erosion.

27 CCR § 21130 requires that the operator maintain a written postclosure emergency response plan that identifies occurrences that may exceed the site design and endanger public health or the environment. The plan must describe specific procedures that minimize these hazards to protect public health and safety and address vandalism; fires; explosions; earthquakes; floods; the collapse or failure of artificial or natural dikes, levees, or dams; surface drainage problems; and other waste releases. The operations, maintenance, and monitoring plan (Appendix H) that accompanies the RD provides information on potential catastrophic events and describes inspection and response actions for each.

27 CCR §§ 21142, 21145, and 21150 specify qualitative CIWMB requirements for final grading, slope stability, and drainage and erosion control. These requirements and the corresponding elements incorporated into the design to meet these requirements are listed in Table 3. As outlined in Table 3, the design meets the grading, slope stability, drainage, and erosion control requirements. The slope stability analysis is presented in Appendix D.

27 CCR §§ 20921, 20923, 20925, 20932, 20933, 20937, and 21160 specify the requirements for construction and operation of a perimeter landfill gas monitoring network and implementation of a LFG monitoring program. These requirements and the corresponding elements incorporated into the design to meet these requirements are listed in Table 3.

27 CCR § 21180(a) requires implementation of a postclosure monitoring and maintenance program for a period of no less than 30 years. The operations, maintenance, and monitoring plan (Appendix H) details the planned procedures to satisfy this requirement. Further, the engineering cost estimate (Appendix I) includes costs for a 30-year postclosure operation, maintenance, and monitoring program, which provides the Forest Service with the necessary information to plan the future activities.

27 CCR § 21190 requires that proposed postclosure land uses be designated and maintained to protect public health and safety and prevent damage to structures, roads, utilities, and gas monitoring and control systems; to prevent public contact with waste, LFG, and leachate; and to prevent LFG explosions. Subsections (a), (d), (e), (f) and (g) are ARARs. The postclosure land uses that affect the RD include developed recreation and unauthorized land uses by OHVs. To accommodate these land uses, the multilayer cover system was designed to withstand OHV traffic. Monitoring wells located on the cover were designed to be flush mounted, and gas vents were designed to be protected by chain-link fence enclosures. These protective elements are meant to minimize the risk of damage by vehicle traffic and vandalism. Lastly, in areas where existing utilities are buried beneath landfill waste, the design specifies that the waste will be excavated and consolidated on site (away from the utilities). On-site consolidation of waste will ensure protection of workers if future utility repairs are necessary.

27 CCR §§ 21769, 21800(c), and 21830 are relevant and appropriate to the OU-1 response action. 27 CCR, § 21769 requires that classified waste management units be closed in accordance with an approved preliminary closure and postclosure maintenance plan, which provides for continued compliance with the applicable standards for waste containment and precipitation and drainage controls and monitoring requirements. 27 CCR § 21830 sets forth requirements for a final postclosure maintenance plan. Lastly, 27 CCR § 21800(c) states the final closure plan must include a detailed description of each item contained in § 21790(b) and a detailed description of the sequence of closure stages. The purpose of the final postclosure maintenance plan is to (1) provide a basis for the operator to establish an accurate detailed cost estimate certified for accuracy by a registered civil engineer or certified engineering geologist; (2) enable the enforcement agencies to assess the reasonableness of the cost estimate; and (3) provide a detailed plan for inspection, maintenance, and monitoring of the landfill during the postclosure maintenance period. The OM&M plan (Appendix H) and the Engineering Cost Estimate (Appendix I) provide the components of the postclosure maintenance plan, providing the following information is included:

- Descriptions of emergency response actions
- Descriptions of proposed LFG control system and monitoring network at the landfill
- Detailed descriptions of methods, procedures, and processes that will be used to maintain, monitor, and inspect the closed landfill during the postclosure maintenance period
- Descriptions of operation and maintenance procedures for the LFG control system and monitoring network

- A summary of the requirements for reporting monitoring results
- Post-closure maintenance cost estimates

California Clean Air Act (17 CCR, El Dorado County Air Quality Management District Rule 223.1): Specifies that grading and earthmoving activities will not cause or allow emissions of fugitive dust such that the presence of such dust remains visible in the atmosphere beyond the property line of the emission source and will not cause or allow concentrations of particulate matter (of 10 micrometers or less) to exceed 50 micrograms per cubic meter when determined, by simultaneous sampling, as the difference between upwind and downwind samples. The design specifications (Appendix F) include safety and occupational health requirements (Section 01 35 29) that identify the fugitive dust control requirements (above) and the associated air monitoring requirements.

Clean Water Act, as Amended (33 U.S.C. §§ 1251–1387), Discharges to Surface Waters: Addresses both point and nonpoint sources of pollution and establishes or requires programs for the control of both sources of pollution. Specifically, owners and operators of construction activities must be in compliance with discharge standards and all direct dischargers to surface waters must meet technology-based requirements, including the best control technology and the best available technology economically achievable. Implementation of these provisions of the Clean Water Act has been delegated to the State Water Resources Control Board. The provisions are implemented through a series of "Board Orders." The following Board Orders are action-specific ARARs for the OU-1 response action:

- State Water Resources Control Board Order No. R6T-2005-0007 (Updated Waste Discharge Requirements and National Pollutant Discharge Elimination System General Permit No. CAG616002-Discharges of Storm Water Runoff Associated With Construction Activity Involving Land Disturbance in the Lake Tahoe Hydrologic Unit, El Dorado, Placer, and Alpine Counties): Sets forth requirements for construction activities that involve 1 acre or more of disturbance to develop and implement a stormwater pollution prevention plan (SWPPP) and perform stormwater discharge monitoring. The substantive requirements for stormwater pollution prevention, erosion control, etc. will be considered ARARs for all actions involving movement of soil.
- State Water Resources Control Board Order No. 97-03-DWQ (Waste Discharge Requirements for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities): Sets forth requirements for industrial activities that include closed or inactive landfills to develop and implement a SWPPP and perform stormwater discharge monitoring. The substantive requirements for stormwater management and pollution prevention are considered ARARs for long-term post-closure care and maintenance.

The design specifications (Appendix F) include earthwork requirements (Section 31 00 00) that identify the requirements for development and implementation of a SWPPP.

3.2. DESIGN SUMMARY

The RD consists of a multilayer cap with surface drainage and erosion controls and a French drain system for groundwater mounding protection. ICs will be implemented to protect the landfill cap and its components. The major design elements include:

- A plan for abandoning unnecessary monitoring wells
- A plan for relocation and consolidation of the landfill waste covering the STPUD sewer line
- A multilayer landfill cap design
- A passive LFG control system design
- A surface water control and infiltration system design
- A plan for improving and extending the existing French drain system
- A plan for protecting surface facilities
- A plan for operating, maintaining, and performing monitoring of the designed system

This multilayer cap is specifically designed to minimize infiltration and meets the minimum design requirements of Title 27 CCR, Chapter 3, Subchapter 5, Article 2, § 21090, with design enhancements to address temperature fluctuations and increased infiltration of water resulting from snow melt at the site and increased loading due to unauthorized future OHV use that may affect the stability of slopes that are associated with the landfill. The overall goals of the design are to isolate landfill waste, eliminate direct contact of surface soil, reduce erosion, reduce migration of COCs in surface soil, and limit surface water infiltration.

Subsections 3.3 through 3.10 discuss the aforementioned design elements in more detail. Appendix E contains the drawings associated with the design. Appendix F provides the design specifications.

3.3. WELL ABANDONMENT

As prescribed in the Supplemental RI/FS Report (Weston, 2007), groundwater wells located within the footprint of the landfill will be properly abandoned by over-drilling each well, removing all casing and filter pack, and grouting the resulting borehole with an appropriate sealing material that is placed either by pressure or by tremie pipe. A total of five wells located within the landfill footprint will be abandoned. The locations of the wells to be abandoned are shown on Drawing 3 (Appendix E).

Well abandonment will be conducted in accordance with state of California and El Dorado County regulations, including all relevant sections of (1) California Water Code Division 7, Chapter 10; (2) California Health and Safety Code Division 104, Part 9.5; (3) California Water Well Standards Bulletins 74-81 and 74-90; and (4) the following standards specified by the El Dorado County Department of Environmental Management (El Dorado County, 2008):

- Prior to destroying a well, it must be investigated to determine the construction details, maintenance history, and current condition. A work plan, including the investigation findings and destruction method, must be submitted with the well abandonment and destruction permit application.
- Wells must be sounded immediately prior to destruction to ensure they are free of obstructions. If any chemicals are observed, the El Dorado County Department of Environmental Management must be immediately notified in writing. Wells will be cleaned to remove and properly dispose of all obstructions and chemicals.
- All material within the original borehole (annular seal, casing, screen, filter pack, etc.) must be removed. The borehole must be completely filled with impervious sealing material.
- Acceptable sealing materials include neat cement, sand-cement grout, or concrete.
- Sealing material will be placed by tremie pipe or equivalent method in one continuous operation. Sealing pressure must be maintained until sealing materials are properly set.

3.4. WASTE RELOCATION AND CONSOLIDATION

The STPUD Trout Creek sewer trunk line is currently located below the existing landfill waste mass. This sewer line is maintained and operated by the STPUD under the terms of a Forest Service special use permit that expired in December 31, 2000 (Forest Service, 1976). This RD requires that all waste material overlying the sewer line be excavated and consolidated within the main body of landfill waste. Once the waste is relocated, the material overlying the sewer line will be regraded to match the proposed final grading design and promote drainage. The top 2 feet of cover soil will be removed from above the existing waste that is to be relocated and will be stockpiled in a temporary location. Similarly, the top 2 feet of cover soil will be stripped from the waste consolidation area and also stockpiled in a temporary location. All waste above and east of the sewer line will be excavated and moved to the waste consolidation area. Additional waste will be excavated from the north slope of the landfill to reduce the steepness of that slope.

To ensure protection of the STPUD sewer line, all relocation of waste in the vicinity of the sewer line will be coordinated with the STPUD well in advance of construction to ensure that an on-site STPUD representative can be present for the work. Contingency planning will be in place prior to the start of work (see Subsection 4.1.10), and STPUD will be kept up to date on construction scheduling, so the appropriate personnel are aware of the dates that waste will be excavated in the vicinity of the sewer line.

Prior to the start of construction work, the contractor will notify STPUD of the precise sequencing and location of planned excavations. The locations of the sewer line and manholes (presented on the drawings in Appendix E) are based on the plan and profile drawings entitled "Trout Creek Trunk Sewer As-Built" completed by Clair A. Hill Associates in October 1968. Prior to the start of work, the construction contractor will consult with STPUD to determine whether more current information of the location of sewer lines is available. The construction contractor will work with STPUD to ensure that excavation areas and the sewer line locations are accurately demarcated on the ground. If possible, the depth to the sewer will be checked by gauging the invert depth in the nearest manholes and creating a profile that indicates the estimated depth of the pipe between the manholes.

The approach for removal of waste in the vicinity of the sewer line is based on removal of bulk waste down to within 5 feet of the line, then removal of any further waste based on visual signs. Extreme care must be taken to ensure that all waste removal activities in the vicinity of the sewer line are conducted with the best available professional practices (e.g., soft digging or using a flat bar attachment) to avoid damaging the pipe. Backfill above the sewer line will be performed in a manner that ensures the pipe is fully supported and protected from damage. No rocks, debris, or organic material will be used near the sewer pipe. Backfill within 4 feet of the sewer line will be carefully placed and compacted with a sheepsfoot roller attached to an excavator or hand-operated compaction equipment. No heavy equipment will be allowed to cross over the sewer line until a minimum 4 feet of cover soil are in place and compacted to specifications.

Based on historic data, waste is not expected to extend to the depth of the top of the sewer line. Historic data indicate that the depth to the bottom of the waste in the vicinity of the sewer line is separated from the sewer line by approximately 8 feet (Weston, 2007). If the excavation requires exposing the top of the sewer, the pipe will be exposed by hand with a maximum of 10 linear feet of the upper half of the sewer pipe exposed at any one time. The bedding material below the mid-line of the pipe will be maintained at all times to support the sewer line. Following waste removal, up to 1 foot of sand-cement slurry or well-graded fill sand will be placed over any exposed sewer pipe to protect it during backfill operations. Backfill materials will be manually spread around the pipe so that, when compacted, the backfill will provide uniform bearing and side support. Any sand-cement slurry used will be given an adequate amount of time to cure before backfilling. Backfill will not be placed around nor upon any structure until sand-cement slurry has attained sufficient strength to withstand the loads placed upon it. Backfill will not be dropped directly upon any sewer structure or pipe. Backfill materials will be placed only after all water is removed from the excavation. Backfill will not be placed around water-retaining structures until the structures have been tested.

During final grading, a minimum of 4 feet of cover soil will be maintained above the STPUD sewer line. As part of the final grading, one manhole (MH48) in waste relocation area will be lowered by removing one 4-foot riser section and then reusing the existing cone and cover. The final elevations of the two manholes covers located in the waste relocation area (MH48 and MH49) will stick up 1 to 3 feet above the surrounding grade, so they can be easily located and to prevent surface water flow from entering the sewer line through the covers (STPUD, 2008; see also Drawing 7, Appendix E).

Drawing 4 (Appendix E) shows the extent of the waste removal areas. The excavated waste will be placed on the west side of the sewer line and graded per the plan shown on Drawing 5 (Appendix E). The cover soils that were stockpiled at the beginning of the work will be placed over the newly consolidated waste areas and the exposed cut areas to provide a foundation layer for the proposed multilayer cap. Additional cover soil will be obtained from the borrow area located on the eastern side of the plateau and the east slope (Drawing 6) (Appendix E). All waste material will be placed in 8-inch loose lifts compacted to 90 percent of the maximum dry density and graded to drain, per the grading plan shown on Drawing 6 (Appendix E).

Volume and grading were calculated to identify the optimal siting, slope, volume, and areal extent of the landfill. A 15 percent swell factor was included in these calculations. Table 4 summarizes the design volumes. Supporting volume calculations are presented in Appendix C.

3.5. MULTILAYER CAP SYSTEM

The waste will be covered with a multilayer cap system consisting of a foundation layer, a geomembrane liner, a drainage layer, and a vegetative cover layer with geogrid reinforcement (Figure 5). Cross-section details for the multilayer cap are provided in Drawing 7 (Appendix E). The following subsections describe the design of each of these components in more detail.

3.5.1. Foundation Layer

The foundation layer for the multilayer cap will be 2 feet thick (Drawing 7, Appendix E) and constructed using on-site materials, including native material and material previously used to cover the original waste area. The foundation layer will be constructed in 8-inch loose lifts and compacted to an average of 90 percent of the maximum dry density, but no less than 85 percent at any location. The material for the foundation layer will be moisture conditioned prior to placement and compaction. The degree of soil compaction will be verified using in-situ testing methods in accordance with the CQA Plan (Appendix G).

3.5.2. Geomembrane Liner

A 60-mil LLDPE geomembrane liner will be placed over the entire waste area to prevent infiltration of surface water (such as precipitation, runoff, runon, and snowmelt). The geomembrane liner will be sloped to promote drainage away from the landfill area and to prevent ponding on its surface. The liner will be installed in accordance with the manufacturer's installation instructions. Liner seams will be welded in place and air tested to verify their integrity. The entire liner will be visually inspected by the on-site engineer to verify that the impermeability is not compromised by holes, tears, or manufacturing defects. Liner quality assurance (QA) testing procedures are specified in the CQA Plan (Appendix G).

3.5.3. Drainage Layer

A 12-inch-thick sand drainage layer was initially included as part of the multilayer cap to promote drainage and reduce ponding above the waste (Weston, 2007). However, HELP modeling conducted during the RD indicated that the sand layer allowed unacceptable ponding to occur above the liner (see Appendix D and Subsection 3.11). As a result, a geocomposite drainage layer will be placed between the LLDPE liner and the vegetative cover layer to provide more adequate cap drainage. It will consist of a manufactured geonet bonded with geotextile fabric on both sides and will promote lateral drainage, allowing water infiltrating through the vegetative cover layer to be routed away from the landfill area. A sand layer will be incorporated into the drainage layer between the geocomposite and the geomembrane to ensure frictional stability between the two geosynthetic layers and to further facilitate drainage along the steeper portions of the slope (areas with 25 percent slopes) (see Subsection 3.11 and Appendix D). The sand layer will consist of 12 inches of clean sand, placed with extreme care to avoid damaging the underlying geomembrane liner. The sand layer will be constructed in a single 12-inch lift and compacted to a minimum of 85 percent of maximum dry density.

3.5.4. Cover and Vegetative Layers

The multilayer cap system will be covered with two distinct layers of protective soils. These layers will consist of a 24-inch thick layer of native material and a 12-inch thick layer of vegetative material. This thickness exceeds the total thickness of 24 inches for the cover and vegetative layers described in the ROD (Forest Service, 2007). The increased total thickness of the cover and vegetative layers was required to protect the geomembrane liner from freezing (based on a frost depth of 2.6 feet).

The lower cover layer will be placed in 12-inch lifts and compacted to 85 percent of the maximum dry density in the first lift where the cover soil is in contact with the geocomposite and 90 percent in the subsequent lifts. The material required to construct the cover layer will be acquired from the on-site borrow area. The upper vegetative layer will consist of the same native material as the cover layer, but it will be amended with a high-organic content topsoil to promote vegetative growth of native species to be planted on the cap. Specifications for the soil amendment process and a list of native plant species for cover revegetation are provided in the project specifications (Appendix F). The vegetative layer will be placed in 8-inch lifts and compacted to 85 percent of maximum density. On-site density testing will be performed to verify that soil compaction requirements are met. Details on the testing procedures to be performed are included in the CQA Plan (Appendix G). Finally, two permanent monuments (settlement markers) will be installed on the final cover by a licensed Land Surveyor. These markers will be used to evaluate future settlement throughout the post-closure maintenance period as described in the OM&M Plan (Appendix H).

To protect the multilayer cap system from in-place erosion, the erosion-resistant vegetative layer will be used as a substrate to grow grasses and other shallow-rooted plants native to the South Lake Tahoe area. Appendix H presents additional detail on the approved native species to be used and the maintenance of the final cap. Following revegetation, temporary erosion controls will be required to protect the cap while vegetation is being established. Figure 6 presents proposed locations of temporary erosion control features to be installed directly following completion of the RD.

The rate of erosion anticipated for the designed cap was estimated using the Universal Soil Loss Equation (presented in Appendix C). The calculated erosion rate was determined to be less than or equal to 0.03 tons per acre per year. Less than 3 tons per acre per year is considered a very low or tolerable erosion rate, and experience with the Department of Toxic Substances Control at the Truckee Landfill Site indicates a preference of less than 2 tons per acre per year for landfill sites. The designed surface water control system (see Subsection 3.6) includes infiltration basins that will serve as settling areas for this sediment and ensure that sediment from the site does not enter Saxon Creek.

3.5.5. Geogrid

Two geogrid layers will be incorporated within the vegetative layer of the cap as reinforcement and to protect from erosion due to rutting and traffic loads on the cap. In addition, the geogrid will minimize cap erosion due to potential future use of the area by foot, bicycle, motorized dirt bike, or OHV traffic. As noted in Subsection 3.11 the stability analyses (Appendix D) determined that the geogrid reinforcement was required to minimize unacceptable seismic deformation on the 25 percent and 6 percent slopes. To evaluate the loading potential from unauthorized use of the cap, a maximum load of 500 pounds distributed over the area of two motorized dirt bike tires was assumed. These calculations indicated that the geogrid would provide needed reinforcement to the cap under this scenario (see Appendix C).

The upper geogrid layer will be placed 6 inches below the final grade in the vegetative layer. The lower geogrid layer will be placed at the base of the vegetative layer, 1 foot below the final grade.

3.6. SURFACE WATER CONTROL AND INFILTRATION SYSTEM

Surface water and erosion control are stipulated throughout the postclosure period by 27 CCR §§ 21090 and 20365. Additional standards and local surface water monitoring requirements compiled by the Tahoe Regional Planning Agency (TRPA)[3] and consistent with the LRWQCB were also evaluated in development of the surface water control and infiltration systems (see Appendix C).

A system of drainage channels, swales, and check dams was incorporated into the RD to remove surface water from the landfill cap, to control erosion, and to prevent off-site migration of sediments and COCs via surface water runoff into Saxon Creek. The system was designed to promote infiltration of all on-site precipitation and snow melt, while minimizing infiltration in areas above the groundwater plume (OU-2). Most of the surface water runoff from the landfill cap will be directed through a series of concrete-, earth-, and rock-lined channels, culverts, swales, check dams, and infiltration areas that will be installed around the landfill. Concrete-lined channels will be used in areas above the groundwater plume to prevent infiltration in these areas. The concrete must be robust enough to withstand the local climate and to account for added loading of dirt bikes or other OHVs (see specifications, Appendix F).

Surface flow from the top of the landfill and the upper north and east sides will be directed into a gently sloped swale area on the east edge of the plateau; from there, surface water will be directed through a series of check dams to another infiltration area in the southeast corner of the site. Additional flow from the west and south sides of the landfill will be directed through the check dam area to the infiltration area

[3] TRPA is a bistate resource management agency that has primary responsibility for the environmental protection of Lake Tahoe. TRPA's principal mission is to reduce the loss of clarity in Lake Tahoe. TRPA oversees the monitoring of existing environmental conditions in the basin through a number of programs and coordinates directly with local, state, and federal agencies (including the Forest Service).

in the southeast corner of the site. Surface flow from the lower north end of the landfill will be directed to an additional infiltration area northeast of the landfill. The layout and design details for the surface water control system are included on Drawing 8 (Appendix E).

Precipitation and drainage control facilities for a Class III municipal solid waste landfill were designed based upon a 100-year, 24-hour design storm per 27 CCR, Table 4.1, "Construction Standards for Units." For the Meyers Landfill area, the anticipated peak flow and volume of precipitation, based on a 100-year, 24-hour storm event, is 9 inches of precipitation in 24 hours (National Oceanic and Atmospheric Administration, 1973). The conveyance channels from the landfill to the infiltration areas were designed based upon a 100-year, 1-hour storm event of 0.76 inches of precipitation (National Oceanic and Atmospheric Administration, 1973). The calculations for the design flows and channel sizing are presented in Appendix C.

3.7. LANDFILL GAS CONTROL SYSTEM AND MONITORING NETWORK

The LFG control system is meant to collect and vent gases generated by the decomposing landfill waste mass. The LFG control system comprises 10 vent wells screened within the waste layer at various locations across the landfill (see Drawing 9, Appendix E). The vents are manifolded together and connected to two discharge points located at high points on the landfill cover. Each vent well consists of an 8-inch slotted polyvinyl chloride (PVC) pipe installed to penetrate approximately 75 percent of the vertical thickness of the waste layer (see detail on Drawing 9, Appendix E). The perforated portion of the vent will be embedded in crushed gravel to facilitate the flow of gases from the waste to the slotted vent pipe. Where the vent pipe exits the waste layer to penetrate the geomembrane liner and extend up into the open air, it transitions from perforated to non-perforated (or solid) PVC pipe. The area where the vent pipes penetrate the geomembrane liner will be sealed with a fabricated geomembrane boot to prevent seepage of infiltrated water (see detail on Drawing 9, Appendix E). The discharge points of the vent wells will be located at least 10 feet above the ground surface to ensure that they are well outside of the breathing zone of any potential site visitors.

The passive LFG vent system was designed to accommodate the anticipated generation of LFG at the site. The evaluation of LFG generation presented in the Supplemental RI/FS Report was based on LFG testing and generation modeling results (Weston, 2007). Modeling results presented in the RI/FS Report predicted that current LFG generation rates are low (less than 400 megagrams per year [Mg/yr] for 2008) and future LFG generation rates are expected to continue to be low and to decrease through time. The following table summarizes gas generation rates for 2008 predicted by the model.

Gas	2008 modeled generation rate	
	m^3/yr	Mg/yr
Nonmethane organic carbons	1,262	4.5
Carbon dioxide	157,700	288
Methane	157,700	105.2
Total Gas	315,500	394

Note: Data from gas model results are presented in Appendix B of the RI/FS Report (Weston, 2007)
m^3/yr = cubic meters per year

Figure 7 presents the results of the LFG modeling through time.

For landfills with typical LFG generation rates, a rule of thumb of one gas vent per 200 feet is commonly accepted (unless site-specific conditions allow for a wider spacing or high gas generation rates require a tighter one) (Peavy, Rowe, and Tchobanoglous, 1985).

Elevated concentrations of VOCs have not been detected in the airspace above the landfill during any of the previous investigation trenching and drilling operations (Weston, 2007) or during ERRG's predesign sampling (presented in Appendix B). The addition of an impermeable cap on the landfill is expected to reduce overall gas production rates by minimizing water infiltration and thereby reducing LFG degradation rates (Weston, 2007). These observations, coupled with the low generation potential of waste that has passed its peak LFG generation (Figure 7), indicate that typical LFG vent spacing of one vent per 200 feet is adequate to vent LFG from the waste.

If future monitoring of LFG concentrations indicate elevated concentrations of LFG, treatment measures may be required, up to including an active LFG extraction system. However, this scenario is not anticipated based on currently available data and historic information for the site. Locations and design details for the LFG control system are included on Drawing 9 (Appendix E). Monitoring requirements for LFG are included in the OM&M Plan (Appendix H).

In accordance with 27 CCR and 17 CCR requirements for LFG monitoring (see Subsection 3.1.2), the RD requires installation of six LFG monitoring points and implementation of a LFG monitoring plan to monitor the migration of LFG, including methane and nonmethane organic compounds, beyond site boundaries. Each monitoring point will be installed as a nested series of LFG probes to evaluate LFG at shallow, intermediate, and deep levels outside the landfill waste footprint. The shallow or intermediate depth intervals may be omitted if site topography causes the depth to waste to be above the depth to the top of the monitoring point casing. Proposed monitoring point locations and a typical construction detail for the nested landfill gas monitoring wells are provided on Drawing 10 (Appendix E). Monitoring requirements for the perimeter monitoring program are included in the OM&M Plan (Appendix H).

3.8. FRENCH DRAIN REPLACEMENT AND EXPANSION

Installation of an expanded French drain will prevent perched water from infiltrating the landfill waste mass from the west boundary of the landfill. The expanded French drain coupled with the lined multilayer cap (see Subsection 3.5) will further ensure that no LFG is discharged to groundwater. The current French drain is a gravel-filled trench approximately 100 feet long. The drain runs northward from the southwestern corner of the landfill, along the western boundary as shown on Drawing 11 (Appendix E). Groundwater entering the French drain is directed south into an open drainage swale. Based on available information, it appears that the existing drain is approximately 6 to 8 feet deep. Photographs taken during installation of the drain indicate the existence of a perforated 10- to 12-inch-diameter corrugated steel pipe at the base of the drain.

Improvement and expansion of the current French drain system will prevent the lateral movement of perched groundwater into the landfill. The French drain will be installed approximately 14 feet bgs (beneath the perched aquifer) and will be a minimum of 2 feet wide. The drain will be keyed a minimum of 2 feet into the underlying clay layer and will extend approximately 750 feet along the western boundary of the landfill (Drawing 11, Appendix E). The location of the French drain will be outside and hydraulically upgradient of the limits of the landfill. The excavation sidewalls and bottom will be lined with permeable geotextile fabric to eliminate sediments from entering into and clogging the gravel drain. A perforated pipe consisting of high-density polyethylene will be placed at the bottom of the trench. The pipe will slope toward the south, with gradients of 1.5 to 2 percent, to drain groundwater into the existing drainage structure at the south end of the landfill. An approximately 10-foot-thick layer of permeable gravel material (e.g., crushed rock or bank run gravel) will be placed inside geotextile fabric and around the collection pipe to fill the lower 10 feet of the trench. The gravel will be covered with geotextile fabric, and the remainder of the trench will be filled with soil, compacted, and graded to drain. French drain details are presented on Drawing 11 (Appendix E).

3.9. PROTECTION OF SURFACE FACILITIES

Following completion of the remedy, surface features located within the area requiring ICs (Appendix A) will require protection from vandalism and physical damage. These features include the landfill cap, monitoring wells and LFG vents located within the landfill cap area, and monitoring wells located outside of the landfill cap area but within the area requiring ICs. Based on discussions during public meetings held during development of the Proposed Plan and the ROD for this site, no permanent perimeter fence will be installed at this site (Forest Service, 2008a)[4].

The vegetative layer, the uppermost layer of the landfill cap, will incorporate two layers of geogrid to provide structural support for the landfill cap surface. The geogrid layers will minimize surface rutting and erosion that may occur from OHV traffic. Excessive rutting or erosion would affect the integrity of the landfill cap.

Surface completions for new monitoring wells to be installed during the remedy will consist of concrete well vaults with bolted covers and locking caps at each well. Surface completions for existing monitoring wells that are not being decommissioned may require modifications to ensure they are not vandalized or damaged. Any existing monitoring wells on the cap with stand-pipe surface completions will be modified by cutting the standpipes and installing locking concrete well vaults around each well. The well vaults will be elevated above the surrounding cap grade to ensure adequate drainage away from the well. Details of typical well vault surface completions for wells located within the cap footprint are presented on Drawing 7 (Appendix E).

[4] Temporary fencing to protect vegetation immediately following landfill cap construction is acceptable.

LFG vents located within the landfill footprint must extend vertically for several feet above the cap; as a result, the vents will also require fenced protection to ensure adequate gas venting during times of snow cover. To avoid vandalism, these vents should be protected using locking chain-link cages that encase the entire well vent. Details of typical LFG vent protections are provided on Drawing 7 (Appendix E).

Finally, existing monitoring wells and perimeter LFG monitoring points located outside of the landfill cap area, but within the area requiring ICs, must be protected. These wells are primarily stand pipe wells and will be protected by installing four 3-foot tall, 4-inch-diameter, concrete-filled steel bollards around each well, as shown on Drawing 7 (Appendix E). In areas where several wells are clustered together, a single cage may be used to enclose several wells.

The specifications for the geogrid, well vaults, and protective cages are included in Appendix F. OM&M requirements for these protective features are presented in the OM&M Plan (Appendix H).

3.10. OPERATIONS, MAINTENANCE, AND MONITORING

The operations, maintenance, and monitoring program will primarily involve inspection and routine monitoring of the integrity of the landfill cap. A comprehensive OM&M Plan is provided in Appendix H. The plan contains the following components:

- Revegetation plan
- Final cover maintenance plan
- LFG monitoring plan
- Description of potential OM&M problems and remedies
- QA plan for operations, maintenance and monitoring
- Procedures to prevent releases or threatened releases of hazardous substances
- Corrective actions to be implemented in the event that cleanup standards are exceeded for any surface water discharges or air emissions, and a schedule implementing these corrective actions
- Safety plan
- Equipment descriptions
- Inspection log sheets, maintenance and monitoring log sheets, and laboratory records
- Groundwater monitoring plan

3.11. SUMMARY OF GEOTECHNICAL ANALYSIS

ERRG performed geotechnical testing and analyses in conjunction with development of this RD. This section summarizes the findings of the geotechnical analyses. A complete discussion of the geotechnical analysis is presented in Appendix D. The geotechnical analyses were performed to evaluate the following:

- Slope stability of the borrow material excavation, the multilayer cap, and the final cover under static and seismic loading conditions
- Percolation rates through the landfill cap using the HELP computer modeling program
- Settlement of the landfill cover

Slope stability analyses were conducted using the XSTABL model (Sharma, 2003). These analyses were performed to determine if the slopes of the designed features could withstand anticipated static and seismic loads without failure. According to the modeling results, the borrow material excavation and the final cover slopes, as designed in the RD, are adequately designed for long-term stability. Analysis of the multilayer cap determined that the drainage sand layer along the 25 percent slopes is necessary to provide sufficient protection against slope failure. Multilayer cap analyses also determined that the geogrid reinforcement included in the RD to protect against damage from OHVs was necessary to minimize excessive seismic deformation on the 25 percent and 6 percent slopes.

Percolation analyses were conducted using the HELP model (EPA, 1994). This model estimates the rate at which water may percolate through the multilayer cap and waste in the landfill. Two multilayer cap configurations were modeled for the 6 percent slopes. The first simulation included a 12-inch-thick sand drainage layer to carry water percolating through the cover soil away from the geomembrane. Modeling results indicated the capacity of the drainage layer was inadequate because the resulting hydraulic head over the liner was higher than the final landfill surface. To resolve this issue, the multilayer cap configuration was modified to replace the drainage sand layer with a geocomposite layer that increases the multilayer cap's capacity to drain water away from the geomembrane along the 6 percent slopes. Modeling results from the second simulation confirmed that inclusion of a geomembrane layer allows for the current multilayer cap configuration to control percolation and the amount of hydraulic head buildup over the geomembrane. Similarly, two configurations were modeled for the 25 percent slope, with and without the 12-inch-thick sand drainage layer. The model results predicted acceptable average hydraulic head in both simulations.

A settlement analysis was performed on the proposed final grade of the landfill to assess the potential for future drainage slope reversal on the cap and to evaluate the potential for damage to landfill gas vents due to settlement. Results of the analysis confirmed that the amount of settlement anticipated for the critical slopes will not hinder site drainage or landfill gas collection system over the lifetime of the landfill.