LMS/RFS/S05516-1.0

U.S. Department of Energy
Rocky Flats Site

Original Landfill Monitoring and Maintenance Plan

September 2009

U.S. DEPARTMENT OF ENERGY | Office of Legacy Management

This page intentionally left blank

LMS/RFS/S05516-1.0

U.S. Department of Energy
Rocky Flats Site

Original Landfill Monitoring and Maintenance Plan

September 2009

This page intentionally left blank

Contents

Abbreviations iii
1.0 Introduction 1–1
1.1 Purpose 1–2
1.2 Facility Location and Units 1–2
1.3 Site Operations 1–2
1.4 OLF Action Plan 1–2
2.0 Site Physical Description 2–1
2.1 Topography 2–1
2.2 Hydrology 2–1
2.3 Climate and Precipitation 2–1
2.4 Hydrogeology 2–1
2.5 Site Features 2–2
2.5.1 Final Cover 2–2
2.5.2 Buttress Fill 2–2
2.5.3 Stormwater Management System 2–2
2.5.4 RCRA Groundwater Monitoring Network 2–4
2.5.5 Surface Water Monitoring 2–4
3.0 Final Cover and Stormwater Management System Inspection and Monitoring 3–1
3.1 Inspection Procedures 3–1
3.2 Subsidence and Consolidation 3–2
3.2.1 Monitoring Locations and Procedures 3–2
3.2.2 Maintenance Action Activities 3–6
3.3 Slope Stability 3–6
3.3.1 Monitoring Locations and Procedures 3–7
3.3.2 Maintenance Action Activities 3–7
3.4 Soil Cover 3–8
3.4.1 Monitoring Locations and Procedures 3–8
3.4.2 Maintenance Action Activities 3–8
3.5 Vegetation 3–11
3.5.1 Monitoring Locations and Procedures 3–11
3.5.2 Maintenance Action Activities 3–12
3.6 Stormwater Management Structures 3–12
3.6.1 Monitoring Locations and Procedures 3–12
3.6.2 Maintenance Action Activities 3–13
3.7 Institutional Controls 3–13
3.8 Condition of Monitoring Points 3–14
3.9 Site Conditions 3–14
3.10 Reporting and Recordkeeping 3–14
4.0 Groundwater Monitoring Plan 4–1
4.1 Purpose and Requirements 4–1
4.2 Data Quality Objectives 4–1
4.3 Well Locations 4–1
4.4 Groundwater Quality Sample Parameters 4–3
4.5 Sampling Procedures 4–3
4.6 Laboratory Procedures Summary 4–3
4.7 Data Evaluation and Reporting 4–3

5.0 Surface Water Monitoring Plan 5–1
5.1 Purpose and Requirements 5–1
5.2 Data Quality Objectives 5–1
5.3 Sample Locations 5–1
5.4 Surface Water Sample Parameters 5–1
5.5 Sampling Procedures 5–1
5.6 Laboratory Procedures Summary 5–1
5.7 Reporting and Scheduling 5–2
6.0 Reporting and Contact Information 6–1
6.1 Reporting 6–1
6.2 Contact Information 6–1
7.0 References 7–1

Figures

Figure 1–1. Location Map 1–3
Figure 1–2. Original Landfill Site Map 1–4
Figure 1–3. Original Landfill Cover 1–9
Figure 3–1. Original Landfill Inspections 3–3
Figure 3–2. Original Landfill Settlement Plates 3–5
Figure 3–3. Original Landfill Stormwater Management Structure Details 3–9
Figure 4–1. Original Landfill Surface Water and Groundwater Monitoring 4–2

Tables

Table 4–1. Groundwater Monitoring Wells—Original Landfill 4–1

Appendixes

Appendix A Original Landfill—Monitoring and Maintenance Program Inspection Forms
Appendix B Groundwater Well Boring Logs/Construction Summaries

Abbreviations

CAD/ROD	Corrective Action Decision/Record of Decision
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
H	horizontal
IDW	investigation-derived waste
IM/IRA	Interim Measure/Interim Remedial Action
OLF	Original Landfill
OU	Operable Unit
M&M Plan	Monitoring and Maintenance Plan
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFLMA	Rocky Flats Legacy Management Agreement
RL	reporting limit
SAP	S*ampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites*
UHSU	upper hydrostratigraphic unit
V	vertical
VOC	volatile organic compound

This page intentionally left blank

1.0 Introduction

This Monitoring and Maintenance Plan (M&M Plan) applies to the Original Landfill (OLF) (Individual Hazardous Substance Site 115 and 196) at the Rocky Flats Site (Rocky Flats). This OLF M&M Plan is a modification of the first OLF M&M Plan (DOE 2006) (2006 OLF M&M Plan), as described further in this section.

Under the Final Interim Measure/Interim Remedial Action (IM/IRA) for the OLF (DOE 2005), a 2-foot-thick soil cover was selected to address closure of the OLF. To enhance the landfill's slope stability, the existing slopes were regraded before the soil cover was placed, and a buttress fill was installed at the toe of the landfill. The remedial action also included the installation of perimeter drainage channels and cover diversion berms to control surface water run-on and runoff around the landfill cover. Construction was completed in September 2005, with the final regulatory walk-down occurring on September 12, 2005.

The 2006 OLF M&M Plan was approved prior to the September 2006 Corrective Action Decision/Record of Decision (DOE, EPA, and CDPHE 2006) (CAD/ROD) for Rocky Flats. Pursuant to the CAD/ROD, Rocky Flats was configured into two Operable Units (OUs). The Central OU consolidates all areas of Rocky Flats that have remaining hazardous substance contamination and require additional remedial actions, including the OLF. The Peripheral OU surrounds the Central OU and includes the other, generally unaffected, portions of Rocky Flats, which served as a buffer zone surrounding the former industrial area. Under the CAD/ROD, the final remedy is no action for the Peripheral OU, and institutional controls, physical controls, and continued monitoring for the Central OU.

The *Rocky Flats Legacy Management Agreement* (DOE, EPA, and CDPHE 2007) (RFLMA), signed by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Public Health and Environment (CDPHE) (collectively, the RFLMA parties), to implement the CAD/ROD became effective March 14, 2007. The OLF M&M Plan is incorporated by reference as an enforceable requirement of RFLMA (see RFLMA Attachment 2, "Legacy Management Requirements," Section 5.3.1). RFLMA terminated and superseded the Rocky Flats Cleanup Agreement (DOE, EPA, and CDPHE 1996) (RFCA). The 2006 OLF M&M Plan referenced RFCA in certain sections.

Modifications to the OLF M&M Plan and to RFLMA requirements pertaining to the OLF monitoring and maintenance are subject to CDPHE review and approval in accordance with RFLMA Part 10, "Amendment of Agreement and Modification of Attachments."

This OLF M&M Plan modification is based on the outcome of consultation in accordance with RFLMA consultative process as documented in Regulatory Contact Record 2008-07 (DOE 2008a), which was approved September 2, 2008. Therefore, this modified OLF M&M Plan revises the original OLF M&M Plan text as appropriate to recognize the implementation of the remedy under RFLMA.

This modified OLF M&M Plan also reflects changes resulting from the implementation of the *Proposed Action Plan for Original Landfill Cover Repairs and Geotechnical Investigation* (DOE 2007a) (OLF Action Plan), approved by CDPHE on July 16, 2007. The OLF Action Plan implementation is discussed further, below.

1.1 Purpose

This OLF M&M Plan is designed to meet the following objectives:

- Describe the procedures to be used to maintain the integrity and effectiveness of the final cover, including making repairs as necessary (Section 3.0);
- Describe the features necessary to maintain and monitor the groundwater monitoring system (Section 4.0); and
- Describe the features necessary to prevent run-on and runoff from eroding or otherwise damaging the final cover (Section 5.0).

1.2 Facility Location and Units

Rocky Flats is a government-owned facility formerly used for the fabrication of miscellaneous weapons components for national defense. Rocky Flats is located in Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1−1). The OLF is located in the Central OU south of the former industrial area on a south-facing hill slope north of Woman Creek (Figure 1−2).

1.3 Site Operations

The OLF was used to dispose of solid sanitary and construction debris wastes generated at the former Rocky Flats Plant from 1952 to 1968 (DOE 1988). The landfill was not designed or operated as an engineered landfill. Aerial photographs indicate that the landfill was operated as an area fill (DOE 1994). Waste was merely dumped in the area vertically below and just south of the southern edge of the alluvial pediment on which the former industrial area was located. The waste disposal area lies north of Woman Creek. The waste was generally spread over the south-facing hillside, serving to fill in the area below the pediment edge. No liner or other collection barrier was installed between the waste and the existing surfaces (DOE 2006).

Waste placed within the OLF is contaminated and commingled with hazardous constituents, including organic compounds and metals at levels greater than RFCA action levels and/or applicable standards. Additional information can be found in the IM/IRA for the OLF (DOE 2006).

1.4 OLF Action Plan

Conditions that warranted further repair and that triggered further investigation were found at the OLF beginning in 2007, as documented in the RFLMA annual reports for 2007 and 2008 (DOE 2008b, 2009). These conditions involved localized slumping and settling of the OLF cover, seeps observed to daylight intermittently on the cover, and the development of a continuous seep at the eastern toe of the buttress (identified as Seep 8). In addition, ponding in lengths of the diversion berm channels from precipitation and snowmelt runoff were observed, and a topographic survey showed that portions of the diversion berms did not meet the minimum original OLF M&M Plan–specified 2-foot height. DOE notified CDPHE and EPA of the observed conditions, and the parties consulted on actions to take. DOE continued monitoring conditions and made minor repairs as provided by the OLF M&M Plan by adding and compacting soil to localized areas to maintain berm and cover integrity.

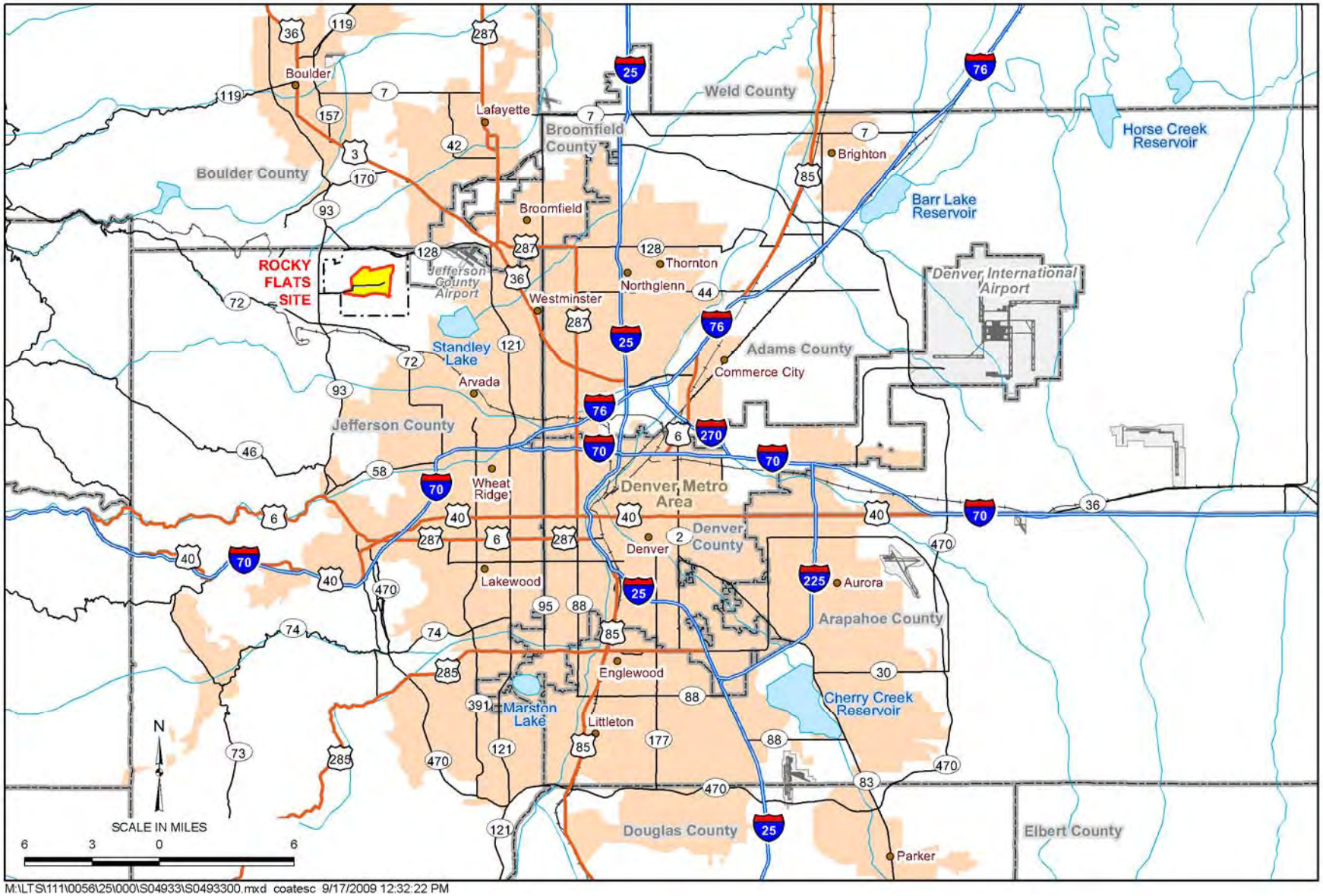


Figure 1–1. Location Map

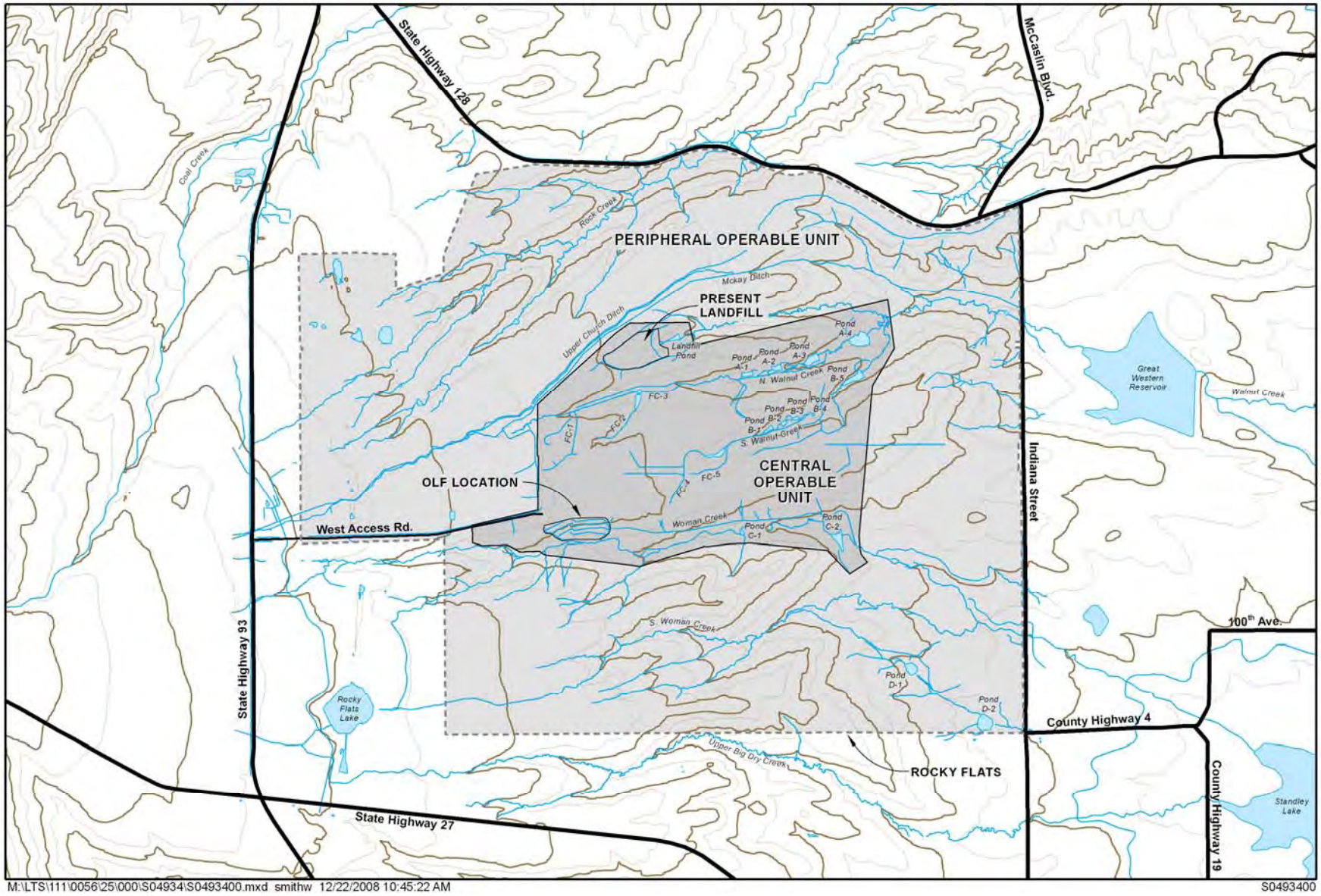


Figure 1–2. Original Landfill Site Map

The OLF Action Plan included Phase 1 (near-term) repair, Phase 2 geotechnical investigation, and Phase 3 design and construction for long-term repair. Phase 1 repairs to address localized differential settlement, slumping, and surface cracks were made in 2007 by filling, grading, and compacting.

CDPHE approved the Phase 2 *Rocky Flats Original Landfill Geotechnical Investigation/ Engineering Work Plan* (DOE 2007d) (Geotech Work Plan) on November 30, 2007. The goal of the Geotech Work Plan was to determine subsurface conditions and the possible causes of observed localized slumping and settling of the OLF cover, and to develop feasible alternatives for mitigating the localized areas of slope instability. The investigation also considered the possible impacts of the seeps and the maintenance of berm heights and channel slopes on the localized areas of slope instability.

Investigation fieldwork for Phase 2 began in December 2007 and was completed in April 2008. Work began with a geophysical survey to help determine the thickness and extent of waste placement and to aid in positioning investigative test pits and boreholes. Next, eight test pits, approximately 20 feet long and 11 to 13 feet deep, and a ninth test pit, approximately 20 feet long and 3 feet deep, were excavated. Seven boreholes, approximately 28 to 39 feet deep (into bedrock), were drilled to obtain continuous core samples and to install inclinometers to accurately measure movement. A geologist made field observations throughout the work, and laboratory analyses were conducted to determine mechanical properties of the test pit and borehole samples.

The *Rocky Flats Original Landfill Geotechnical Investigation Report* (Tetra Tech 2008) (Geotech Report) describes the Phase 2 work performed and concludes that a clay layer containing organic materials at or near the bedrock contact appears to be a weak interface area. As described in the Geotech Report, modeling predicts small-scale instability due to percolating moisture that lubricates this weak interval. The OLF buttress is providing stability as intended, and there is no large-scale instability predicted; therefore, the observed conditions do not appear to indicate a need for urgent or major responses.

CDPHE notified DOE on June 24, 2008, that the Geotech Report, having met the criteria agreed to in the Work Plan for the investigation, was acceptable.

The 2006 OLF M&M Plan required a uniform diversion berm height of at least 2 feet, as a simplifying approach based on the *Final Design Analysis, Accelerated Action Design for the Original Landfill*, Appendix D (Earth Tech 2005) (Final Design Analysis). A Hydraulic/Hydrologic Analysis of the Original Landfill Diversion Berms (Tetra Tech 2008a) (Tetra Tech analysis) was also prepared in 2008 under the OLF Action Plan to reevaluate the minimum diversion berm heights required to convey precipitation run-on and runoff for the 1,000-year, 24-hour storm event using a smaller berm length sub-drainage area than that used in the Final Design Analysis.

A summary of the results of the OLF Action Plan implementation and the path forward is included in RFLMA Contact Record 2008-07, approved by CDPHE on September 2, 2008 (DOE 2008a). The construction to complete the necessary repairs and to implement design changes was completed in November 2008, and the as-built surveys for inclusion in this revised

OLF M&M Plan were completed in March 2009. The following items resulted from the implementation of the OLF Action Plan.

Construction of approved design changes and repairs and maintenance activities were performed as follows:

1. Diversion berm height—Minimum heights are based on subdrainage areas calculated for 200-foot lengths of each berm, and the minimum calculated height to convey the 1,000-year, 24-hour event, calculated in the Tetra Tech analysis. This provides freeboard capacity to convey the 100-year, 24-hour event, which is a design criterion for the berms. Approximately 24 percent of the total berm lengths had soil added to the top to meet this minimum height (which will represent the required berm height). This approach will minimize the impact to established vegetation because it will not require wholesale regrading or the use of heavy construction equipment. Soil was added to raise berm heights in September and November 2008. The 2009 as-built topographic survey completed after this work, shown in Figure 1−3, will serve as a baseline for continued observation of berms and to identify areas for additional maintenance. Inspections and future topographic surveys will also be used to identify areas that require additional soil to maintain minimum heights.

2. Diversion berm channels—Channels were regraded as needed during the berm height construction, based on observations of significant ponding, to promote drainage to the perimeter channels. This included installing a gravel drain at the western end of diversion berm 3 to improve drainage below seep 4 into the west perimeter channel. The 2009 as-built topographic survey shown in Figure 1−3 will serve as a baseline for continued observation of the channels and to identify areas for additional maintenance. Inspections and future topographic surveys will be used to identify areas of ponding or slopes that indicate which channel areas may be conducive to ponding.

3. Seep 7 drain extension—An extension to the original drain was installed in September 2008 upgradient within the 2-foot cover depth in the general area where this seep has expressed (“day-lighted”) on the surface and saturated surface soil. At its southern end, the excavation extended below the cover material for a short distance to a depth of 4 to 5 feet and was tied into the existing drain. The 2009 as-built topographic survey shown in Figure 1−3 shows the location of the drain extension and tie-in.

4. Inclinometers and settlement monuments—Seven inclinometers were installed during the geotechnical investigation. Installation of settlement monument E, between berms 1 and 2, was originally planned for completion in 2006, and was delayed during the severe weather in the winter of 2006−2007. Due to the observed slumping in this area, it was not installed pending the completion of the geotechnical investigation. Settlement monument E was installed during the construction of the seep 7 drain extension. The 2009 as-built topographic survey shown in Figure 1−3 shows the location of the inclinometers and settlement monuments.

5. West perimeter channel side slope stability—The area generally between the western ends of diversion berms 1 and 3 was regraded by cutting and filling to lessen the OLF side slope and improve stability. The construction was completed in November 2008. The existing gravel drain between diversion berms 1 and 2 was located and tied into an extension of the gravel drain to the southern end of the perimeter channel. The diversion berm 3 gravel drain was also tied into the extension of the gravel drain to the southern

end of the perimeter channel. The 2009 as-built topographic survey, shown in Figure 1−3, shows the contours resulting from the regrading and the location of the gravel drain.

6. Other repairs and maintenance—Localized slumping, differential settling, and cracks observed between the western ends of diversion berms 1 and 2, and between the eastern end of diversion berms 5 and 6, were addressed by adding soil, regrading, and compacting, as specified in the original OLF M&M Plan. The geotechnical investigation concluded that adding soil and regrading was acceptable to maintain cover integrity and would not have a significant negative impact on slope stability.

This page intentionally left blank

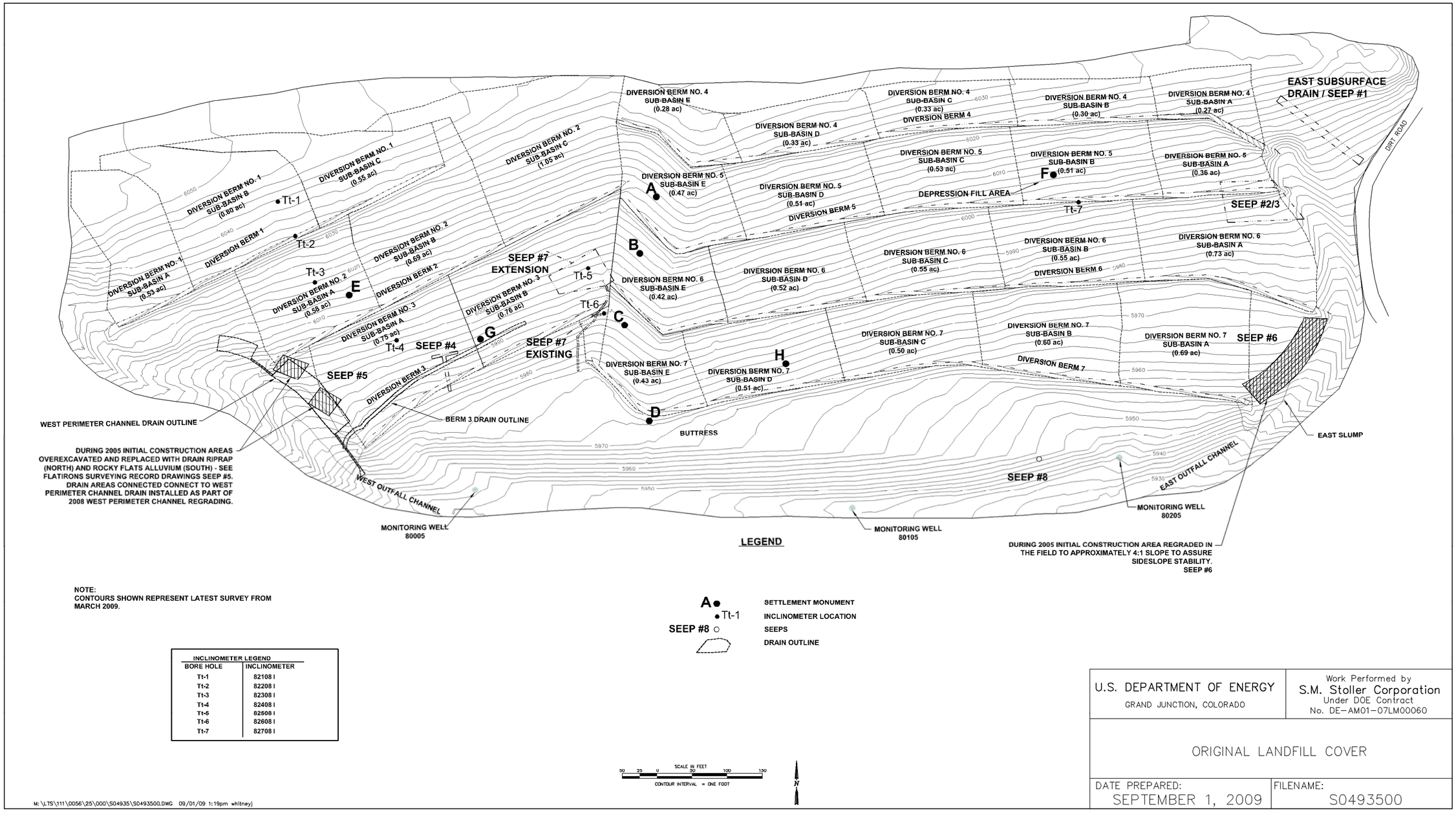


Figure 1–3. Original Landfill Cover

This page intentionally left blank

2.0 Site Physical Description

This section describes the physical conditions at the OLF site, such as topography, hydrology, climate and precipitation, hydrogeology, and site features, which include the final cover, the buttress fill, the stormwater management system, the Resource Conservation and Recovery Act (RCRA) groundwater monitoring network, and the surface water monitoring locations.

2.1 Topography

Average slopes at the OLF, based on the post-construction survey, are as follows:

- Soil cover slope—18 percent;
- Top of buttress fill slope—2−5 percent;
- Buttress fill (south) sideslope—3 horizontal (H):1 vertical (V);
- Perimeter channel sideslope—generally 3H:1V; and
- Perimeter channel slopes—approximately 12 percent.

As discussed in Section 1.4, an as-built topographic survey of the OLF was performed in the first quarter of 2009 following the completion of maintenance and repairs under the OLF Action Plan and after the geotechnical investigation. The 2009 topographic survey is shown in Figure 1−3. The average slopes are the same as the post-construction survey, but the 2009 topographic survey reflects changes in elevations of portions of the diversion berms and the west perimeter channel.

2.2 Hydrology

The OLF is within the Woman Creek drainage. Diversion berms constructed on the soil cover are designed to minimize surface water overland flow and divert run-on and runoff to the perimeter channels. The perimeter channels divert the surface water south of the landfill to below the buttress fill. Below the buttress fill, the perimeter channel slopes decrease, and flow encounters rock outfalls that dissipate the flow energy and allow the surface water to return to overland or sheet flow between the buttress fill and Woman Creek.

2.3 Climate and Precipitation

Rocky Flats is in the southern Rocky Mountains and has a continental, semiarid climate. The region is noted for large seasonal temperature variations, occasional dramatic short-term temperature changes, and strong, gusty winds that reach more than 75 miles per hour. Mean annual precipitation is approximately 15.5 inches, with approximately one-half of that amount occurring as snow.

2.4 Hydrogeology

In the area of the OLF, groundwater flows predominantly within the upper hydrostratigraphic unit (UHSU). The UHSU is composed of materials that include the quaternary Rocky Flats Alluvium, colluvium, Valley Fill Alluvium, and weathered claystone bedrock. Unweathered

bedrock claystones are included as part of the lower hydrostratigraphic unit. Groundwater elevations typically vary seasonally less than 5 feet, mostly in response to direct precipitation recharge in wetter periods and evapotranspiration in warmer months. Water levels above the weathered bedrock range from 0 to 5 feet along Woman Creek, 5 to 10 feet in the central waste area, 0 to 5 feet in the western waste area, and from 10 to more than 40 feet above the bedrock north of the OLF (DOE 2006).

Natural groundwater seeps were discovered during construction of the soil cover and perimeter channels. Several seeps were mitigated with a subsurface drain to the buttress sub-drain. The buttress sub-drain was constructed beneath the buttress fill to prevent buttress saturation. This drainage layer directs water to the south of the buttress into the Valley Fill Alluvium.

2.5 Site Features

Site features included in the monitoring program at the OLF include the final cover, the buttress fill, the stormwater management system, the RCRA groundwater monitoring network, and the surface water sampling locations. Construction included regrading of the site to consistent slopes. This included regrading the waste and placement of clean imported soil gradefill material. A minimum of 2 feet of Rocky Flats Alluvium soil cover was placed within the limit of waste. Monitoring procedures are provided in subsequent sections.

2.5.1 Final Cover

The final cover of the OLF includes a 2-foot-thick Rocky Flats Alluvium soil cover that was constructed over both the regraded surface and the buttress fill. The 2-foot-thick soil cover was constructed within the limit of waste and does not extend to the perimeter channels. Surface soil between the limit of waste and the perimeter channels is also Rocky Flats Alluvium, but was placed as regrade material.

Inspection and monitoring procedures to maintain the integrity and effectiveness of the final cover are included in Section 3.0.

2.5.2 Buttress Fill

The buttress fill is an approximately 20-foot-high, 1,000-foot-long soil mass placed at the toe of the OLF (Figure 1-3. The compacted soil for the buttress fill was continuously tested for compaction and moisture content to meet design specifications. A sub-drain lies beneath the buttress fill and consists of drainage rock covered with a geotextile separation layer. The sub-drain is located below the surface and cannot be visually inspected. The buttress fill was constructed over the sub-drain with engineered fill compacted in 1-foot lifts.

2.5.3 Stormwater Management System

2.5.3.1 Introduction

The original stormwater management plan is presented in Appendix D of the Final Design Analysis (Earth Tech, Inc. 2005). Appendix D of the Final Design Analysis presents the results of calculations used to determine the stormwater run-on and runoff volumes to adequately design the diversion berms and perimeter channels. The stormwater management structures are designed

to the 100-year, 24-hour storm event and include capacity to handle a 1,000-year, 24-hour storm event.

Based on the Final Design Analysis calculations, a minimum diversion berm height of 2 feet was established in the 2006 OLF M&M Plan. However, by the middle of 2008, the berm heights had decreased by several inches or more below the minimum along approximately 60 percent of the length of the berms. Because maintaining the 2 foot minimum height with Rocky Flats Alluvium is difficult, the minimum berm heights to handle the design storm event were reconsidered as part of the OLF action plan. The surface area handled by each diversion berm was divided into sub-drainage areas to determine run-on and runoff volumes for each 200-foot length of berm. The calculated revised minimum berm height for each 200-foot length is based on the capacity to handle the 24-hour 1,000-year storm event. Figure 3−1 shows the revised minimum berm heights.

Filling and regrading portions of the west perimeter channel to improve the stability of the cover along the eastern side of the channel was designed to meet the 2005 stormwater management plan design criteria.

2.5.3.2 Applications

Effective stormwater management is achieved in the system by applying the following principles:

- Protect the land surface from erosion (Section 2.5.3.3),
- Manage run-on and runoff (Section 2.5.3.4), and
- Inspect and maintain the erosion and stormwater management structures (discussed in Section 3.0).

In the long term, the system is designed as an erosion control system so sediment control will not be necessary since limited sediment will be generated. In the short term, sediment will be controlled with temporary erosion lining and check dams (GeoRidge™).

2.5.3.3 Erosion Control

At the OLF, stormwater management features have been designed with erosion control features to limit both short- and long-term erosion. Erosion control is any practice that protects soil surfaces and prevents the soil particles from being detached by rainfall or wind. Following construction, the soil cover was covered with both straw mulch and a spray-on erosion control medium called Flexterra™. The diversion berms and upper slope portions of the buttress fill are lined with temporary erosion mat. The diversion berms included temporary check dams (GeoRidge™) to limit sediment transport. These measures will limit short-term erosion until vegetation is established. The perimeter channels and lower sideslope of the buttress are lined with permanent erosion mat. Rock outfalls are present at the diversion berm outfalls to the perimeter channel outfalls to prevent scouring. All areas have been seeded to aid in long-term erosion protection.

2.5.3.4 Run-on and Runoff Control

The stormwater management system is designed to collect, route, and discharge stormwater run-on and runoff. Run-on stormwater is conveyed from upper portions of the OLF as overland flow and then enters either the diversion berms or perimeter channels. Runoff enters the perimeter channel from overland flow on the cover and from the diversion berms constructed on the cover.

2.5.4 RCRA Groundwater Monitoring Network

Four RCRA monitoring wells are used for groundwater monitoring at the OLF as discussed in Section 4.0. These wells will be monitored in accordance with RFLMA (DOE et al. 2007). Of the four wells, one is upgradient and three are downgradient of the OLF.

2.5.5 Surface Water Monitoring

Surface water monitoring will be conducted at two locations in accordance with RFLMA, one upgradient and one downgradient of the OLF. Surface water monitoring will be performed in accordance with RFLMA.

During construction, intermittent seeps were discovered and remedied if necessary. Seep inspection is required and is discussed in Section 3.3.

3.0 Final Cover and Stormwater Management System Inspection and Monitoring

This section outlines the inspection and monitoring program to be undertaken at the OLF to ensure that the integrity of the cover is not compromised and continues to function as designed. Inspection and monitoring tasks will include monitoring subsidence and consolidation, slope stability, soil cover, vegetation, and stormwater management structures so that any potential maintenance actions can be taken in a timely manner. If actions that go beyond routine maintenance are needed, and if such actions require engineering design, the RFLMA parties will be notified and consulted regarding proposed actions.

3.1 Inspection Procedures

The frequency for each inspection and monitoring item will be conducted as specified in RFLMA. Modifications to the inspection program, including inspection frequency, will be evaluated using the RFLMA consultative process, and approved as specified by RFLMA modification requirements. More frequent inspection may occur any time conditions warrant.

In accordance with the IM/IRA (DOE 2006), site inspections of the area will be conducted periodically following construction of the final cover. In addition to regularly scheduled inspections, weather-related inspections will be conducted as follows:

- The site shall be inspected within 2 days after a storm event of 1 inch or more of rain in a 24-hour period; and
- The site shall be inspected within 2 days after significant melt of a 10-inch or more snow storm, assuming 10 inches of snow equals 1 inch of water.

In addition, the vegetation was required to be inspected monthly from April to September and quarterly the rest of the year for the first three growing seasons following initial seeding: 2006, 2007, and 2008.

After the first year of required monthly inspections, it was anticipated that the frequency of inspections would be changed to quarterly, but the observations of conditions that warranted further repair and that triggered further investigation at the beginning in 2007 resulted in continued monthly inspections.

Inspections will be performed by qualified personnel and reviewed by a competent professional. Inspections will encompass the following subjects, as described in Sections 3.2 through 3.8: subsidence and consolidation, slope stability, soil cover, vegetation, stormwater management structures, run-on erosion controls, and institutional controls and related matters. OLF inspections will be performed using a prescribed form containing a checklist of items that documents the evaluation of site conditions. The inspection form is included in Appendix A. The inspector and the reviewer will sign and date the inspection form. The findings and observations of the site inspection will be entered on the form and presented in an annual OLF monitoring report. Minor repairs or maintenance may be performed in conjunction with the inspection and will be noted on the inspection form.

Also, as a result of the RFLMA party consultation for the OLF Action Plan, a topographic survey will be conducted approximately every 2 years as an aid in periodically evaluating the subsidence and consolidation, slope stability, and stormwater management structure conditions at the OLF.

The inspection forms shall serve to keep the RFLMA parties informed of the OLF conditions and to facilitate the RFLMA consultative process regarding OLF conditions. DOE will follow RFLMA requirements to inform the RFLMA parties if any deficiencies that are found during inspections are determined to be reportable conditions as defined by RFLMA.

3.2 Subsidence and Consolidation

Subsidence and consolidation at the OLF largely depend on how well the waste, fill, and cover were compacted when placed, and the thickness, age, and composition of the waste. Waste subsidence or continued consolidation may result in differential settlement, which generally occurs when one area of waste settles more readily than another because of differences in waste composition, compaction, thickness, and moisture content. Differential settlement across the landfill may create cracks on the surface, which would allow precipitation to infiltrate more easily.

Differential settlement can also change the topography of the landfill and create areas on the surface where ponding of water can occur—this is particularly important regarding the diversion berms on the OLF cover. Localized waste subsidence can manifest itself in the form of cracks, depressions, and sinkholes. Construction of the final cover system included the placement of engineered fills. Therefore, cover subsidence or consolidation is less of a concern than is waste subsidence.

3.2.1 Monitoring Locations and Procedures

Subsidence and consolidation monitoring will be conducted to evaluate actual settlement compared to the expected settlement calculated in the final design and to observe areas of water ponding on the landfill surface or other indicators of differential settlement. Subsidence and consolidation at the OLF will be monitored by visually inspecting the surface of the landfill cover for cracks, depressions, and sinkholes. Visual inspections will involve traversing the landfill to gain perspective on regions of the landfill (i.e., every square foot of the landfill is not inspected). In addition, the seven diversion berm flow lines will be traversed to look for sloughing or differential settling that could change the flow line slope or berm height.

Eight settlement monuments have been installed at locations that the RFLMA parties have agreed on, as shown in Figure 3−1. For each monument location (A-F in Figure 3−1), the calculated settlement from the final design (Figure 3−2) will be compared with measured settlement. Monuments G and H have no calculated settlement values.

After the first year of required quarterly settlement monument monitoring, an annual monitoring frequency was assumed in the 2006 OLF M&M Plan, but the observations of conditions that warranted further repair and that triggered further investigation at the beginning in 2007 resulted in continued quarterly monitoring.

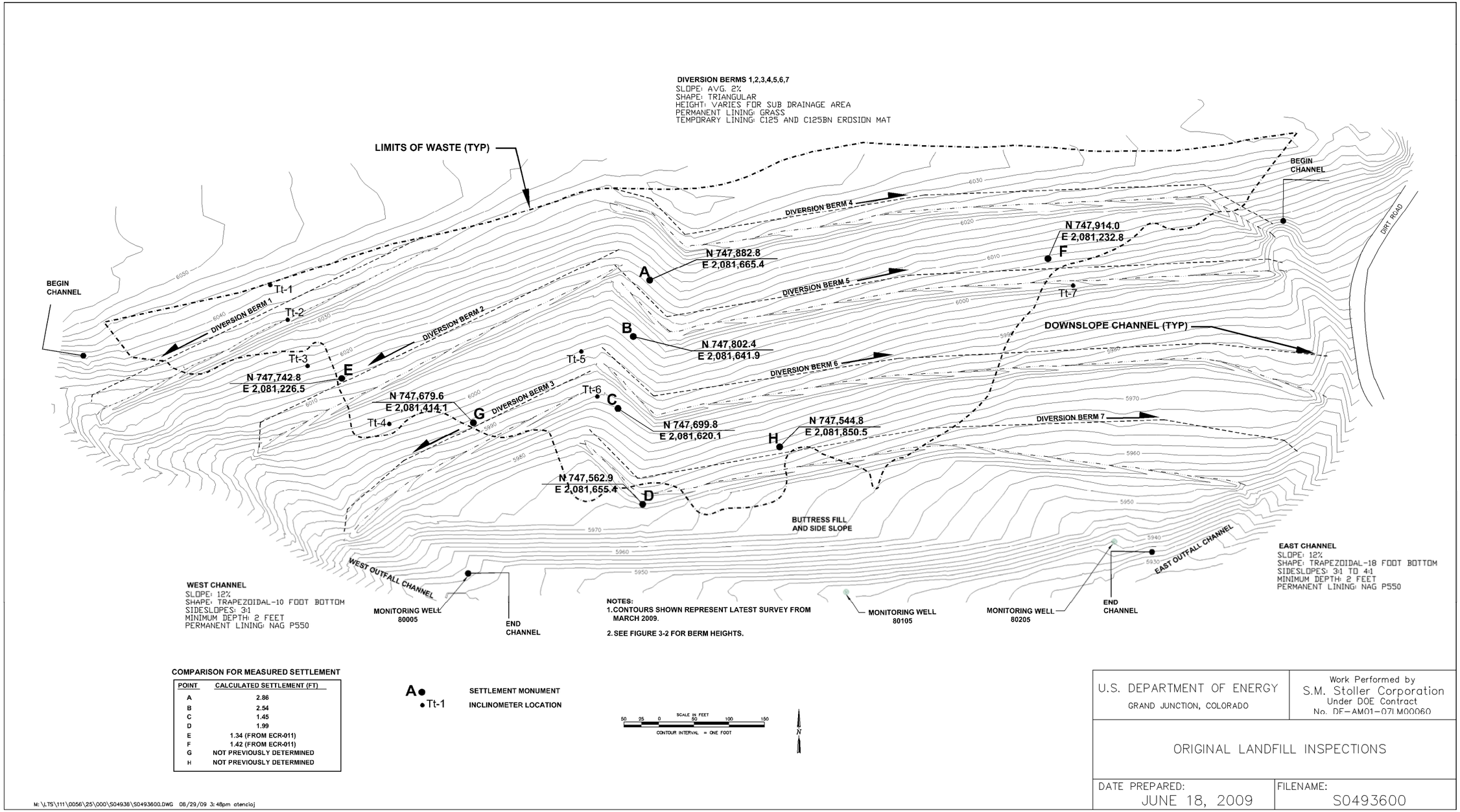


Figure 3–1. Original Landfill Inspections

This page intentionally left blank

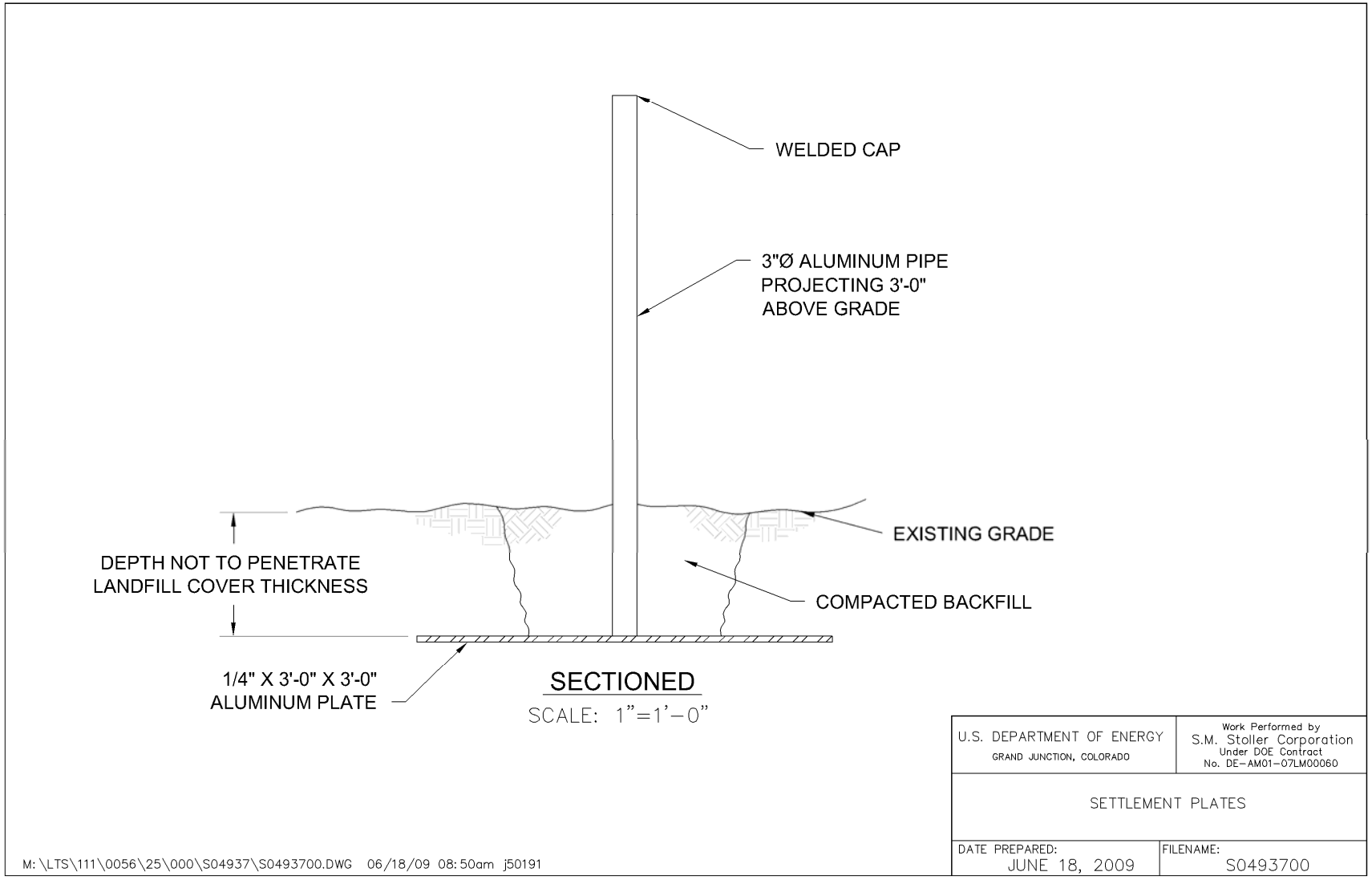


Figure 3–2. Original Landfill Settlement Plates

Settlement monuments will be monitored as frequently as RFLMA specifies. Modifications to the monitoring frequency will be evaluated using the RFLMA consultative process, and approved as specified by RFLMA modification requirements. More-frequent monitoring may occur any time conditions warrant.

Areas of observed differential settlement, including ponding, will be staked, photographed, measured, and located on the landfill site map prior to any maintenance action. Control Point 1001 will be maintained as the control for surveying the OLF.

3.2.2 Maintenance Action Activities

The maintenance actions that will normally occur to correct the effect of adverse differential settlement are placing additional soil and regrading the affected area. Replacement soil will be Rocky Flats Alluvium as was used in the construction derived from or near the site. This action will eliminate the potential for ponding and correct the slope of the surface. Maintenance that addresses differential settlement will be photographed, and the area will be measured and located on an OLF site map.

Settlement plate data will be tabulated, and the measured settlement will be compared to the anticipated settlement calculated in the final design, based on the final settlement plate locations. Should measured settlement exceed 30 percent of the calculated maximum settlement and be expressed as differential settlement, the area will be photographed, located on the OLF site map, repaired, and reported on the inspection forms. Should the measured settlement exceed 90 percent of the calculated maximum settlement and be expressed as differential settlement, a qualified geotechnical engineer will be consulted to determine a maintenance action, and the results of the geotechnical engineer's evaluation will be reported to the RFLMA parties. The areas where maintenance actions have taken place will be inspected specifically and reported on (during the inspections of the cover) to monitor any continued subsidence. If differential settlement or localized subsidence appears to be substantial and likely to influence the integrity of the existing cover and surface water drainage over the OLF, maintenance actions will be taken to mitigate these concerns (e.g., areas of ponding water on the cover).

DOE will follow RFLMA requirements for reportable conditions if differential settlement or localized subsidence is determined to be a reportable condition as defined by RFLMA.

3.3 Slope Stability

A landfill site may be susceptible to instability due to lateral movement. Slope failures can be caused by the weight of the wastes and cover material, steeply regraded slopes, inherently weak zones or layers in underlying formational materials, or seepage resulting from water infiltration. Seismic forces can also cause slope failures. Steep slopes produce less stable conditions and are more susceptible to failure. Slope failures can also occur within the waste mass, resulting in downslope sliding of the cover components. The cover system with buttress fill has been designed and constructed with applicable safety factors to guard against slope failure. Nevertheless, slope stability will be monitored to verify that slope failure is not in progress. In addition, if areas of slope stability concerns are found outside the boundaries of the OLF

footprint but within the general area of the OLF, the area of the inspection will be expanded to include them.

3.3.1 Monitoring Locations and Procedures

Slope stability at the OLF will be monitored by visually inspecting the cover, the stormwater diversion berms, the perimeter channel sideslopes, and the buttress fill sideslope for signs of cracks, evidence of block failure, seeps, and evidence of rotational failure. The inspection will categorize the observed cracking. Visual inspection will involve traversing the slope to gain a perspective of the entire slope. Specific attention will be paid to areas where small seeps occurred at the surface of the OLF during construction, and that have been observed after completion of construction. These areas are shown in Figure 3−1. Any areas where a surface seep is identified will be photographed, marked, located on the OLF map, and monitored for signs of slope instability.

Seven inclinometers were installed during the geotechnical investigation at locations shown on Figure 3−1. The movement of the inclinometers has been monitored approximately monthly since installation. Inclinometers deflect based on lateral movement of the ground in which the inclinometer is located, and can deflect enough to cause the inclinometer tube to break. Once an inclinometer tube breaks, it will no longer be monitored.

Inclinometers will be monitored as frequently as RFLMA specifies. Modifications to the monitoring frequency will be evaluated using the RFLMA consultative process, and approved as specified by RFLMA modification requirements.

Areas that are identified during the inspections as potential slope stability concerns will be photographed, as appropriate, located on the OLF site map, and staked for further monitoring. If adverse surface water flow into cracks is likely, actions such as filling the cracks or controlling surface water flow will be taken to prevent surface water from entering the cracked area. In addition, inclinometer deflection from the initial location more than 1 inch on any axis is an indication of a potential slope stability concern, and the surface of the surrounding area should be closely observed for signs of instability. If further monitoring indicates a continued stability concern, a qualified geotechnical engineer will be consulted.

3.3.2 Maintenance Action Activities

Based on the site monitoring data and consultation with a qualified geotechnical engineer, maintenance actions will be taken to address any potential slope failure at the OLF that would likely compromise the remedy. The maintenance actions may include, but are not limited to, regrading affected areas, filling areas, maintaining positive drainage of surface water, constructing seep drains, and regrading steep sections to achieve side slopes no greater than 4H:1V. Areas where maintenance actions have taken place will be closely monitored for further slope stability concerns.

DOE will follow RFLMA requirements for reportable conditions if a slope stability concern is determined to be a reportable condition as defined by RFLMA.

3.4 Soil Cover

The cover system at the OLF is designed to meet the minimum soil erosion requirements from both water and wind erosion. During the post-closure period, it is important to ensure that both temporary and permanent erosion controls are functioning properly. Regardless, the soil cover thickness may change over time due to wind and water erosion. Subsidence due to waste settlement and lateral movement of wastes or slopes may also contribute to changes in differential soil cover thickness. The soil cover is monitored to verify that it is performing in accordance with the design and that the OLF system as a whole continues to meet performance objectives.

3.4.1 Monitoring Locations and Procedures

Monitoring of the soil cover at the OLF will include the following:

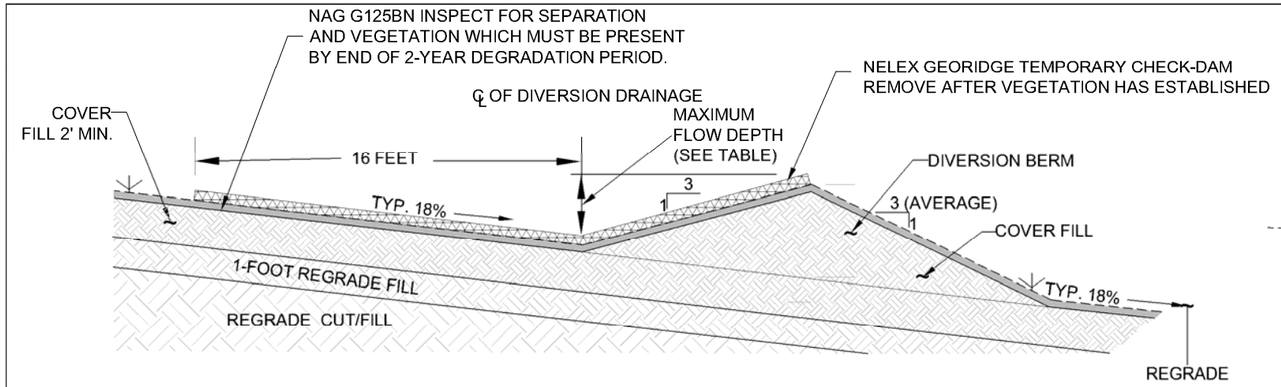
- Visually inspecting the soil cover for erosion or deposition areas;
- Visually inspecting the soil cover for signs of burrowing animals;
- Visually inspecting previously identified seep areas and noting any new ones that may have developed; and
- Visually inspecting the diversion berms, diversion berm outfalls, and the perimeter channels for erosion rills or excessive deposition. Particular attention will be paid to—and appropriate measurements will occur regarding—the design parameters for the diversion berms and gradient, with the primary focus being the performance objective of the berms. The design parameters are in the Final Design Analysis, and modified by the Tetra Tech analysis.

Visual inspection will involve traversing the slope to gain a perspective of the entire area. Signs of rill and gully erosion greater than 6 inches deep will be photographed, marked with stakes, measured, located on the landfill site map, and reported on the inspection form. Areas of observed soil deposition indicating possible significant scouring of soil-reducing cover thickness will also be photographed, marked, measured, located on the landfill site map, and reported on the inspection form. If visual inspections of the diversion berms indicate a departure from the design heights, as shown in Figure 3−3, the height and gradient will be measured to determine if maintenance is required. In addition, the periodic topographical survey results shall be evaluated to determine if berm maintenance is required.

The soil cover will be monitored as frequently as RFLMA specifies. Modifications to the monitoring frequency will be evaluated using the RFLMA consultative process, and approved as specified by RFLMA modification requirements.

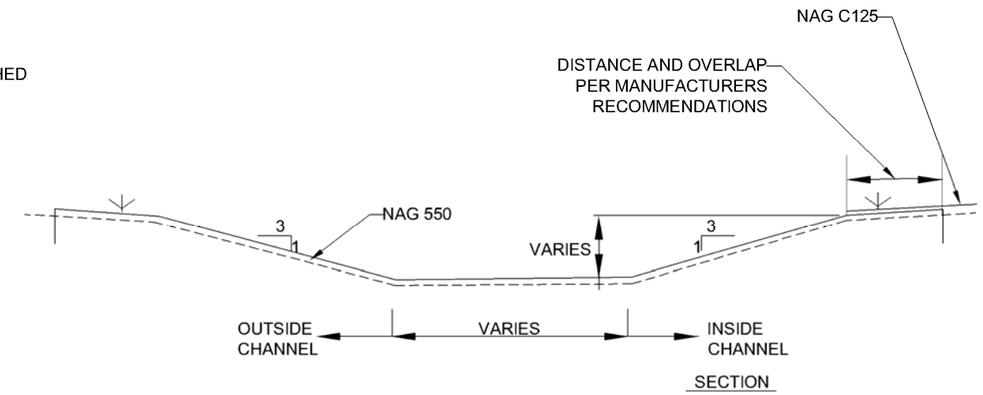
3.4.2 Maintenance Action Activities

If monitoring indicates significant loss of soil over time, maintenance actions will be taken. If any section of gully is greater than 6 inches deep, maintenance actions will be implemented. Maintenance actions may include, but are not limited to, soil replacement, regrading the affected areas to maintain the minimum design soil cover thickness, and removing and relocating eroded soils (if necessary). The regraded areas will be vegetated per design criteria to prevent further erosion. Erosion control measures will be implemented to prevent further erosion of



SECTION

NOTE:
IN AREAS OUTSIDE OF THE WASTE "FOOTPRINT" COVER SOIL MAY BE
LESS THAN 2" ON TRANSITION AREAS OR NO COVER SOIL.

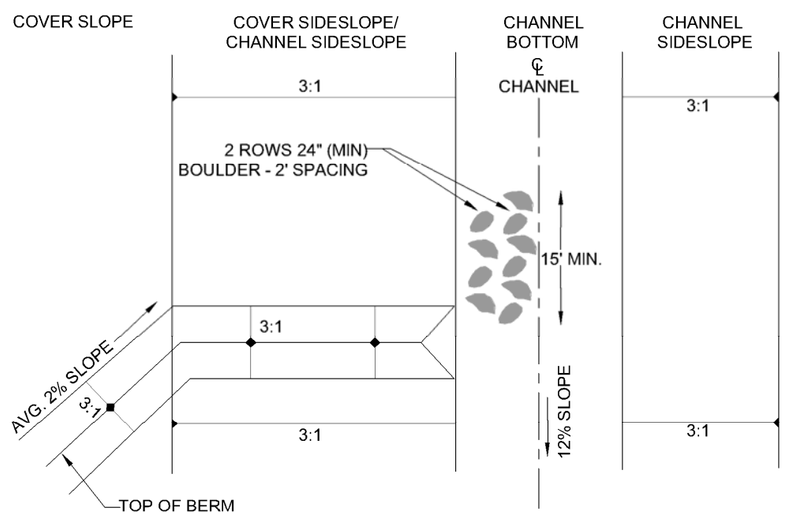


SECTION

PERMANENT/GRASS-LINED CHANNEL DETAIL (SECTION)
NTS

BERM HEIGHT SUMMARY
ROCKY FLATS-ORIGINAL LANDFILL

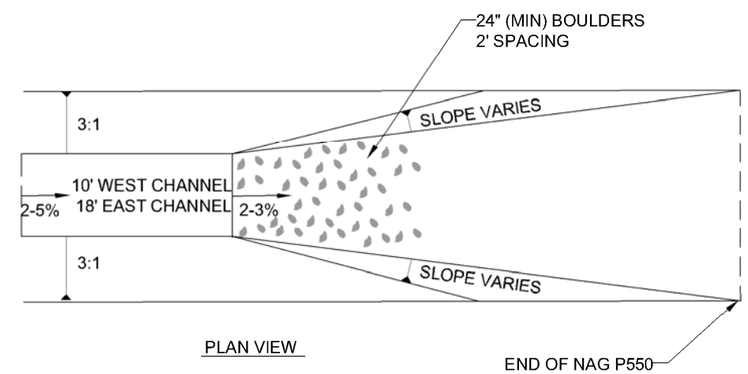
AREA ID		MAXIMUM FLOW DEPTH FT 1,000-YR
DB-1	A	1.48
	B	1.68
	C	1.46
DB-2	A	1.66
	B	1.69
	C	1.67
DB-3	A	1.62
	B	1.34
DB-4	A	1.33
	B	1.52
	C	1.29
	D	1.06
	E	1.06
DB-5	A	1.80
	B	1.87
	C	1.51
	D	1.39
	E	1.52
DB-6	A	2.01
	B	1.97
	C	1.55
	D	1.33
	E	1.21
DB-7	A	1.90
	B	1.67
	C	1.74
	D	1.47
	E	1.23



PLAN VIEW

NOTE:
NAG P550 EROSION MAT ON CHANNEL BOTTOM, CHANNEL SIDESLOPES.
DOWNSLOPE CHANNEL BOTTOM, AND DOWNSLOPE CHANNEL SIDESLOPES.

DOWNSLOPE CHANNEL TRANSITION FROM DIVERSION BERM TO CHANNEL (PLAN VIEW)
NTS



PLAN VIEW

END CHANNEL (PLAN VIEW)
NTS

U.S. DEPARTMENT OF ENERGY GRAND JUNCTION, COLORADO	Work Performed by S.M. Stoller Corporation Under DOE Contract No. DE-AM01-07LM00060
STORMWATER MANAGEMENT STRUCTURE DETAILS	
DATE PREPARED: JUNE 17, 2009	FILENAME: S0493800

M:\LTS\111\0056\25\000\S04938\S0493800.DWG 06/18/09 08:43am j50191

Figure 3–3. Original Landfill Stormwater Management Structure Details

This page intentionally left blank

cover soils (e.g., erosion control mat, revegetation), if necessary. The amount of soil used to fill areas of erosion will be estimated, recorded, and reported in the quarterly monitoring report. The RFLMA parties will be notified and consulted if soil erosion concerns persist. Areas of soil deposition that hinder the flow of surface water in a stormwater channel will be removed to maintain the designed channel configuration of at least average 2 percent grade and flow capacity as well as minimum berm height to provide adequate drainage. Maintenance of these areas will also be documented and reported in the quarterly report.

3.5 Vegetation

Vegetation is important to long-term erosion protection for the cover, the upper portion of the buttress sideslope, and the diversion berms. Permanent erosion mat has been placed in the perimeter channels and the lower portion of the buttress sideslope; nevertheless, vegetation is important to reinforcing the erosion mat and providing long-term protection. For short-term protection, Flexterra™ and crimped straw were placed on the cover, and temporary erosion mat, which has a 2- to 3-year lifespan, was placed on the diversion berms and upper buttress fill sideslope. In addition, check dams (GeoRidge™) have been placed in the diversion berms. Vegetation inspections will ensure that vegetation is established properly and will be consistent with the *Rocky Flats, Colorado, Site Revegetation Plan* (DOE 2007b) and the *Rocky Flats, Colorado, Site Vegetation Management Plan* (DOE 2007c).

3.5.1 Monitoring Locations and Procedures

Vegetation at the OLF was inspected by visual surveys each month from April to September for the first three growing seasons following initial seeding: 2006, 2007, and 2008. The vegetation will be monitored as frequently as RFLMA specifies. Modification to the monitoring frequency will be evaluated using the RFLMA consultative process, and approved as specified by RFLMA modification requirements. These surveys will help identify problematic weeds, which can grow quickly, and potential drought conditions, which can harm young vegetation. During the vegetation surveys, the cover will be traversed, the vegetation's health will be evaluated, and any unwanted vegetation (such as weeds and woody vegetation) will be searched for. Particular attention will be paid to the berms, channels, and buttress sideslope. The percentage of weeds versus grass on the cover will be estimated. At least one of the inspections during the spring and summer months must be conducted by a competent person capable of identifying weed species known in the area. If the erosion controls are not adequate and vegetation is sparse, maintenance action will be necessary on the cover. Woody vegetation is not permitted on the OLF cover within the footprint of the waste; if it is present, it shall be removed. Woody vegetation shall also be removed from diversion berms and diversion berm channels so that these plants do not impede surface water flow. However, woody vegetation that does not interfere with the integrity of the cover or hinder the ability of stormwater management structures or the buttress drain to convey the design flows are allowed to grow outside of the waste footprint. Woody plants may be desirous, especially in moist areas (including those related to seeps), to help stabilize the soil and potentially transpire some of the moisture from the cover. The design documents assumed a vegetation density on the diversion berms and upper buttress fill sideslope of at least 75 percent after two full growing seasons. This vegetation density is equivalent to a good stand of unmowed grass.

3.5.2 Maintenance Action Activities

If visual inspections indicate vegetation concerns on the cover, maintenance actions will be taken. Actions will include, but not be limited to, the following:

- Reseeding the soil cover;
- Applying spot herbicide;
- Maintaining or repairing erosion controls; and
- Mowing, trimming, or removing vegetation to maintain clear water flow pathways behind berms.

3.6 Stormwater Management Structures

Stormwater management inspections will be required at the OLF to ensure that existing stormwater control structures (manmade drainage features) are functioning adequately to achieve the following objectives:

- Reduce flow onto the landfill (run-on controls);
- Reduce overland flow on the landfill;
- Collect and transport runoff from the OLF; and
- Limit transport of sediment from the disturbed areas to off-site drainage ways.

Existing stormwater controls at the OLF include the following:

- Diversion berms 1 through 7;
- Diversion berm outfalls 1 through 7;
- Diversion berm temporary check dams (GeoRidge™);
- West perimeter channel;
- East perimeter channel;
- West perimeter channel outfall;
- East perimeter channel outfall;
- Permanent erosion mat-lined lower buttress fill sideslope;
- Vegetation/temporary erosion mat-lined upper buttress fill sideslope; and
- Temporary, naturally degradable, straw waddles between the diversion berms for additional erosion control.

Details of each type of structure are included in Figure 3−1 and Figure 3−3. Refer to Section 3.4 for additional information regarding inspection and maintenance requirements for the diversion berms.

3.6.1 Monitoring Locations and Procedures

Stormwater management structures will be monitored visually by walking the structures and examining all components. Problem areas will be noted on the inspection form, graphically

depicted, and photographed. At a minimum, these structures will be inspected for signs of excessive erosion, settlement, bank failure, breaches in the diversion berms, subsidence, burrowing animals, and blockage. Signs of potential problems include, but are not limited to, ponding water, gullying, sediment buildup, and depressions.

The perimeter channel lining and temporary diversion berm lining will be inspected for evidence of damage, displacement, undermining, scour, or deterioration. Repairs will be made to re-stabilize the channel in accordance with the design specifications. Permanent and temporary erosion control mat lining on the buttress fill sideslope will also be inspected. The erosion control mat will be inspected for holes, rips, and separation. In addition, any evidence of erosion rills or gullies will be noted during the inspection. The temporary check dams placed perpendicular to the flow lines of the berms will be inspected for excessive sediment and removed after vegetation is established. Riprap in the diversion berm and perimeter channel outfalls will be inspected for integrity and excessive sediment.

The diversion berm channels shall be maintained by removal of high spots and filling of low spots created by flow during storm events to prevent ponding along significant lengths of the berm channel areas. An average slope of 2 percent for the diversion berm channels shall be maintained.

3.6.2 Maintenance Action Activities

If the inspections indicate that the existing stormwater management structures are not adequately controlling surface water run-on and runoff, maintenance actions will be taken.

Routine maintenance of the surface water controls will include removing any blockages, filling eroded areas, replacing temporary erosion control mat (where necessary due to inadequate vegetation), or repairing other disturbances as necessary. If permanent erosion control mat is replaced or repaired, the changes will be made in accordance with the manufacturer's specifications, or equivalent matting will be used. Sediment may be removed periodically from the stormwater management structures to restore their design characteristics. Areas that exhibit excessive erosion may the require placement of erosion control material or strengthening of the existing erosion control measures.

DOE will follow RFLMA requirements for reportable conditions if a stormwater management structure concern is determined to be a reportable condition as defined by RFLMA.

3.7 Institutional Controls

Institutional controls are used to control access to and restrict activities at the OLF to ensure the effectiveness of the engineered controls and monitoring systems. The OLF will be inspected for evidence that the institutional controls were violated or physical controls were damaged. Inspections will be conducted to look for evidence of the following activities:

- Excavations of the cover and in the immediate vicinity of the cover;
- Construction of roads, trails, or buildings on the cover;
- Drilling of wells or use of groundwater for any purpose other than the accelerated action;

- Damage or removal of any signage or groundwater monitoring wells at the OLF; and
- Evidence of unauthorized entry.

A checklist of these items is included on the inspection form found in Appendix A.

3.8 Condition of Monitoring Points

All established monitoring locations, such as groundwater wells, will be evaluated for ongoing integrity. The inspection will include documentation of any damage to the monitoring points that would impact their usefulness for inspections.

3.9 Site Conditions

During site inspections, signs, markers, and the overall condition of the OLF site will be checked to determine the continuing effectiveness of institutional and physical controls.

3.10 Reporting and Recordkeeping

Inspection forms and findings will be included in the annual OLF monitoring reports discussed in Section 6.0. These reports will be submitted as required by RFLMA.

4.0 Groundwater Monitoring Plan

This section presents the groundwater monitoring plan for the OLF during the post-closure period. The plan establishes the frequency of, and locations for, monitoring.

4.1 Purpose and Requirements

The OLF groundwater monitoring plan has been implemented to determine groundwater quality impacts of the OLF (DOE 2006). The groundwater monitoring system was first implemented under the Integrated Monitoring Plan (DOE 2005) in accordance with 6 *Colorado Code of Regulations* 1007-3, 265.90[d], and is now performed in accordance with RFLMA (DOE et al. 2007). Groundwater monitoring results will be used to evaluate upgradient versus downgradient groundwater quality at the OLF. Downgradient groundwater will also be compared to surface water standards (RFLMA Attachment 2, Table 1). RFLMA Attachment 2 includes decision flowcharts to evaluate groundwater monitoring results.

4.2 Data Quality Objectives

Detailed data quality objective (DQO) information can be found in Attachment 2 of RFLMA (DOE et al. 2007). Groundwater monitoring wells at the OLF are categorized as RCRA monitoring wells under RFLMA; results are evaluated, and decisions are made, in accordance with RFLMA.

4.3 Well Locations

Four RCRA groundwater monitoring wells are installed at the OLF. The well locations were selected in consultation with the CDPHE and EPA (Figure 4−1). One of the RCRA groundwater monitoring wells is upgradient of the OLF, and the other three are downgradient of the OLF.

The upgradient monitoring well is identified as well P416589. Downgradient monitoring wells include wells 80005, 80105, and 80205. Table 4−1 gives more information on the monitoring wells. Boring logs are included in Appendix B.

Table 4–1. Groundwater Monitoring Wells—Original Landfill

Well ID	Type	Installation Date	Screen Length (feet)	Borehole Depth (feet bgs)	Well Diameter (inches)	Depth to Top of Screen (feet bgs)	Depth to Bedrock (feet bgs)
P416589	Upgradient	9/14/89	4	36.5	2	27.05	30.50
80005	Downgradient	8/9/05	15	21.0	2	5.80	7.10
80105	Downgradient	8/8/05	15	20.1	2	4.95	7.50
80205	Downgradient	8/10/05	15	19.8	2	4.75	8.35

Notes: bgs = below ground surface

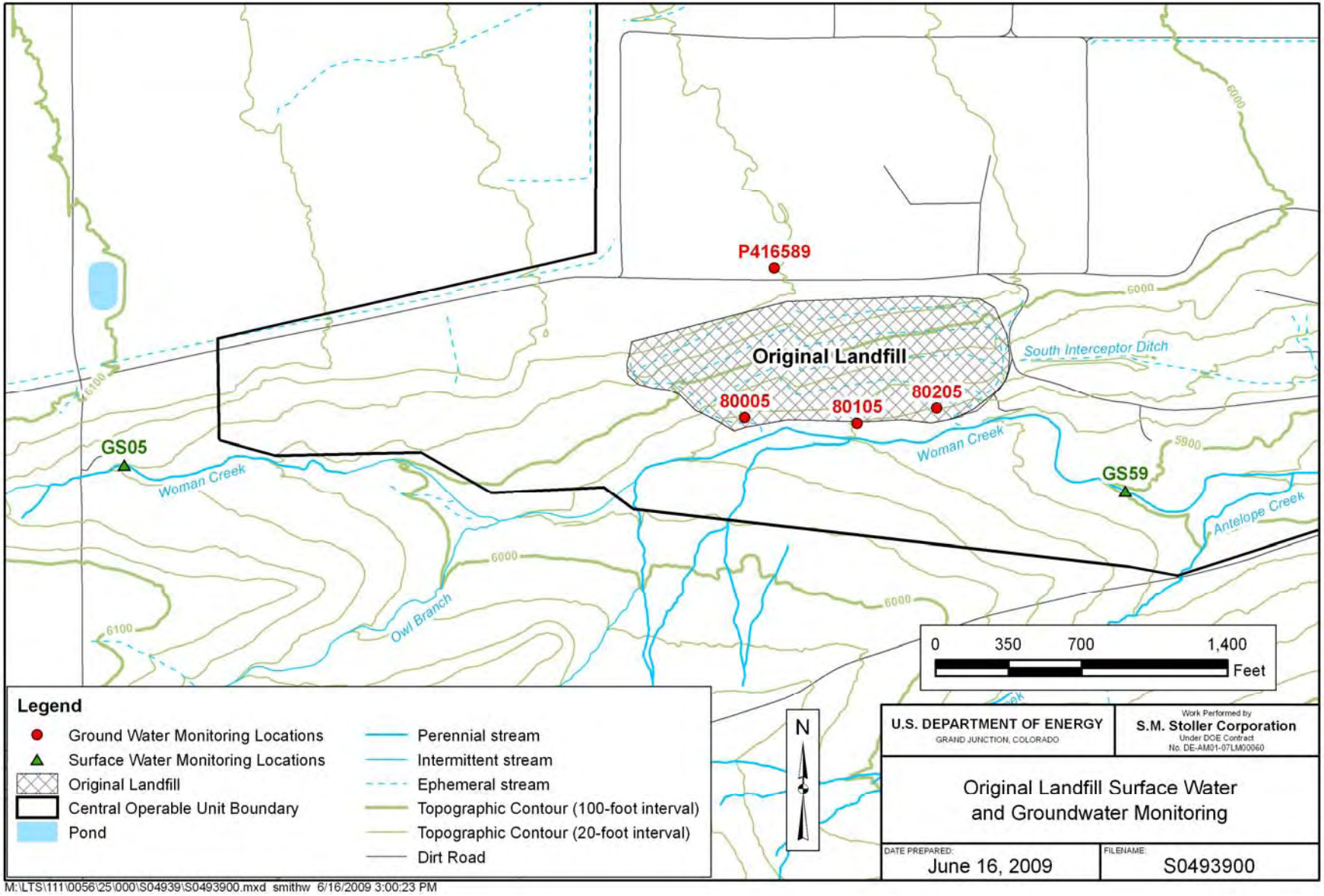


Figure 4–1. Original Landfill Surface Water and Groundwater Monitoring

4.4 Groundwater Quality Sample Parameters

Groundwater samples will be submitted for laboratory analysis for the following EPA-approved methods, in accordance with the IM/IRA (DOE 2006):

- SW-846 Method 8260B—Volatile Organic Compounds (VOCs)
- SW-846 Method 6010B—Metals (including uranium)
- SW-846 Method 7470A—Mercury
- SW-846 Method 8270C—Semivolatile Organic Compounds

The analytical results derived through the use of these methods for those analytes listed in Table 2 of RFLMA Attachment 2 will be reported.

4.5 Sampling Procedures

Groundwater sampling will be conducted in accordance with the most current version of the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PLN/S04351) (SAP). Groundwater monitoring will include water level measurements, conventional groundwater purging and sampling, quality control field samples, and proper equipment decontamination. Investigation-derived wastes (IDW) (e.g., for purge waters) will be managed in accordance with the SAP.

4.6 Laboratory Procedures Summary

Analytical methods and reporting limits (RLs), data reporting procedures, laboratory quality assurance and quality control procedures, and laboratory data validation and contractor validation procedures will be conducted in accordance with EPA-approved methods. Groundwater samples will be submitted to an EPA-approved analytical laboratory for the analyses listed in Section 4.4.

Sample results are reported according to laboratory analytical method standard operating procedures or contract specifications. The laboratory will report any analyte of interest detected at or above the reporting limit (RL) as a positive value. Any analyte of interest not detectable or detected below the RL will be reported as “not detected” at the RL or as an estimated value between the RL and the instrument or method detection limit. Data are generally reported in a tabular format or posted on maps and figures. RLs are adjusted for dilution when necessary.

4.7 Data Evaluation and Reporting

Groundwater monitoring results will be included in the annual OLF monitoring reports discussed in Section 6.0. Groundwater monitoring will be conducted as specified in RFLMA.

This page intentionally left blank

5.0 Surface Water Monitoring Plan

As part of OLF post-closure monitoring, surface water will be monitored at both upgradient and downgradient locations and at frequencies required by RFMLA.

5.1 Purpose and Requirements

The OLF surface water monitoring plan has been implemented to determine surface water quality impacts of the OLF (DOE 2006). Applicable surface water standards are listed in RFLMA Attachment 2, Table 1. RFLMA Attachment 2 includes decision flowcharts to evaluate surface water monitoring results.

5.2 Data Quality Objectives

Detailed DQO information can be found in Attachment 2 of RFLMA (DOE et al. 2007). Surface water monitoring results are evaluated, and decisions are made, in accordance with RLMA Attachment 2.

5.3 Sample Locations

Sampling for water quality will be conducted at the locations specified in RFLMA Attachment 2.

5.4 Surface Water Sample Parameters

Surface water samples will be submitted for laboratory analysis in accordance with the IM/IRA (DOE 2006) for the following EPA-approved method:

- SW-846 Method 8260B—VOCs
- SW-846 Method 6010B—Metals
- SW-846 Method 7470A—Mercury
- Alpha Spectrometry—Isotopic Uranium

The analytical results derived through the use of these methods for those analytes listed in Table 2 of RFLMA Attachment 2 will be reported.

5.5 Sampling Procedures

Surface water sampling will be conducted in accordance with the most current version of the SAP. Surface water monitoring will include quality control field samples and proper equipment decontamination. IDW (e.g., excess sample waters) will be managed in accordance with the SAP.

5.6 Laboratory Procedures Summary

Analytical methods and RLs, data reporting procedures, laboratory quality assurance and quality control procedures, and laboratory data validation and contractor validation procedures are to be

conducted in accordance with EPA-approved methods. Samples will be submitted to an EPA-approved analytical laboratory for the analyses listed in Section 5.4.

5.7 Reporting and Scheduling

Surface water sampling results will be included in the annual OLF monitoring report discussed in Section 6.0.

6.0 Reporting and Contact Information

6.1 Reporting

The annual OLF monitoring report, including inspection results, repairs, groundwater monitoring data, and surface water monitoring data, if applicable, will be submitted as part of the RFMLA annual report. Any maintenance actions during the year will be detailed in the report. DOE will follow RFLMA requirements for reportable conditions, and potentially impacted communities will be notified immediately of conditions that occur at any time that require immediate attention. The annual OLF monitoring report will include at a minimum:

- Vegetation inspection forms;
- All inspection forms and reports for the year;
- Notations of problems, maintenance actions taken, and maintenance or repairs as a result of the inspections;
- Any deviations from the OLF M&M Plan and the rationale for such deviations;
- Summary of monitoring locations;
- Tables with depth to water, well elevations, and groundwater elevations;
- Table with groundwater results and associated qualifiers;
- Tables with surface water results and associated qualifiers;
- Figures with groundwater monitoring points and locations of problems or repairs; and
- Groundwater and surface water sampling forms.

During the year, DOE will transmit completed inspection forms as they become available; in no case will they be submitted later than 1 month after the field activity is completed.

6.2 Contact Information

The point of contact and contact information for the OLF during the monitoring and maintenance phase is as follows:

Scott Surovchak/Department of Energy
Rocky Flats Office of Legacy Management
11025 Dover Street, Suite 1000
Westminster, CO 80021
Ph. 720-377-9682

This page intentionally left blank

7.0 References

DOE (U.S. Department of Energy), 1988. *Remedial Investigation and Feasibility Study Plans for Low Priority Sites*, Volume I – Site Descriptions, Groupings and Prioritization, June.

DOE (U.S. Department of Energy), 1994. Technical Memorandum No. 15, Addendum to Final Phase I RFI/RI Work Plan, Amended Field Sampling Plan, Volume 2, Woman Creek Priority Drainage, Rocky Flats Plant, Golden, Colorado, May.

DOE (U.S. Department of Energy), 2005. *RFETS Integrated Monitoring Plan FY2005*, Revision 1, Background Document; Rocky Flats Environmental Technology Site, Golden, Colorado, September.

DOE (U.S. Department of Energy), 2006. *Final Interim Measure/Interim Remedial Action for the Original Landfill*, Rocky Flats Environmental Technology Site, Golden, Colorado, Minor Modification, January.

DOE (U.S. Department of Energy), 2007a. *Proposed Action Plan for Original Landfill Cover Repairs and Geotechnical Investigation*, prepared for the U.S. Department of Energy, Office of Legacy Management, Westminster, Colorado, July 2.

DOE (U.S. Department of Energy), 2007b. *Rocky Flats, Colorado, Site Revegetation Plan*, LMS/RFS/S04513, prepared for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado, May.

DOE (U.S. Department of Energy), 2007c. *Rocky Flats, Colorado, Site Vegetation Management Plan*, prepared for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado, May.

DOE (U.S. Department of Energy), 2007d. *Rocky Flats Site Original Landfill Geotechnical Investigation/Engineering Work Plan*, U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado, November.

DOE (U.S. Department of Energy), 2008a. Regulatory Contact Record 2008-07, Path Forward for Original Landfill (OLF) Seep 7 Drain Extension, Berm Maintenance and Repair, Perimeter Channel Slope Cut and Fill, and Modification of the OLF Monitoring and Maintenance Plan (M&M Plan), U.S. Department of Energy, Office of Legacy Management, Westminster, Colorado, September 2.

DOE (U.S. Department of Energy), 2008b. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2007*, DOE-LM/1611-2008, prepared for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado, April.

DOE (U.S. Department of Energy), 2009. *Rocky Flats Site Annual Report of Site Surveillance and Maintenance Activities, Calendar Year 2008*, LMS/RFS/S05247, prepared for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado, April.

DOE, CDPHE, and EPA, 2007. *Rocky Flats Legacy Management Agreement*, effective as of March 14.

Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites, LMS/PLN/S04351, continually updated, prepared by S.M. Stoller Corporation for the U.S. Department of Energy Office of Legacy Management, Grand Junction, Colorado.

Earth Tech, Inc., 2005. *Final Design Analysis, Accelerated Action Design for the Original Landfill*, May.

Tetra Tech, 2008. *Rocky Flats Original Landfill Geotechnical Investigation Report, Jefferson County, Colorado*, June 4.

Appendix A

Original Landfill—Monitoring and Maintenance Program Inspection Forms

This page intentionally left blank

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

INSPECTOR: _____ DATE: _____TIME:_____REVIEWED BY: _____

TEMPERATURE: _____ WEATHER CONDITIONS: _____REVIEW DATE:_____

SUBSIDENCE / CONSOLIDATION

REGION	EVIDENCE OF CRACKS?	EVIDENCE OF DEPRESSIONS?	EVIDENCE OF SINK HOLES?	EVIDENCE OF PONDING?	OTHER (DESCRIBE BELOW)
COVER – WEST	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
COVER – EAST	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
BUTTRESS FILL	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 1	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 2	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 3	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 4	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 5	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 6	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
DIVERSION BERM 7	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	

Settlement Plates – Inspect integrity. Intact? ☐ Yes ☐ No

MAINTENANCE REQUIRED / COMMENTS / PHOTO LOG

_____

_____

_____

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

SLOPE STABILITY

REGION	EVIDENCE OF CRACKS?	EVIDENCE OF SEEPS?	EVIDENCE OF BLOCK OR CIRCULAR FAILURE?	OTHER (DESCRIBE BELOW
COVER – WEST	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
COVER – EAST	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
BUTTRESS FILL SIDESLOPE	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
WEST PERIMETER CHANNEL SIDESLOPES	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
EAST PERIMETER CHANNEL SIDESLOPES	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
COVER SEEPS (IF PRESENT)	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	

MAINTENANCE REQUIRED / COMMENTS / PHOTO LOG

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

SOIL COVER

REGION	EVIDENCE OF SOIL DEPOSITION OR EROSION?	EVIDENCE OF EROSION RILLS/GULLIES?	EVIDENCE OF BURROWING ANIMALS?	OTHER (DESCRIBE BELOW)
COVER – WEST	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
COVER – EAST	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
BUTTRESS FILL	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	
BUTTRESS FILL SIDESLOPE	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	

MAINTENANCE REQUIRED / COMMENTS / PHOTO LOG

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

VEGETATION

REGION	CONDITION OF GRASS	UNWANTED VEGETATION PRESENT*?	PERCENTAGE OF GRASS VERSUS BARE GROUND?	PERCENTAGE OF UNWANTED VEGETATION?
COVER- WEST		☐ Yes ☐ No		
COVER - EAST		☐ Yes ☐ No		
DIVERSION BERM 1		☐ Yes ☐ No		
DIVERSION BERM 2		☐ Yes ☐ No		
DIVERSION BERM 3		☐ Yes ☐ No		
DIVERSION BERM 4		☐ Yes ☐ No		
DIVERSION BERM 5		☐ Yes ☐ No		
DIVERSION BERM 6		☐ Yes ☐ No		
DIVERSION BERM 7		☐ Yes ☐ No		
WEST PERIMETER CHANNEL		☐ Yes ☐ No		
EAST PERIMETER CHANNEL		☐ Yes ☐ No		
UPPER BUTTERESS FILL SIDESLOPE		☐ Yes ☐ No		
LOWER BUTTRESS FILL SIDESLOPE		☐ Yes ☐ No		

* Unwanted vegetation includes weeds and “woody vegetation.” Woody vegetation within the OLF waste footprint shall be removed. Other locations shall be evaluated per Section 3.5.

MAINTENANCE REQUIRED / COMMENTS / PHOTO LOG

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

STORMWATER MANAGEMENT STRUCTURES

CHANNELS

STRUCTURE	EVIDENCE OF EXCESSIVE EROSION, GULLYING, SCOUR, OR UNDERMINING?	EVIDENCE OF SETTLEMENT/ SUBSIDENCE OR DEPRESSIONS?	EVIDENCE OF BREACHING OR BANK FAILURE?	EVIDENCE OF BURROWING ANIMALS?	EVIDENCE OF SEDIMENT BUILD-UP OR OTHER BLOCKAGE?
DIVERSION BERM 1	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
DIVERSION BERM 2	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
DIVERSION BERM 3	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
DIVERSION BERM 4	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
DIVERSION BERM 5	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
DIVERSION BERM 6	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
DIVERSION BERM 7	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
TEMPORARY CHECK DAMS*	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
WEST PERIMETER CHANNEL	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
EAST PERIMETER CHANNEL	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No

* Check dams may be removed after vegetation is established.

OTHER DEFICIENCIES?

_____

_____

MAINTENANCE REQUIRED / COMMENTS / PHOTO LOG

_____

_____

STORMWATER MANAGEMENT STRUCTURES (CONTINUED)

OUTFALLS

CHECK EACH STRUCTURE FOR EXCESSIVE EROSION AND SEDIMENT DEPTH. IF SEDIMENT DEPTH IS COMPROMISING THE DESIGN CHARACTERISTICS, REMOVE SEDIMENT.

STRUCTURE	CONDITION / SEDIMENT DEPTH
DIVERSION BERM OUTFALL 1	
DIVERSION BERM OUTFALL 2	
DIVERSION BERM OUTFALL 3	
DIVERSION BERM OUTFALL 4	
DIVERSION BERM OUTFALL 5	
DIVERSION BERM OUTFALL 6	
DIVERSION BERM OUTFALL 7	
WEST PERIMETER CHANNEL OUTFALL	
EAST PERIMETER CHANNEL OUTFALL	
FRENCH DRAIN OUTFALL (SID)	

OTHER DEFICIENCIES?

MAINTENANCE REQUIRED / COMMENTS / PHOTO LOG

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

"RUN-ON" CONTROL

AREA	ADVERSELY AFFECTING OLF?		
NORTH OF THE ORIGINAL LANDFILL	☐ Yes	☐ No	COMMENT:
WEST OF THE WEST PERIMETER CHANNEL	☐ Yes	☐ No	COMMENT:
EAST OF THE EAST PERIMETER CHANNEL	☐ Yes	☐ No	COMMENT:
NORTH OF WOMAN CREEK	☐ Yes	☐ No	COMMENT:

MAINTENANCE REQUIRED

_____

_____

_____

_____

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

INSTITUTIONAL CONTROLS

ITEM			
EVIDENCE OF EXCAVATION(S) OF COVER AND IMMEDIATE VICINITY OF COVER?	☐ Yes	☐ No	COMMENT:
EVIDENCE OF CONSTRUCTION OF ROADS, TRAILS, OR BUILDINGS ON COVER?	☐ Yes	☐ No	COMMENT:
EVIDENCE OF DRILLING OF WELLS OR USE OF GROUNDWATER?	☐ Yes	☐ No	COMMENT:
DAMAGE OR REMOVAL OF ANY SIGNAGE OR GROUNDWATER MONITORING WELLS?	☐ Yes	☐ No	COMMENT:

OTHER DEFICIENCIES / PHOTO LOG

ORIGINAL LANDFILL – MONITORING AND MAINTENANCE PLAN INSPECTION FORM

ACTION ITEMS

DEFICIENCY	DATE NOTED	ACTION	DATE COMPLETED	COMMENTS

INSPECTOR SIGNATURE: _____ DATE: _____

REVIEWER SIGNATURE: _____ DATE: _____

This page intentionally left blank

Appendix B

Groundwater Well Boring Logs/Construction Summaries

This page intentionally left blank

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 36 5	GROUND ELEVATION (FT)	6041.20	OLD WELL NUMBER	P260-89	LOG OF BORING NUMBER
NORTH:	748211	AREA: PLANT	CASING DIAMETER (IN)	2-3/8 O.D.	GEOLOGIST	SPC	P416589
EAST	2081546	LOCATOR NUMBER: I8	BOREHOLE DIAMETER (IN)	7 25	DATE DRILLED	09/14/89	

REMARKS: Hollow Stem Auger Weston Log

GEOTECHNICAL SAMPLE DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/ INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
										Asphalt
					6041	0			SM	Silty Sand - olive gray (5 Y 4/1), non-stratified F g. to v c g sand Trace gravel, poor sorting, sub-angular, quartzose, granite Dense, moist
	P76089002			2.00 /2.00	6040	1			CL	Gravelly Sandy Clay - olive black (5 Y 2/2), mod. brown (5 YR 3/4), mod reddish brown (10 R 4/6), non-stratified F g to v c g sand 1 cm to 4 cm gravel, poor sorting, sub-angular, quartzose. Very stiff, low plasticity, moist
	P76089003									
					6039	2			CL	Gravelly Sandy Clay - same as above, no olive black
									CL	Gravelly Sandy Clay - same as above. Varicolored, with grayish red (5 R 4/2), light brown (5 YR 5/6) Trace cobbles
	P76089004			1.40 /2.00	6038	3				
					6037	4			SC	Gravelly Clayey Sand - light brown (5 YR 5/6), pale yellowish brown (10 YR 6/2), non-stratified F g. to v c.g sand, 1 cm to 7 cm gravel, some silt, trace cobbles, poor sorting, sub-angular, quartzose Low to no plasticity, dense, moist
	P76089006									
	P76089007			1.10 /2.00	6036	5				
					6035	6			SC	Gravelly Clayey Sand - same as above Calcareous in part
	P76089008			1.20 /2.00	6034	7				
					6033	8			SC	Gravelly Clayey Sand - same as above, as indicated by cuttings
				0.00 /2.00	6032	9				
						10				

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 36.5	GROUND ELEVATION (FT)	6041.20	OLD WELL NUMBER:	P260-89	LOG OF BORING NUMBER
NORTH	748211	AREA: PLANT	CASING DIAMETER (IN)	2-3/8 O.D	GEOLOGIST	SPC	P416589
EAST	2081546	LOCATOR NUMBER I8	BOREHOLE DIAMETER (IN)	7.25	DATE DRILLED	09/14/89	

REMARKS: Hollow Stem Auger Weston Log.

CHEMICAL SAMPLE DEPTH / GEOTECHNICAL SAMPLE DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE (0% 50% 100%)	PERCENT RECOVERY (0% 100%)	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
				0.00/1.00	6031	10			SC	Gravelly Clayey Sand - same as above, as indicated by cuttings.
				0.00/1.00	6030	11			SC	Gravelly Clayey Sand - same as above, as indicated by cuttings.
	P260891214 P260891216			1.50/2.00	6029 6028	12 13			SC	Gravelly Clayey Sand - banded, varicolored, mod red (5 R 5/4), pale reddish brown (10 R 5/4), light brown (5 YR 5/6), dark yellowish orange (10 YR 6/6), yellowish gray (5 Y 7/2), non-stratified F g to v c g sand, some gravel, some silt, poor sorting, sub-angular, quartzose. Low plasticity, iron staining, calcareous 0.5 cm. lense of Silty Clay, dense to med dense, damp.
	P260891415			0.40/0.70	6027	14			SC	Gravelly Clayey Sand - same as above, with scattered cobbles.
				0.00/1.30	6026	15			NO SAMPLE	NO SAMPLE.
	P260891618 P260891620			1.30/2.00	6025 6024	16 17			SC	Gravelly Clayey Sand - same as above Increased clay content
	P260891820			0.90/2.00	6023 6022	18 19			SM	Gravelly Silty Sand - same as above Light brown (5 YR 5/6), light olive gray (5 Y 6/1) Some clay, quartzose.
						20				

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 36 5	GROUND ELEVATION (FT)	6041 20	OLD WELL NUMBER:	P260-89	LOG OF BORING NUMBER:
NORTH:	748211	AREA: PLANT	CASING DIAMETER (IN)	2-3/8 0.0	GEOLOGIST	SPC	P416589
EAST	2081546	LOCATOR NUMBER I8	BOREHOLE DIAMETER (IN)	7 25	DATE DRILLED	09/14/89	

REMARKS: Hollow Stem Auger Weston Log

CHEMICAL SAMPLE DEPTH / GEOTECHNICAL SAMPLE DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
					6021	20			SC	Gravelly Clayey Sand - same as above Light brown (5 YR 5/6), pale yellowish orange (10 YR 8/6), pale reddish brown (10 R 5/4), banded No cobbles
	P6092022			2.00 /2.00	6020	21				
	P6092024									
					6019	22			SC	Gravelly Clayey Sand - same as above Trace cobbles, quartzose to granites
	P6092224			0.90 /2.00	6018	23				
					6017	24			SC	Gravelly Clayey Sand - same as above, with very thin lenses (3 cm.) of very Silty Sand at 25.3' to 25.4'
	P6092426			1.60 /2.00	6016	25				
	P6092428				6015	26			CL	Gravelly Sandy Clay - same as above
							01/16/90		CL	Sandy Clay - pale reddish brown (10 R 5/4), dark yellowish orange (10 YR 6/6), light olive gray (5 Y 6/1), mottled, non-stratified V f g to f g sand. Some silt, very stiff, med plasticity, damp
	P6092628			2.00 /2.00	6014	27				
							09/14/89		SC	Clayey Sand - mod. reddish brown (10 R 4/6), light brown (5 YR 5/6), non-stratified F g to c g sand, some silt, poor sorting, sub-angular Iron staining, low plasticity, dense, damp
					6013	28				
	P6092830			1.40 /2.00	6012	29			SM	Silty Sand - same as above Some clay Trace of gravel, no plasticity, wet
	P6092831					30				

STATE PLANE COORDINATE		TOTAL DEPTH (FT) 36.5	GROUND ELEVATION (FT)	6041.20	OLD WELL NUMBER:	P260-89	LOG OF BORING NUMBER:
NORTH:	749211	AREA: PLANT	CASING DIAMETER (IN)	2-3/8 O.D.	GEOLOGIST:	SPC	P416589
EAST	2081546	LOCATOR NUMBER: I8	BOREHOLE DIAMETER (IN)	7.25	DATE DRILLED	09/14/89	

REMARKS: Hollow Stem Auger Weston Log.

CHEMICAL SAMPLE DEPTH / GEOTECHNICAL SAMPLE DEPTH	SAMPLE NUMBER	SAMPLE GRAIN SIZE	PERCENT RECOVERY	RECOVERY/INTERVAL	DATUM (FT)	DEPTH (FT)	WELL OR PIEZOMETER CONSTRUCTION	LITHOLOGY	UNIFIED SOILS CLASSIFICATION OR ROCK TYPE	DESCRIPTION
					6011	30			SM:	Silty Gravelly Sand - same as above
	P260893032			2.00 /2.00	6010	31			CLAYSTONE	Top of Bedrock Yellowish gray (5 Y 7/2), dusky yellowish orange (10 YR 6/6), mottled, blocky, med. high plasticity, weathered, oxidized, med. hard, damp, minor silty sand laminations
	P260893234				6009	32			CLAYSTONE	Same as above
	P260893135			0.20 /2.00	6008	33				
	P260893436			0.40 /1.00	6007	34			CLAYSTONE	Same as above - silty Trace sand, med plastic
					6006	35			CLAYSTONE	Same as above - some silt to silty
	P260893537			1.50 /1.50	6005	36				
					6004	37				TD = 36.5'
					6003	38				
					6002	39				
						40				

STATE PLANE COORDINATES AREA: GRND ELEV. (FT): 5957.54 CASING DIA (IN): 2"
NORTH: 747489.979 TOTAL DEPTH (FT): 21.0 BH DIA. (IN): 8"
EAST: 2081404.042 COMPLETION DATE: 8/9/05 GRID LOCATOR:
PROJECT: Original Landfill GEOLOGIST: E. Warp
REMARKS:
Routine well installation

LOG OF BORING NUMBER: 80005

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
5961					
	Protective Casing, Steel, 6 in. ID.	3			
	Casing, Sch 40-PVC, 2 in. ID.				
5960		2			
5959		1			
5958		0			GC/CL: Gravelly, Sandy Clay with silt, brown (7.5YR4/4). 8 - 10% gravel (1/8" - 1/4" diameter, subangular to subrounded, composed of granite, schist, and quartzite). ~8% sand (coarse grained, subrounded to subangular). Clay has medium plasticity. Moist. 1" to 1-1/2" diameter cobbles of quartzite and granite at 0.4'.
5957		1			CL: Clay with trace gravel and sand, dark brown (7.5YR3/2). ~3 - 5% gravel (1/8" - 1/2" diameter, subangular), ~3 - 5% sand. Clay has medium plasticity. Shattered quartzite cobble at 0.6'. Roots at base of interval. Moist.
5956	Hydrated Bentonite Chips	2			CL: Clay with trace gravel and trace sand, brown (10YR4/3) with dark yellowish brown (10YR4/6) mottling. Possibly re-worked claystone with gravel and sand. Weak iron oxidation mottled throughout and disseminated at base. Trace roots. Moist.
5955		3			No recovery.
					CL: Clay with trace gravel and trace sand, same as interval from 0.8' to 1.3'. Moist.
5954		4			GP: Gravel/Cobbles, schist and quartzite cobbles (3/4" - 2" diameter, subangular) with gravel (1/4" - 1/2" diameter, subangular, composed of amphibolite (?)). Gravel is greenish gray (GLEY5/1).
					No recovery
5953					GC/CL: Sandy, Gravelly Clay with silt, dark brown (7.5YR3/2) clay matrix with ~30% gravel (1/4" - 3/4" diameter, subangular, composed of quartzite and schist). 5 - 10% sand (coarse grained,

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
					subangular to subrounded). Clay has medium plasticity. Moist. Shattered cobbles (1" - 2" diameter) at base of interval from 4.6' to 4.8'.
5952	Filter Pack, 16/40 Silica Sand	5			SC/CL: Silty, Sandy Clay with some gravel, brown (7.5YR4/3 to 7.5YR4/4). Sand and gravel increase at base of interval. ~35% sand from 5.1' to 5.4', sand is coarse grained, subangular. ~25% gravel (1/4" - 1/2" diameter, subangular) from 5.1' to 5.4'. Moist. Possibly fluvial in origin (?)
		6			No recovery.
5951	Screen Sch 40-PVC, 2 in ID, 0.010 in slots				
		7			SC/CL: Silty, Sandy Clay with some gravel, same as interval from 4.8' to 5.4'. Moist.
5950					SILTSTONE: TOP OF BEDROCK. Clayey Siltstone with some fine grained sand. Bedrock is gray (10YR6/1) with abundant yellowish brown (10YR5/6) mottling. Siltstone interbedded with claystone and fine grained sandy lenses. Some caliche as stringers and blebs throughout interval. Strong pervasive iron oxidation from 8.5' to 8.7' with ironstone fragments. Moist.
		8			
5949					
		9			
5948					SILTSTONE: Sandy Siltstone, grayish brown (10YR5/2) with light yellowish brown (10YR6/4) iron oxidation mottled throughout. Abundant very fine grained sand in siltstone. Friable. Caliche along internal bedding at 10.7'. Decreasing moisture to slightly moist.
		10			
5947					
		11			SILTSTONE: Clayey, Sandy Siltstone, yellowish brown (10YR5/6) with gray (10YR6/1) and light brownish gray (10YR6/2) mottling. Clayey lenses at 10.9' and from 11.65' to 11.8'. Black organic stringers associated with clayey lenses. Interval is friable and slightly fissile. Rip-up clasts common. Small healed fracture (45 deg) with iron oxidation at 11.95'. Abundant very fine grained sand from 11.2' to 11.4'. Slightly moist.
5946					
		12			
5945					SILTSTONE: Clayey Siltstone, yellowish brown (10YR5/6) with gray (10YR5/1) mottling from 12.4' to 13.0'. Color changes to brown (10YR5/3) from 13.0' to 14.0'. Decreasing very fine grained sand to trace. Black organic stringers common from 13.0' to 14.0'. Interval is competent, yet weak to moderately friable. Rip-up clasts common. Weak to moderate iron oxidation throughout. Slightly moist.
		13			
5944					
		14			

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
5943					CLAYSTONE: Claystone with trace silt, gray (10YR5/1) with grayish brown (10YR5/2) and yellowish brown (10YR5/4) mottling. Weak to moderate pervasive iron oxidation. Some black organic stringers. Interval is firm and dense. Decreased moisture to very slightly moist.
		15			
5942					
		16			
5941					
		17			CLAYSTONE: Claystone, un-weathered, dark gray (2.5Y4/1) to gray (2.5Y5/1). Trace iron oxidation along internal fractures from 16.8' to 17.0', and at 17.0'. Interval is highly fissile and friable. Dry.
5940					
		18			
5939					
		19			No recovery.
5938					
		20			CLAYSTONE: Claystone, un-weathered, dark gray (2.5Y4/1). Dense and firm, weakly fissile, dry.
5937	Threaded End Cap - Sump, Sch				
		21			

STATE PLANE COORDINATES AREA:
NORTH: 747463.414
EAST: 2081942.494
PROJECT: Original Landfill
REMARKS:
Routine well installation

GRND ELEV. (FT): 5939.29
TOTAL DEPTH (FT): 20.15
COMPLETION DATE: 8/8/05
GEOLOGIST: E. Warp

CASING DIA (IN): 2"
BH DIA. (IN): 8"
GRID LOCATOR:

LOG OF BORING NUMBER: 80105

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
5942	Protective Casing, Steel, 6 in ID. Casing, Sch 40-PVC, 2 in. ID	3			
5941		2			
5940		1			
5939		0			GC/CL: Gravel/Sandy Clay with silt mixture. Imported Qalrf fill. Strong brown (7.5YR4/6). 20 - 25% gravel (1/8" - 1" diameter, subrounded to subangular), predominately quartzite with less schist and granite. 20% sand (coarse grained, subangular to subrounded). Clay has medium plasticity. Dark brown (7.5YR3/2) clay lense from 0.4' to 0.5'. Disseminated caliche, tiny white specks common throughout interval. Moist.
5938		1			No recovery.
5937		2			GC/CL: Gravel/Sandy Clay with silt mixture, same as interval from 0.0' to 1.2'. Moist.
5936	Hydrated Bentonite Chips	3			No recovery
5935	Filter Pack, 16/40 Silica Sand	4			CL: Gravelly, Sandy Clay, dark brown (7.5YR3/2). Distinct color change. ~10% sand (coarse grained, subangular), 5 - 8% gravel (1/8" - 1/2" diameter, subrounded to subangular). Trace to some

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
					organic material (woodchips). Medium to high plasticity, very moist. Color change may indicate prior ground surface (before fill added).
		5			GC/CL: Gravelly, Sandy Clay, dark gray (7.5YR4/1) to brown (7.5YR4/4). ~30% sand (coarse grained, subangular), 20 - 25% gravel (1/8" to 1-1/2" diameter, subrounded to subangular). Possible fluvial deposit. Well graded, poorly sorted, very moist.
5934	Screen, Sch 40-PVC, 2 in ID. 0.010 in. slots				
		6			CL: Silty Clay. Re-worked bedrock. Light gray (10YR6/2) with brownish yellow (10YR6/6) mottling. Weak iron oxidation mottling. Trace caliche. [Very poor recovery, clay has been extruded like a "ribbon" due to a clogged cutting shoe.] Very moist.
5933					No recovery.
		7			CL: Silty Clay. Re-worked bedrock. Light gray (10YR7/1) with some light yellowish brown (10YR6/4) iron oxidation mottling. Trace alluvial clastics indicate not yet bedrock.
5932					CL: Clay with trace to some sand, gravel, and silt. Dark grayish brown (10YR4/2) with some light brownish gray (10YR6/2). 3 - 5% gravel (1/8" - 1/4" diameter), 3 - 5% sand (coarse grained, subangular). Weak to moderate iron oxidation mottled throughout. Very moist.
		8			SILTSTONE: TOP OF BEDROCK. Clayey Siltstone, gray (10YR6/1) with yellowish brown (10YR6/4) iron oxidation mottled throughout. Very subtle bedrock contact. [Very poor recovery, cutting shoe is clogged causing siltstone to appear "ribboned" in sample tube.] Very moist.
5931					No recovery.
		9			CLAYSTONE: Claystone, gray (10YR5/1) with yellowish brown (10YR5/6) mottling. Caliche blebs and stringers common throughout. Weak iron oxidation mottling. Massive texture. Moderately friable. Notable decrease in moisture to slightly moist.
5930					
		10			CLAYSTONE: Claystone, very dark gray (10YR3/1) to gray (10YR5/1). Massive texture. Abundant black organic stringers from 10.4' to 10.6'. Very rare caliche stringers. Moderately friable. No iron oxidation. Slightly moist.
5929					
		11			
5928					
		12			CLAYSTONE: Claystone, grayish brown (10YR5/2). Weak pervasive iron oxidation. Trace caliche blebs. Trace black organic material. Weakly friable. Organics or trace iron oxidation along internal fractures at 12.3', 12.6', and 13.4'. Decreased moisture to very slightly moist.
5927					
		13			
5926					

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
		14			
5925					SILTSTONE: Clayey Siltstone, light brownish gray (10YR6/2) with some light yellowish brown (10YR6/4) iron oxidation mottling throughout. Massive texture. Weakly friable. Trace black organic stringers. Trace iron oxidation on minor internal fractures at 15.1', 15.5', 15.8', and 16.3'. Trace moisture. Occasional rip-up clasts.
		15			
5924					
		16			
5923					
					No recovery.
		17			
5922					CLAYSTONE: Claystone, dark gray (10YR4/1) to very dark gray (10YR3/1). Very fissile, friable, and dry. Abundant black carbonaceous material from 18.0' to 18.5'.
		18			
5921					
		19			
5920					No recovery. Reamed with augers from 19.0' to 20.15'. Did not sample this interval.
		20	Threaded End Cap Sump. Sch 40-PVC		

STATE PLANE COORDINATES AREA: GRND ELEV. (FT): 5938.52 CASING DIA (IN): 2"
NORTH: 747535.636 TOTAL DEPTH (FT): 20.0 BH DIA. (IN): 8"
EAST: 2082324.443 COMPLETION DATE: 8/10/05 GRID LOCATOR:
PROJECT: Original Landfill GEOLOGIST: E. Warp
REMARKS:
Routine well installation

LOG OF BORING NUMBER: 80205

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
5942	Protective Casing, Steel, 6 in ID.	4			
	Casing, Sch 40-PVC, 2 in. ID	3			
5941		2			
5940		1			
5939		0			
5938		1		GC/CL	GC/CL: Gravel/Sandy Clay with silt, strong brown (7.5YR4/6). 15 - 25% gravel (1/8" - 3/4" diameter, subrounded to subangular, predominately quartzite and granite). 20 - 25% sand (coarse grained, subangular). Clay has medium plasticity. Moist from 0.0' to 1.0'. Saturated, but not flowing, from 1.0' to 1.5'.
5937		2		CL	CL: Silty Clay with trace sand and trace gravel, dark brown (7.5YR3/2) with some yellowish brown (10YR5/4) mottling. Clay has medium plasticity. Granite clast (3/4" diameter, angular) at 1.7'. Saturated, but not flowing.
					No recovery
5936		3			CL: Clay with trace silt, trace gravel, and trace sand, brown (7.5YR4/3) from 2.0' to 2.2', yellowish brown (10YR5/4) to dark yellowish brown (10YR4/4) from 2.2' to 4.0'. Appears to be re-worked claystone bedrock (?). Interval is firm and dense but pliable due to moisture. Trace black organic stringers. Trace caliche blebs at base of interval. Roots and twigs common throughout. Gravel (1/4" - 1/2", subrounded) from 3.4' to 3.6', and at base of interval. Decreased moisture to very moist.
5935	Bentonite Chips	4			

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
5934	Filter Pack. 16/40 Silica Sand; Screen, Sch 40-PVC, 2 in ID., 0.010 in. slots	4			CL: Clay (re-worked claystone), gray (10YR5/1) with trace yellowish brown (10YR5/6) mottling. Roots common throughout interval. Trace caliche blebs. Caliche stringer with iron oxidation halo at 5.1'. Slight color change from 5.9' to 6.7' to light brownish gray (10YR6/2) with faint mottling. Decreased moisture to moist.
5933		5			
5932		6			
		7			No recovery.
5931					CL: Clay with trace gravel (probably re-worked claystone), grayish brown (10YR5/2). Roots common. Soft and pliable. Saturated, free water from 7.6' to 8.0'. Gravel (1/2" diameter, subrounded) at 7.6' with trace iron oxidation in clay surrounding gravel clast.
5930		8			GC/CL: Gravelly Clay, dark brown (7.5YR3/3) with some strong brown (7.5YR5/6) iron oxidation at 8.15'. Strongly fractured and crumbly. 20 - 25% gravel (1/4" - 3/4" diameter, subrounded to subangular). Composition of gravel (?) - possible conglomerate, coated with iron oxide and manganese oxide. Interval is saturated with free water.
5929		9			CLAYSTONE: TOP OF BEDROCK. Claystone (bedrock) - possibly re-worked. Grayish brown (10YR5/2) to gray (10YR5/1) with minor yellowish brown (10YR5/6) mottling. Roots common. Trace caliche stringers. Interval competent from 8.35' to 9.0'; friable from 9.0' to 9.45'. Distinct decrease in moisture to very moist, further decreasing to moist at base.
5928		10			CLAYSTONE: Claystone, grayish brown (10YR5/2) to gray (10YR5/1) with trace brownish yellow (10YR6/8) iron oxidation mottling throughout. Massive texture. Interval is moderately friable. Slightly moist.
5927		11			
		12			No recovery.
5926					CLAYSTONE: Claystone, pale brown (10YR6/3). Massive texture. Trace iron oxidation along bedding planes. Silty lense (~1/8" thick) with iron oxidation at 13.8'. Firm and dense. Decreased moisture to very slightly moist. Trace silt at 12.5' and below.
		13			

Elev (Ft)	Well or Piezometer Construction and Materials	Depth (Ft)	Lithology	Unified Soils Classification or Rock Type	Lithologic Description
5925					
		14			CLAYSTONE: Claystone, gray (10YR5/1) to dark gray (10YR4/1). Massive textured. Trace iron oxidation along bedding planes (sub-horizontal). Disseminated caliche coating from 15.2' to 15.8' along vertical fracture with iron oxidation. Interval weakly friable. Trace black organic stringers. Decreased moisture to trace.
5924					
		15			
5923					
		16			
5922					
		17			
5921					
		18			CLAYSTONE: Claystone, dark gray (10YR4/1) to very dark gray (10YR3/1). Massive texture. Moderately fissile and friable. No iron oxidation. Trace moisture to dry.
5920					
		19			
5919					
		20	Conical Threaded End Cap - Sump, Sch 40-PVC		

This page intentionally left blank