NOTICE

All drawings located at the end of the document.

KAISER♦HILL, LLC

Land Configuration Design Basis - Preliminary

Prepared By:

LCDB Project Team

Prepared For:

Rocky Flats Environmental Technology Site

United States Department of Energy
Golden, Colorado

March 2002

PARSONS

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PREAMBLE TO LAND CONFIGURATION DESIGN BASIS - PRELIMINARY

The Land Configuration Design Basis (LCDB) Project has developed the design basis for final land configuration at the Rocky Flats Environmental Technology Site (RFETS). A design implemented to this basis will maintain compliance with the current Rocky Flats Clean-up Agreement (RFCA) requirements, including surface water quality standards at the points of compliance (POCs), after Site closure. This design basis includes:

- Site information and technical data,
- Functional design objectives (FDOs),
- Design criteria, and
- Other engineering codes and standards.

The design basis provides information to maintain compliance and balance between the various closure objectives and to guide, integrate, and develop individual remediation and closure projects but is not itself a decision document.

The scope of work for the LCDB Project consisted of:

- Preparing a work plan,
- Developing the design basis for the final land configuration,
- Developing and evaluating several plausible land configurations (bounding scenarios),
- Developing an initial conceptual land configuration that incorporates the design basis and synthesizes the results of the bounding scenario evaluation, and
- Preparing a Conceptual Design Report (CDR).

The work plan for the LCDB Project dated May 2001 was issued to the Department of Energy (DOE), and U.S. Fish and Wildlife Service (FWS) for review and comment and except as noted, responses to the DOE/FWS comments were incorporated into a July 2001 revision. This was subsequently issued to the regulatory agencies and other stakeholders for review and comment. (Incorporation and resolution of the remaining DOE/FWS comments was deferred until after receipt of regulatory agency comments).

Comments from the regulatory agencies were received in August 2001. These comments could not be resolved at that time. After several meetings and discussions with the regulatory agencies, the scope of the LCDB Project was adjusted to bring in-progress work to a reasonable point of completion while deferring the preparation of the CDR until such time when the required information is acquired.

The work developed by the LCDB Project Team was compiled into this report (Land Configuration Design Basis – Preliminary) and will be used to develop the detailed design for the final land configuration at closure. The format of this report is unconventional and in three main sections reflecting the compilation: The first section contains a revised work plan for the LCDB Project that incorporates DOE/FWS and regulatory agency comments, which are also included. The second section contains the information developed to support the work plan. The third section provides information developed as a result of implementing the work plan and its associated appendices.

Section 1 (Tab 1) - Revised Draft Work Plan

The first section contains the Work Plan revised per DOE/FWS and regulatory agency comments. Those comments along with the KH responses are also included. Some of these issued raised by the comments cannot be resolved until additional information is available and these are noted as being deferred.

Section 2 (Tab 2) - Work Plan Appendices

This section contains the information developed to support the work plan. The following appendices are included in Section 2:

- **Appendix A** contains the Data Quality Objectives (DQOs) that were established for the LCDB Project.
- **Appendix B** contains the design basis for the final land configuration. The design basis consists of pertinent Site information, identified functional design objectives, and relevant engineering design criteria. The Design Basis will be used as the foundation to develop the detailed design for the final land configuration.
- **Appendix C** contains an updated list of the data gaps, missing information, and uncertainties that should be resolved to complete the detailed design for the final land configuration. Also identified are sub-studies and activities that may be initiated to resolve specific data gaps and to advance the design of the final land configuration. This appendix will be used to track resolution of significant data gaps.
- **Appendix D** contains the annotated outline for the CDR. This outline will be used to guide the development of design documentation for the final land configuration.
- **Appendix E** identifies the specific methods to evaluate ecological impacts resulting from bounding scenarios and the initial conceptual design. The tasks identified in this appendix have not been completed. This appendix will be used to evaluate the ecological impacts associated with the initial conceptual design to ensure a balance between closure and ecological objectives and to identify if mitigative measures are required.
- **Appendix F** identifies the specific methods that were implemented to evaluate the erosion and hydrologic performance of each bounding scenario. The erosion and hydrologic evaluation results are presented in Tab 3, Attachment B.
- **Appendix G** identifies the specific methods that were implemented to evaluate the geomorphic considerations associated with each bounding scenario. The evaluation report is provided in Tab 2, Appendix G.2. The geomorphic report will be used to identify where sector-specific engineered features are required to stabilize hillsides and drainage channel to provide long-term integrity of remediation systems.

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These appendices include revisions per DOE/FWS comments, regulatory agency comments, and the recently acquired information. The revisions made to each appendix are summarized on the cover sheet of each appendix.

Section 3 (Tab 3) - Additional LCDB Project Information

The third section provides information developed as a result of implementing the work plan to support the design concepts. The following appendices are included in Section 3:

- **Attachment A** presents the development and evaluation of potential bounding scenarios. The evaluation results were used to identify individual components for inclusion as an initial conceptual design. The information provided in this attachment could be used to support the development of decision document for the final land configuration.
- **Attachment B** contains the combined results for the erosion and hydrologic evaluation that was performed by the LCDB and Actinide Migration Evaluation (AME) Project Teams for the bounding scenarios. Specific results for the initial conceptual design have not been developed. The information provided in this attachment is useful for assessing the relative performance of individual scenario components.
- **Attachment C** contains the description of an initial conceptual design (ICD) for the final land configuration of RFETS. The ICD description provides an initial starting point to discuss the final land configuration with stakeholders.
- **Attachment D** contains the Pond Reconfiguration Strategy that was developed for use in the initial conceptual design to guide decisions for the final configuration of the existing ponds. This attachment also identifies the information that would be considered in determining the reconfiguration.
- **Attachment E** contains a grading and drainage (G&D) concept for the Industrial Area (IA). The G&D concept provides conceptual plans for a final surface topography and drainage routing to guide D&D and ER closure projects. The information provided in this attachment is useful in scoping the restoration tasks for D&D projects.
- **Attachment F** contains a Site-Wide Water Balance Report for the initial conceptual design and grading and drainage concept. This information will be useful in identifying potential impacts of Site closure on surface water and ground water hydrology.

Other items identified in the Work Plan and which need to be completed prior to developing the CDR include, but are not limited to:

- Revise the design basis and project documents to reflect designation of RFETS as a National Wildlife Refuge. Legislation has been enacted to designate RFETS a National Wildlife Refuge. The information contained in this report is based on a final land use at RFETS of open space. At the time this report was issued, the implications of designating RFETS a National Wildlife Refuge could not be fully evaluated. Any required revisions to the design basis will be compiled during development of the CDR.

- Use the erosion and hydrologic results for the evaluation of the bounding scenarios (see Tab 3, Attachment B.2) and the results of other ongoing investigations (e.g., Site Wide Water Balance) to refine the ICD description presented in Tab 3, Attachment C.
- Prepare the ecological evaluation for the refined initial conceptual design (see Tab 2, Appendix E).
- Conduct the erosion and hydrology evaluation for the refined initial conceptual design (see Tab 3, Attachment B.1).
- Finalize the geomorphic evaluation for the refined initial conceptual design and identify sectors where engineering controls may be necessary to ensure long-term stability (see Tab 2, Appendix G).
- Develop design drawings, sizing calculations, and outline specifications for the refined initial conceptual design.
- Develop project schedule and implementation plan, and
- Compile cost estimate.

LAND CONFIGURATION DESIGN BASIS - PRELIMINARY

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Revised Draft Work Plan for Land Configuration Design Basis Project

prepared by

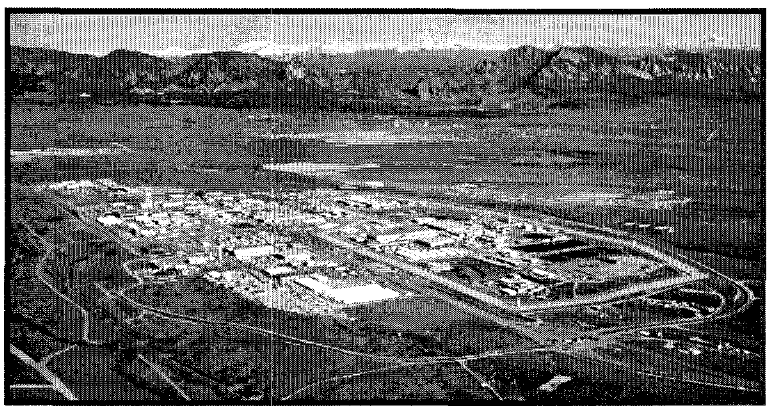
LCDB Project Team

for the

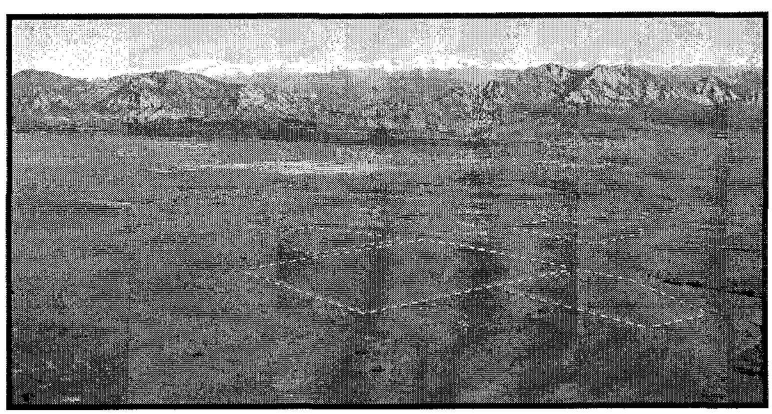
Rocky Flats Environmental Technology Site

Golden, Colorado

March 2002



Rocky Flats in 1998



Rocky Flats End State

KAISER♦HILL, LLC

Revised Draft Work Plan
for
Land Configuration Design Basis Project

Prepared By:

LCDB Project Team

Prepared For:

Rocky Flats Environmental Technology Site

United States Department of Energy
Golden, Colorado

March 2002

Note:

This work plan has been revised since its last issuance dated July 2001 to incorporate responses to DOE/FWS Comments 4, 9, 12, 75, 82, 92, 108, and 110, and Regulatory Agency Comments 1, 4, 6, 14, 15, 17, 18, 19, 21, 32, and 48 (see Tab 1).

To complete this work plan, responses to Regulatory Agency Comments 5, 7, and 20 need to be incorporated.

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
ac	acre(s)
ac-ft/yr	acre-feet per year
ac-ft	acre-feet
ALF	action levels and standards framework for surface water, ground water, and soil
Am-241	americium-241
AME	Actinide Migration Evaluation
BTPD	Black-Tailed Prairie Dog
BZ	Buffer Zone
CAD/ROD	Corrective Action Decision/Record of Decision
CDPHE	Colorado Department of Public Health and Environment
CDR	conceptual design report
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter(s)
CMP	corrugated metal pipe
CNHP	Colorado Natural Heritage Program
CSI	Construction Specification Institute
CWQCC	Colorado Water Quality Control Commission
CWTF	Combined Water Treatment Facility
D&D	deactivation and decommissioning
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DQO	data quality objectives
EDDIE	(RFETS) Environmental Data Dynamic Information Exchange Web Site
EG&G	EG&G, Inc. (formerly Edgerton, Germeshausen and Grier, Inc.)
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
FDO	functional design objective
ft	foot (feet)
GAC	granular activated carbon
GIS	geographic information system
GW	groundwater
HDPE	high density polyethylene
HEC-6T	Sediment in Stream Network, Version 6T (computer code to simulate drainage hydrology and stream channel erosion)
IA	Industrial Area
Kaiser-Hill	Kaiser-Hill Company, LLC
L	liter(s)
LCDB	Land Configuration Design Basis

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

LHSU	lower hydrostratigraphic unit
mg/L	milligram(s) per liter
mm	millimeter(s)
mph	mile(s) per hour
OFE	overland flow element
OU	Operable Unit
PCB	polychlorinated biphenyl
pCi/g	picocurie(s) per gram
pCi/L	picocurie(s) per liter
Preble's Mouse	Preble's Meadow Jumping Mouse
POC	point of compliance
POE	point of evaluation
Pu	plutonium
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RFA	Rocky Flats Alluvium
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI	RCRA facility investigation
RMRS	Rocky Mountain Remediation Services, LLC
Rocky Flats	Rocky Flats Environmental Technology Site
RSOP	RFCA Standard Operating Protocol
SAR	Safety and Analysis Report
SCS	Soil Conservation Service (now Natural Resources Conservation Service)
SEL	stream egress location
SEP	Solar Evaporation Pond
SID	South Interceptor Ditch
Site	Rocky Flats Environmental Technology Site
SW	surface water
SWWB	Site-Wide Water Balance
T/E	threatened and endangered (species)
TSS	total suspended solids
U	uranium
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
UHSU	upper hydrostratigraphic unit

1.0 INTRODUCTION

The Land Configuration Design Basis (LCDB) Project is being conducted to define the design basis to allow development of the final topography and closure configuration (including drainages, ponds, roads, and other post-closure components) for the Rocky Flats Environmental Technology Site (RFETS or Site) that is consistent with Site closure, remediation, and final land use. For the purpose of the LCDB Project, it is assumed that the final land use designated for RFETS will be open space. However, legislation to designate RFETS a National Wildlife Refuge was enacted. The potential impacts associated with changing the final land use from open space to National Wildlife Refuge are discussed in Section 2.8 of Appendix B and the final design basis will be appropriately modified as required.

The principle objective for the final land configuration is compliance with the surface water quality standards identified in the Rocky Flats Clean-up Agreement (RFCA) at the points of compliance (POCs). In conjunction with establishing the functional design objectives (FDOs) and the design basis, various bounding scenarios will be developed and evaluated. The bounding scenarios will be used to illustrate the spectrum of viable approaches to meet the reconfiguration and FDOs established for the project. For example, one approach (i.e., bounding scenario) may include extensive use of wetlands to promote sedimentation and filtering of suspended solids. Another bounding scenario may rely on retaining all runoff in onsite ponds for evaporation and infiltration (zero surface water discharge). The strengths, weaknesses, effectiveness, and limitations of each bounding scenario will be identified and evaluated. An initial conceptual design for the final land configuration will be formulated based on this evaluation. The initial conceptual design will be developed to capitalize on the strengths associated with each bounding scenario by incorporating their unique features where it is advantageous to do so.

The LCDB Project Team will coordinate with other closure project efforts throughout the execution of the LCDB Project to develop an integrated Design Basis and Initial Conceptual Design for the RFETS final land configuration that is effective and acceptable to the RFCA parties. The results from the Actinide Migration Evaluation (AME) and Site Wide Water Balance (SWWB) studies, as well as the expected actions for Site remediation and closure, will be integrated into the LCDB Project. Section 8 of the work plan provides additional details regarding the various interfaces for the LCDB Project. Specifically, the following integration efforts will occur:

- The AME Project Team will predict actinide concentrations at various locations within the drainages for the bounding scenarios and the initial conceptual design. With this information, the LCDB Project Team will evaluate various components associated with each bounding scenario and assess the effectiveness of the initial conceptual design in maintaining the RFCA defined surface water quality standards at the POCs.

- Similarly, the SWWB Project Team is developing a water balance model that will help estimate the significance of Site closure activities such as cessation of imported water, removal of Site structures, and land reconfiguration to identify potential changes in the Site hydrology and hydrogeology. The LCDB Project Team will utilize the SWWB results to evaluate the predicted changes to seeps and groundwater flow patterns to identify changes to wetlands, habitat, and groundwater remediation systems. The specific results from SWWB will be incorporated into the initial conceptual design to minimize ecological impacts and to identify areas where mitigation planning may be required.

The resulting design basis and initial conceptual design will be compiled into a conceptual design report (CDR) to provide the information required for designing the final land configuration and to identify missing information with a plan for its acquisition. The CDR is intended to provide information and guidance to the United States Department of Energy (DOE) and Kaiser-Hill Company, LLC (Kaiser-Hill) that will be used to support decisions for the final closure and land configuration for the Site, as well as natural resource decisions. Specifically, environmental restoration (ER) and deactivation and decommissioning (D&D) will use the CDR to confirm the extent of action to be taken during active remediation to support the implementation of the final land configuration.

The CDR is also intended to provide the RFCA parties and stakeholders with a viable reference point for discussing the final land configuration design. Although the CDR may be used to support the development of the Corrective Action Decision/Record of Decision (CAD/ROD) for the Site, it is not intended to be the decision document for the final land configuration. Formal consultations and discussions regarding mitigation plans (if required) may occur after the CDR is developed when the nature and extent of any potential depletion to water and ecological resources can be reasonably identified. The initial conceptual design may be developed into the final design or may be appropriately modified to incorporate any changes to meet the closure requirements established for the Site identified in the CAD/ROD and other approved RFCA decision documents.

Stewardship generally addresses the need for continued protection of human health and the environment once remediation activities are completed. Stewardship activities may include: operations, maintenance, inspection, monitoring, physical controls, institutional / administrative controls, management (including records and information systems), periodic assessment, and other activities required to ensure that remedial actions remain effective. The RFETS Stewardship Plan, under development, will describe both the current and post-closure stewardship activities including performance and compliance monitoring. The plan will be developed in consultation with the Stewardship Working Group. The LCDB Project results (i.e. the Final Land Configuration Design Basis and the Initial Conceptual Design) should prove useful in providing the technical basis for planning these stewardship activities by DOE.

This work plan describes the tasks that will be completed to define the design basis and to develop the initial conceptual design for the final land configuration. The work processes and procedures that will be followed during the execution of this work plan are also addressed. The LCDB Project activities were initiated in December 2000 with the development of the data quality objectives (DQOs) as presented in Appendix A. The final design basis and CDR will be issued to the RFCA Parties [United States Environmental Protection Agency (EPA), and Colorado Department of Public Health and Environment (CDPHE)] for review and comment. The CDR will be issued concurrently to stakeholders (including easement, mineral, and water right holders), natural resource trustees, and local community representatives for review. The CDR will be revised in response to comments and reissued.

1.1 Site Location and Background

RFETS is located 16 miles northwest of Denver, Colorado in Jefferson County as shown on Figure 1. The Site, which encompasses approximately 6,500 acres, is owned by the DOE. The integrating management contractor is Kaiser-Hill. Before its current closure mission, RFETS was part of the nationwide nuclear weapons research, development, and production complex.

The Site is primarily divided into the Industrial Area (IA) and the Buffer Zone (BZ). The major plant facilities, including all production buildings and infrastructure, are located within the centralized, 400-acre IA. The BZ is a 6,150-acre area that surrounds the IA. The BZ is mainly open grassland, but also includes access roads; clay and gravel pits; two landfills; the water supply pond; much of the Building 130 complex; the South Interceptor Ditch (SID); the Western Diversion Ditch; the A-, B-, C- and D-series ponds; and several water supply and irrigation ditches. Additional details for the IA and BZ are provided in Appendix B.

The Site is currently undergoing cleanup with a goal for physical completion of remediation by 2006. The cleanup is required and guided by RFCA, which was signed by the DOE, EPA, and CDPHE. Attachment 5 of this agreement specifies the action levels and standards framework (ALF) for surface water, ground water, and soil that is used to determine the need, scope, and extent of remedial efforts during the period of active remediation. The action levels and standards for surface water are based on a single set of numeric values. The action levels for other media (groundwater, surface soils, and subsurface soil) consist of two sets of numeric values (Tier I and Tier II). When these action levels are exceeded, an evaluation, remedial action, and/or management action may be triggered. The interim cleanup levels are set to be equal to Tier I action levels unless some other ALF provision requires a greater level of cleanup (e.g., protection of surface water).

The principal contaminants at the Site include plutonium, americium, uranium, volatile organic compounds (VOCs), and nitrate. Plutonium and americium are primarily associated with surface and subsurface soils. Studies performed by the AME Project Team and published literature indicates that plutonium and americium are insoluble and strongly associated with soil particles. As such, the primary transport mechanism for these insoluble actinides to surface water is erosion via storm water runoff. Uranium, VOCs, and nitrate are the principle constituents detected in ground water plumes at the

Site. As such, the transport mechanism of these constituents to surface water would be through ground water seeps and springs.

Closure and remedial actions are being conducted to address these contaminants to meet RFCA requirements for protecting human health and the environment. For the purpose of the LCDB Project, it is assumed that these closure and remedial actions will be effective. It is also assumed that ER and D&D will address the substantive regulatory and RFCA closure requirements for these closure and remediation projects during their implementation.

Final remedial/corrective action decisions, including final cleanup levels will be documented in the Site's CAD/ROD. Because the topography of the Site has been altered by buildings and infrastructure such as roads, parking lots, storm water drainage control and waste water impoundments, the present topography may promote erosion and water runoff that could impact earlier remediation actions and natural drainage systems as these structures are removed. Unless controlled, these impacts may prevent compliance with surface water quality standards onsite and at the Site boundary as measured at the POCs. As such, the design of the final land configuration will be an important factor in achieving the surface water quality standards specified in RFCA.

1.2 Project Objectives

The objectives of the LCDB Project as identified in the *Strategy for Land Configuration Design Basis Project* (Kaiser-Hill, 2001c) include:

- Develop the information (Design Basis) required for the design of the RFETS land surface to meet human health, environment, and surface water quality standards at closure.
- Develop the land surface information required to support natural resource decisions for Site closure.
- Develop an initial conceptual design of the land configuration that supports the planning for remediation and Site closure.
- Provide documentation to demonstrate that the initial conceptual design developed in the LCDB will meet the requirements for closure of RFETS stipulated in RFCA.

In addition to the above project objectives, FDOs for the LCDB Project have been developed and are presented in Section 3.0 of Appendix B.

Because the Comprehensive Risk Assessment for the CAD/ROD has not been completed, the design basis and associated initial conceptual design will be based only on compliance with the surface water quality standards at the POCs following completion of active remediation as specified in RFCA, Attachment 5. The application of the surface water quality standards and the location of the POCs are further discussed in Section 2.5.1 of Appendix B. For the purpose of the LCDB Project, it is assumed that these surface water quality standards will be protective of the human health and ecological risk-based remediation levels derived from the Comprehensive Risk Assessment and include in the CAD/ROD.

1.3 Project Scope

The tasks associated with the scope of work, a reference to the section of the work plan that describes the task, and the status of the task are presented in Table 1. Specifically, the development of the design basis and initial conceptual design will include:

- Reviewing historical surface water monitoring results and AME erosion modeling predictions.
- Evaluating the need for water detention and minimization of runoff from the Site.
- Determining the need for and extent of erosion and runoff controls, infiltration and evapotranspiration (ET) measures, and hydrologic modifications to limit contaminant transport via the erosion and sediment transport pathway.
- Evaluating the need for ponds to meet the LCDB Project objectives. If ponds are required, the adequacy and safety of the current dams will be considered in developing the design basis and initial conceptual design.
- Demonstrating that surface water discharges from the Site will meet applicable standards, within an acceptable level of confidence.
- Determining if the collective design inputs and outputs are within acceptable uncertainties to allow management decisions.
- Providing information to further identify the potential affects on operation of third party onsite water supply ditches, easements, and mineral rights.
- Providing information to allow identification of potential implications to offsite community water management operations.
- Developing information for the determination of post-closure stewardship obligations and associated cost.
- Providing details and data that can be used by DOE to develop a final water management policy for the Site.
- Assessing potential environmental impacts to special interest resources such as Preble's Meadow Jumping Mouse (Preble's mouse), wetlands, and tall grass prairie, and identifying the potential need to mitigate these impacts.
- Incorporating provisions to minimize ecological disturbance, especially to wetlands and the habitats of the threatened Preble's mouse, to the extent practicable considering the availability of surface water after Site closure to support wetlands and habitats.
- Developing revegetation specifications that are consistent with generally accepted environmental restoration principles including the use of native plant species wherever possible, the blending of restoration vegetation into dominant local species and plant communities, and the avoidance of monocultures.

- Developing an initial conceptual design that is consistent with open space/wildlife refuge designations.

The scope of the LCDB Project will be based on the anticipated conditions at the completion of active remediation. The conditions and physical constraints expected at the completion of active remediation are described in Section 2.1 of Appendix B. Where appropriate, existing information and characterization data were extrapolated to predict the Site conditions at the completion of active remediation. Briefly, these anticipated conditions include:

- Surface and subsurface soil contamination will have been removed to below Tier I levels or appropriately stabilized.
- Above grade structures and buildings will have been removed to 3 feet below grade.
- ET covers will have been installed over the Original Landfill, Present Landfill, and Solar Evaporation Ponds.
- The Mound, East Trenches, and Solar Evaporation Ponds ground water plume collection and treatment systems will continue to be operated and maintained, if required based on ground water quantity and quality.
- The East Entrance Road, West Entrance Road, and North Perimeter Road will remain intact or minimally altered.
- Current open roads within the BZ will remain except where removal is required for long-term erosion control.
- Other components not planned to be remediated or closed will remain in their current configuration.

The final configurations for the A-, B-, and C-series ponds and the Present Landfill Pond have not been determined. This final pond configuration will be influenced by required remedial actions (such as removal of pond sediments, if required) and the approach taken to achieve the FDOs established for the final land configuration. A Pond Reconfiguration Strategy is being developed under this work plan to aid in decisions regarding the final disposition of the ponds (see Section 6.1 for additional discussion of this strategy). In order to develop and evaluate various scenarios and to bound the scope of the initial conceptual design, the anticipated conditions at the completion of active remediation will be based on retaining the A-, B-, and C-series ponds in their current configuration. [Note: The reconfiguration of the ponds will be evaluated during the LCDB Project.]

To prevent sloughing and accelerated deterioration of the evapotranspiration (ET) cover being planned for the Present Landfill, it may be necessary to extend the cover well into the Present Landfill Pond. Although the design of the ET cover is ongoing, for the purpose of the LCDB project, the anticipated conditions at the completion of active remediation are based on the Present Landfill pond and dam having been covered and eliminated to accomplish the required remedial actions. The design work and costing to support a decision is ongoing.

The LCDB Project will take a "blank sheet" approach to developing the final land configuration. The "blank sheet" approach will consist of first determining the information required to develop a final land configuration. The information will then be used to develop the design basis and initial conceptual design. The "blank sheet" approach allows a fresh look to identify the provisions required to meet the LCDB Project objectives and not to be influenced by previously developed plans. As such, components anticipated to be present at the completion of active remediation will be evaluated and will be retained if they serve a legitimate function in achieving the FDOs.

1.4 Project Boundaries

The Project boundaries are dictated by the POCs as specified under RFCA and define the area where physical alterations to the land configuration may occur to meet surface water quality standards at the POCs. A detailed description of the LCDB Project boundaries is provided in Section 2.1 of Appendix B. In general, the boundaries are the watersheds of Walnut and Woman Creeks that have a potential to come in contact with runoff from the IA or other areas that could contain contamination. The Rock Creek and Upper Big Dry Creek drainage basins are not included in the LCDB Project boundaries because drainage into these basins is unlikely to be affected by activities conducted at RFETS.

Although the LCDB Project boundary is influenced by upgradient drainage sub-basins that are offsite, the application of land configuration options will be restricted to the RFETS property boundary. The upgradient sub-basins are included for evaluating the hydrologic regime to design control structures and determine compliance with surface water quality standards. Water supply ditches that may transport water into the LCDB Project boundaries (including the McKay, Kinnear, and Smart Ditches) will also be considered.

1.5 Work Plan Structure

This work plan is organized as follows:

- Sections 2 through 7 provide the details and scope for each task that has been or will be completed to achieve the objectives stated in Section 1.2.1.
- A description of the interfaces between other projects being conducted at RFETS is provided in Section 8.
- The expected issue dates for the deliverables associated with this work plan are presented in Section 9.
- The quality assurance provisions that will be implemented during the execution of this work plan are discussed in Section 10.
- A list of references used to compile this work plan and the associated appendices is provided in Section 11.

2.0 GATHER INFORMATION AND DEVELOP DESIGN BASIS

The design basis for the LCDB Project was developed to stipulate the FDOs, criteria, and conditions for reconfiguring the Site's ponds, Walnut and Woman Creek drainages, and land surfaces. The design basis, in conjunction with other closure and remediation efforts, needs to achieve long-term compliance with RFCA that is consistent with anticipated future land use. The approach used to develop the design basis included:

- Identifying the data quality objectives (DQOs).
- Gathering and reviewing pertinent information.
- Attending technical meetings with Kaiser-Hill Subject Matter Experts.
- Documenting and summarizing information.
- Identifying the FDOs and engineering design criteria.

The DQO process is a series of planning steps designed to ensure that the type, quantity, and quality of work performed for decision-making are appropriate for the intended purpose. The DQO process that was implemented for the LCDB Project is consistent with EPA guidance documents, which consists of the following seven steps:

- Step 1: State the problem;
- Step 2: Identify the decision;
- Step 3: Identify the inputs to the decision;
- Step 4: Define the study boundaries;
- Step 5: Develop the decision rules;
- Step 6: Specify tolerable limits on decision errors; and
- Step 7: Optimize the design

The resultant DQOs are used to guide the project to help ensure that the stated objectives are met with assurance of usability. Documentation of the DQOs is included as Appendix A.

Based on the LCDB Project objectives and identified DQOs, pertinent documents were compiled and reviewed to determine availability of information required for developing the design basis. As part of the information-gathering task, technical meetings between the LCDB Project team members and Kaiser-Hill Subject Matter Experts occurred during 15 and 30 January 2001. The meetings covered the following topic areas:

- Design and installation of final covers,
- D&D of the IA,
- Environmental restoration activities,
- Geographical information systems,
- RFCA requirements,

- Sediment and soil characterization,
- Ecological resources,
- Ground water characterization and monitoring,
- Risk assessment,
- Air transport modeling,
- Surface water characterization, monitoring, and pond operation,
- Actinide migration, and
- Site-wide water balance.

Additional follow-up meetings were held to elaborate on and clarify specific information. A tour of the IA and BZ was provided to LCDB Project Team members on 6 February 2001. Visual observations and evaluations of Site drainages, ponds, and dams were conducted during the week of 26 February 2001.

A summary of the compiled information is provided in Section 2 of Appendix B. This information includes Site topography, climate, hydrology, erosion dynamics, geology, seismic conditions, hydrogeology, current drainage morphology, Site-wide water balance, environmental characterization, monitoring systems, D&D end-states, remediation systems, actinide migration, wildlife, threatened and endangered species, habitats, wetlands, vegetation, and final land uses.

The FDOs for the LCDB Project were identified in conjunction with compiling and reviewing the Site information. The FDOs specify the conditions and limitations that the design must meet to fulfill the objectives and desired functions established for the project. The FDOs include appropriate RFCA closure and post-closure requirements.

The FDOs for the LCDB Project are identified in Section 3 of Appendix B. The FDOs were identified as either primary objectives or balancing performance functions / criteria. The final land configuration must achieve each primary objective. Balancing performance functions / criteria will form the basis for developing and evaluating various bounding scenarios and will be incorporated into the initial conceptual design to the extent practicable.

Engineering design criteria includes RFETS engineering manuals, approved engineering codes and industrial standards that depict acceptable methods and practices for the design and specification of required components. The engineering design criteria that are appropriate to the LCDB Project are identified in Section 4 of Appendix B.

3.0 DATA GAPS AND ASSUMPTIONS

Data gaps include missing or unsubstantiated information, uncertainties, and constraints that could not be verified during the development of the work plan. A list of the identified data gaps, their significance, proposed resolution, and expected date for resolution is provided in Table C-01 of Appendix C. Many data gaps are related to the anticipated Site conditions that will be encountered upon the completion of active remediation. Where appropriate, specific actions to resolve each data gap are provided in Table C-01. It is expected that critical data gaps will be resolved during implementation of this work plan by acquiring additional information, electronic data, results from ongoing studies, and discussions with site personnel.

The assumptions identified in Table C-01 of Appendix C were developed to indicate how each data gap would be incorporated into the initial conceptual design if the data gap is not resolved within the schedule for completing the initial conceptual design. The list of data gaps and associated assumptions will be updated during the execution of the work plan. Detailed testing / work plans to address significant data gaps and attain required design-related data may be developed in the future as the initial conceptual design progresses.

Data gaps that cannot be resolved prior to the completion of the initial conceptual design will be carried forward and presented in the CDR. The presentation of data gaps in the CDR will include a recommendation for the subsequent method of acquisition of information necessary to fill each gap.

4.0 POTENTIAL LAND CONFIGURATION OPTIONS

Based on the review of gathered information and development of the functional objectives for the final land configuration, various potential land configuration options were identified. These land configuration options will be further refined into bounding scenarios. The various bounding scenarios will be evaluated and an initial conceptual design will be prepared. Sections 5.3 and 5.4 provide additional details regarding the bounding scenario development and evaluation tasks.

The land configuration options were identified based on controlling the primary pathways for contaminant transport to surface water. As discussed in Section 1.1, these pathways include transport of insoluble actinides due to soil erosion and the discharge of ground water containing soluble contaminants (nitrate, uranium, and VOCs). The land configuration options include both methods to control and remove contaminants from surface water and methods to prevent the transport of contaminants into surface water. The range of land configuration options, including their relative costs, advantages, disadvantages, and additional considerations are identified in Table 2. The listed advantages and disadvantages are based on the anticipated positive or negative impact with respect to meeting the FDOs. The additional considerations column provides a list of items that may require further evaluation during bounding scenario development and subsequent evaluation.

A brief description of each land configuration option and how each option could be used to address the transport mechanisms are discussed in the following subsections.

4.1 Surface Water Retention (Zero Discharge)

This option involves the collection and retention of runoff from one or more specific drainage areas in onsite ponds upstream from the POCs. The ponds would be sized to retain runoff from a specified design storm event (100-year storm event) and provide adequate surface area and/or vegetative growth to allow evaporation and transpiration of the accumulated water. A series of ponds may be required to provide the necessary retention capacity and surface area.

Although this option would be designed for total retention (zero discharge), runoff in excess of the design storm event or from consecutive storm events that exceed the design capacity of the ponds would be discharged via an emergency spillway into the drainage. Alternatively, accumulated water may be batch released on an infrequent basis to maintain a minimum operating capacity. The batch release of water would be contingent on demonstration of compliance with water quality standards.

This option would be applied to the LCDB Project as the primary component of a scenario and could be used in conjunction with drainage diversion to isolate particularly susceptible portions of the Site to minimize the retention capacity required. Because this option would be designed for zero discharge, it provides a high degree of confidence in achieving the surface water quality standards. However, this option would be costly to implement and may require water augmentation to offset the amount of water retained. The need for long-term sediment management and the potential accumulation of salts within the retention basis due the evaporation process would need to be considered.

4.2 Surface Water Detention

This option consists of the collection and temporary detention of runoff from one or more specific drainage areas in onsite ponds upstream from the POCs for removal of actinide-bearing sediment by gravity settling or active treatment. Settling ponds would be designed with sufficient detention capacity to allow sufficient settling time for a specified design storm event (100-year storm event), particle size and contaminant distribution, particle settling velocities, predicted sediment loading and concentration, and required removal to meet surface water quality standards. The effluent from the settling ponds would be discharged into the drainage either using a passive flow-through system or manually on a batch basis after the prescribed settling time has been achieved.

Active treatment would consist of a physical process, such as pressure filtration, to remove suspended solids or a chemical process, such as addition of a flocculant to the pond, to expedite settlement. If required, active treatment could also be used to treat other constituents (nitrate, uranium or VOCs) that may be present in the runoff. The effluent from the treatment process would be discharged into the drainage.

This option would be applied to the LCDB Project as the primary component of a scenario and could be used in conjunction with drainage diversion to isolate particularly susceptible portions of the Site to minimize the detention capacity required. The use of detention ponds provides operational flexibility and would allow the addition or elimination of treatment systems, as required, to meet the standards.

4.3 Removal of Surface Water Controls

This option consists of the potential removal of an existing pond / dam, ditch, culvert, and other drainage structure if it is not required to meet surface water quality standards. This option would allow runoff from one or more specific drainage areas to flow offsite unabated. The final disposition of the existing ponds and other drainage structures would be in accordance with the Pond and Sector Reconfiguration Strategies (see Section 6.1 and 6.2). For example, an existing pond would be breached if it is not required to meet the standards and does not provide any other benefit such as flood control, maintaining wetlands or ecological habitats, or diverting runoff around downstream water supplies. If the surface water controls were removed, the Site would be allowed to return to a more natural, pre-RFETS condition.

4.4 Wetlands

This option consists of establishing wetlands upstream from one or more POCs to reduce the surface water velocity and allow sedimentation of suspended solids, which potentially contain actinides. Wetlands could also be used to reduce the concentration of other pollutants (including nutrients, petroleum hydrocarbons, and certain metals) in surface waters. Wetlands also provide habitat for wildlife, which would complement the open space uses of the Site after closure.

This option would likely be applied to the LCDB Project as the secondary component of a scenario to address specific issues within a given drainage. This option would only be implemented if an adequate water supply would be available after closure to sustain the wetland. An upstream detention pond may be needed to provide primary settling and a more continuous flow of water. Water augmentation to sustain the wetland or to replace water losses due to increased evapotranspiration may also be required. Long-term sediment management would need to be considered.

4.5 Drainage Diversion and Land Recontouring

This option consists of altering the flow of runoff / runon in one or more specific sectors that are susceptible to contaminant migration. Runoff / runon alterations include drainage diversion and land recontouring. Typically, this option would be applied to the LCDB Project as the secondary component of a scenario to address specific sectors.

Drainage diversion could be used to divert runon around specific sectors. For example, drainage could be diverted away from erosion prone areas (unpaved roads, hillsides) to minimize the potential erosion of actinide-bearing sediments. Alternatively, drainage diversion could be used to isolate specific sectors that pose higher risks to surface water. Drainage isolation may be used in conjunction with other options to consolidate and reduce the size of detention or retention structures.

Land recontouring could be used to direct runoff from clean sectors of the Site away from areas that require controls. Land recontouring would also be utilized with the IA to eliminate unnecessary drainage ditches or to redirect runoff from one drainage to another (e.g., Woman to Walnut Creek) recognizing its potential limitations with respect to downstream water uses.

4.6 Source Isolation and Removal

This option utilizes regrading, backfilling, or excavation to isolate or remove actinide-bearing soils that are susceptible to erosion. This option would be applied only to localized sectors that are most susceptible to contaminant migration and has limited applicability on a Site-wide basis. This option would be in addition to the currently planned active remediation actions and applied to the LCDB Project to achieve compliance with surface water quality standards.

4.7 Erosion Controls

This option covers the application of various engineered controls to reduce erosion rates and associated transport of actinide-bearing sediment to surface water. These erosion controls include, but are not limited to: riprap, check dams, hillside armoring, grade reduction, ditches, benching of slopes, and channel flumes. These controls would be applied on an individual sector basis to address specific erosion concerns and slope stability issues. For example, erosion controls may be employed to protect ET covers, dams, and other remediation systems.

4.8 Vegetation Restoration

This option relies on the establishment of natural vegetation to reduce erosion rates and associated transport of actinide-bearing sediment to surface water by increasing ground cover. This option would likely be applied to the LCDB Project in combination with other options, such as land recontouring and evapotranspiration, for developing a scenario. Vegetation restoration will also be applied on an individual sector basis to address closure of the IA and unneeded roads located in the BZ.

Organic material, such as peat moss or organic-rich topsoil, may be used to aid in the establishment and promotion of vegetation. The restoration efforts would be performed in a manner that minimizes the establishment of non-native vegetation.

Organic materials in the soil may also serve to immobilize actinide-bearing sediments, thus reducing their mobility. It is reported that sorption of hydrolyzed Pu (IV) in natural water on mineral surfaces and surfaces coated with organic material is accountable for the very low observed concentrations of dissolved Pu even in the absence of $Pu(OH)_4$ (am) or PuO_2 (c) (Choppin, 2000). It is also reported that humic and fulvic acids can impart a negative surface charge to particles and colloids, which can promote disaggregation and dispersion of aggregates, and thus, increased mobility and concentrations of colloidal species in surface waters. However, large, surface-active, organic molecules, such as exopolymeric acid polysaccharides from bacteria and algae, act to bind colloidal and particulate species together, and thus, cause their removal and lower their concentrations in surface waters (Santschi, 1999).

4.9 Evapotranspiration Provisions

This option would be used to promote evapotranspiration (ET) in specific sectors that are susceptible to contaminant migration to reduce runoff and associated erosion of actinide-bearing soils. ET provision could also be used to minimize infiltration to reduce the mobility of subsurface ground water plumes. This option would be primarily applied to the IA and selective areas in the BZ by altering vegetation mix to provide a greater ET rate. This would be accomplished by reseeding specific sectors. As such, extensive soil disturbance would not be expected. Water augmentation may be required to replace the amount of water that is lost through implementation of the ET provisions. Decreases in runoff could also have a greater impact on wetlands and habitats.

4.10 Infiltration Provisions

This option would be used to promote infiltration to reduce the amount and associated sediment load transported into surface water from specific sectors that are susceptible to erosion of actinide-bearing surface soils. Increased infiltration may enhance preservation of wetlands by increasing flow to seepage areas. However, hillsides may become unstable and be prone to landslides. Ground water plumes may also be positively or negatively affected. For example, increased infiltration may allow contaminants to be flushed to the treatment systems, thereby expediting their remediation. On the other hand, increased infiltration may alter ground water flows and/or increase the contaminant flux to the surface water. This option would be primarily applied to the IA and selective areas in the BZ.

4.11 No Action

No action may be applied to specific sector, existing feature, drainage, or other portions of the Site if it is determined that additional actions are not required to achieve the FDOs or other actions (existing or planned) will be sufficient to achieve the FDOs. However, administrative or institutional controls may be added or revised to facilitate the application of the no action option.

5.0 DEVELOP AND EVALUATE BOUNDING SCENARIOS

This section describes the work processes for developing and evaluating the bounding scenarios for the final land configuration, which includes the following tasks:

- Gather remaining information for the data gaps identified in Appendix C,
- Evaluate the Site conditions that are anticipated to be present at the completion of active remediation,
- Identify and develop bounding scenarios using a multi-disciplinary approach, and

- Evaluate the strengths, weaknesses, effectiveness, and limitations of each bounding scenario to develop an initial conceptual design that incorporates the strengths and unique features associated with each bounding scenario to achieve the reconfiguration objectives and FDOs.

The initial conceptual design will be prepared and presented in a CDR. Details regarding the development of the initial conceptual design and preparation of the CDR are provided in Sections 6 and 7 of this work plan.

5.1 Gather Remaining Information

This task involves collecting additional information and data that is relevant to developing the bounding scenarios and initial conceptual design for the final land configuration. A summary of the information that has been reviewed by the LCDB Project Team is presented in Appendix B. The potential sources of the missing information are identified in Table C-01 of Appendix C.

It is expected that a majority of the missing information will be acquired from electronic databases and GIS, results from ongoing studies being conducted by other projects (AME, SWWB, and ET Cover projects), discussions with Site personnel, and information that have been previously developed for other projects. This information will be incorporated into the design process as it becomes available. The interfaces to attain this information are identified in Section 8.

If required, a separate task or special sub-study may be initiated to fill some of the data gaps that have a high significance. The collected information will be compared to the data gap resolutions identified in Appendix C to verify that the proper information was obtained.

Data gaps that cannot be resolved will be carried forward into the initial conceptual design as an assumption. A list of the current assumptions and their significance is provided in Appendix C. As the initial conceptual design effort progresses, these data gaps and assumptions will be updated. An updated Appendix C will be included in the CDR to summarize any remaining data gaps, assumptions, and acquisition methods to fill each gap.

5.2 Evaluate Anticipated Conditions at Completion of Active Remediation

The anticipated conditions at the completion of active remediation will be evaluated to identify potential areas where engineered features or controls may be required to comply with surface water quality standards. The anticipated conditions at completion of active remediation are described in Section 2 of Appendix B. The evaluation will also be used to provide a baseline to evaluate the performance of each bounding scenario. The baseline will include an evaluation of the ecological, erosion, hydrologic, and geomorphic conditions that would be expected. The procedures for conducting the baseline evaluations are presented in Appendices E, F, and G.

5.3 *Develop Bounding Scenarios*

Various bounding scenarios that could meet the LCDB Project objectives and FDOs will be developed. The bounding scenarios will represent a different or unique approach to satisfy the FDOs and objectives considering the options described in Section 4. It is intended that the bounding scenarios be realistic and bound the range of approaches that could be reasonably implemented. The practicability, reliability, and cost-effectiveness of the various configuration options will be considered to develop the bounding scenarios and to eliminate those options that have fatal flaws in achieving the FDOs. A general description of how each bounding scenario achieves the Design Basis, sketches to illustrate the general approach and concepts of each bounding scenario, and conceptual-level cost estimates will be presented in the CDR.

5.4 *Bounding Scenario Evaluation*

The bounding scenarios will be evaluated to develop an initial conceptual design for the final land configuration. Each bounding scenario will be evaluated on its reliability to meet the primary (mandatory or "must have") objectives and its ability to achieve balancing (desirable or "want to have") performance functions / criteria. The evaluation results will be presented in the CDR. If it is not possible to evaluate all criteria within the timeframe of completing the CDR, the unevaluated criteria will be identified as data gaps in the CDR. The evaluation process will be used to assess the relative performance of each bounding scenario against the following criteria:

- Compliance with surface water quality standards.
- Compliance with RFCA closure and post-closure requirements.
- Reliability to meet FDOs under a variety of probable conditions and storm events.
- Reduction of contaminant mobility and migration.
- Ecological preservation (including consideration of wetlands, habitats, and water depletions to the South Platte River).
- Effect on remedial systems.
- Surface water runoff quantity and flooding.
- Performance of bounding scenario in other similar applications.
- Short-term effectiveness.
- Implementability and constructability.
- Long-term effectiveness, durability, and permanence to prevent contaminant migration, including resistance to seismic events, geomorphic changes, and long-term climatic changes.
- Minimization of long-term stewardship provisions for maintaining "post-cleanup" controls on residual hazards and safety concerns.
- Minimization of total (capital and annual operating) costs.
- Implications for offsite water management operations.

- Implications for DOE Water Management Policy.
- Consistency with open space land usage.
- Regulatory agency, stakeholder, and public acceptance.

In addition to the above, scenario-specific input from AME and SWWB Project Teams will be considered and incorporated during the scenario evaluation task. The DOE policy and procedure contained in 10 CFR 1022 for assessing actions to be taken that may impact floodplains or wetlands will also be considered during the evaluation process. The following subsections provide further details regarding some of the specific methods that will be used to evaluate each bounding scenario.

5.4.1 Ecological Evaluation

An ecological evaluation will be conducted to predict the potential ecological implications associated with each bounding scenario. The ecological evaluation will also include a discussion of how potential impacts were considered in the development of the initial conceptual design and were balanced, to the extent possible, with achieving the surface water quality standards to minimize ecological disturbance. The procedures for conducting the ecological evaluation are presented in Appendix E. The ecological evaluation results will be included as an appendix to the CDR.

5.4.2 Erosion and Hydrologic Evaluation

An erosion and hydrologic evaluation will be conducted to quantify the sediment loading and hydrology in order to assess the ability of each bounding scenario to meet FDOs for surface water quality and flow controls. The procedures for conducting the erosion and hydrologic evaluation are presented in Appendix F. The erosion and hydrologic evaluation results will be included as an appendix to the CDR.

5.4.3 Geomorphic Evaluation

A qualitative and semi-quantitative geomorphic evaluation will be conducted to predict the long-term evolution of landscape landforms for the bounding scenarios. The evaluation results will be used to identify long-term soil erosion characteristics, assess the potential for damage to remediation systems due to mass wasting, and determine the appropriate engineered features / controls to preclude adverse impacts. The procedures for conducting the geomorphic evaluation are presented in Appendix G. The geomorphic evaluation results will be included as an appendix to the CDR.

6.0 DEVELOP INITIAL CONCEPTUAL DESIGN

The evaluation of the bounding scenarios will be used to identify the components that will be compiled and expanded as the initial conceptual design. Each drainage (North and South Walnut Creeks, Woman Creek, SID, etc.) may be considered separately or together to determine the best option(s) that should be incorporated into the initial conceptual design. This approach will allow consideration and adoption of one configuration option that may be ideal for one drainage, but infeasible for another. In addition, several configuration options may be combined together within individual drainages. The goal of the initial conceptual design is to satisfy all of the primary objectives and provide the best value in achieving the balancing FDOs.

The initial conceptual design will be prepared based on the Site information, FDOs, design criteria, and assumptions identified in Appendix B. Information being generated by the SWWB and AME Project Teams will be used to further refine the initial conceptual design. The rationale for the initial conceptual design will be presented in the CDR and will include the following items:

- Drawings showing the anticipated conditions after active remediation and final land configuration (based on the initial conceptual design).
- Drawings identifying the reconfiguration aspects of drainages, ditches, culverts, storm water structures, ponds, and dams.
- Drawings depicting the areas where specific sector reconfiguration, such as recontouring, erosion controls, revegetation, road closure, and infiltration or evapotranspiration provisions, need to be applied.
- Structural components that are needed to withstand seismic activity associated with a design basis event.
- Specification for seed/hydro-mulching/topsoil to be used for restoration.
- Material quantity estimates.
- Construction cost estimate (-30 to +50 percent).
- A rough order of magnitude operating and maintenance cost estimate.
- Implementation schedule.

To aid in the development of the initial conceptual design, strategies to reconfigure the ponds and discrete sub-areas (sectors) of the Site will be developed (see Sections 6.1 and 6.2). Each strategy will address the need for reconfiguration and identify the pertinent factors that determine the scope of the required reconfiguration. Logic diagrams will be prepared to illustrate the decision process. A description of the strategies will be included as a section in the CDR.

6.1 Pond Reconfiguration Strategy

Eleven storm water retention ponds, designated as the A-, B-, and C-Series Ponds, are currently in use at RFETS to control runoff from the IA. The Present Landfill Pond is also currently being used to manage storm water and seepage from the Present Landfill, but is assumed to be eliminated when the ET Cover is installed. A description of the current operation and characteristics for each pond is provided as Section 2.3.6 of the Design Basis (see Appendix B). The Pond Reconfiguration Strategy will identify the factors, considerations, and information that are required to determine the final configuration for the existing ponds. These factors and considerations include:

- Need for retention and settlement to meet surface water quality standards;
- Point of compliance location for surface water quality standards;
- Need for flood control;
- Preservation of ecological habitats, wetlands, and wildlife of special interest;
- Downstream water rights;
- Current dam safety and adequacy (if it is determined that a pond is required at the locations of the existing ponds); and
- Feasibility and cost for modifying the existing dams versus new construction.

The need to reconfigure individual ponds will be determined during the design process through the application of the Pond Reconfiguration Strategy on a pond-by-pond basis. For example, some ponds may be reconfigured to allow flow-through operation while others may be retained in their current configuration or breached. The existing pond will be retained if application of the Pond Reconfiguration Strategy indicates that the pond serves a legitimate function in achieving the LCDB Project objectives or FDOs. The management of sediments from ponds that are proposed to be breached will be considered in the decision making process. The reconfiguration of peripheral structures (bypasses, outlet structures, spillways, etc.) will also be addressed.

6.2 Sector Reconfiguration Strategy

A consistent strategy will be developed to identify standard design solutions that can be applied on an individual sector basis to mitigate areas that may pose significant concerns or issues in achieving compliance with surface water quality standards. Problem sectors would be identified throughout the closure of RFETS as additional characterization data and other information are obtained. The Sector Reconfiguration Sector will identify the factors and considerations to allow consistent application of the design solutions to the identified problem sectors. The application of a design solution to a specific sector will include consideration of:

- Areas that are susceptible to contaminant migration,
- Unstable areas prone to slumping or erosion,
- Proximity of wetlands and wildlife habitats,
- Location/mitigation of ground water plumes, and
- Potential impacts to remediation systems and drainages.

The reconfiguration options described in Section 4 may be further developed as part of the Sector Reconfiguration Strategy. The potential design solutions may include:

- Drainage diversion and land recontouring;
- Infiltration provisions;
- Evapotranspiration provisions;

- Closure of BZ access roads;
- Hillside stability improvements (e.g., armoring, riprap, slope reduction);
- Source removal or isolation;
- Erosion controls;
- Revegetation; and
- No action.

A decision matrix for the Sector Reconfiguration Strategy will be developed and applied on a sector-by-sector basis to refine the initial conceptual design. Existing components will be subjected to design solutions if application of the Sector Reconfiguration Strategy indicates that the component may contribute to exceedences of the surface water quality standards or does not serve a legitimate function in achieving the LCDB Project objectives or FDOs. For example, existing open roads in the BZ would be closed and revegetated if they are not required for access or other legitimate use.

7.0 CONCEPTUAL DESIGN REPORT

The design basis and initial conceptual design will be compiled into a CDR to provide the information required to prepare the final design for the final land configuration at RFETS. As discussed in the Introduction to the work plan, the CDR is not intended to be the decision document for the final land configuration. As such, the initial conceptual design documents may be developed into the final design or may be appropriately modified to incorporate any future changes to meet the closure requirements established for the Site in the CAD/ROD. The annotated outline for the CDR is provided as Appendix D. The CDR will contain the following information:

- Design basis including relevant information, FDOs, and other design criteria.
- Description of the bounding scenario development and evaluation.
- Description of the initial conceptual design and the rationale for its individual components.
- Discussion and application of the pond and sector reconfiguration strategies used to refine the scope of the initial conceptual design.
- Demonstration that the initial conceptual design meets the objectives and FDOs specified for the LCDB Project.
- Identification for the need to eliminate subsurface pathways.
- Hydrologic evaluation of Walnut and Woman Creeks for storm-event integrity.
- Description of how the initial conceptual design considered the local ecology, particularly wetlands and wildlife habitats, and how adverse impacts to these resources (if any) were balanced against the need to comply with surface water quality standards. This description will include a ledger to account for any reduction in wetlands, and other adverse affects to ecological habitats, especially to the Preble's mouse.

- Specification for revegetation.
- Cut and fill calculations.
- Project planning and implementation information, such as quantity estimates, estimated cost, and implementation schedule.
- Discussion of remaining data gaps and assumptions that need to be resolved prior to completing the final design.
- Summary of regulatory agency, stakeholder, public, and other review comments.

In addition to the above, any evaluation performed by the AME and SWWB Project Teams to verify the effectiveness of the initial conceptual design will be presented in the CDR.

The CDR may be used to support remedial action decisions regarding removal of subsurface structures; support Site closure decisions regarding post-closure institutional controls, water management, and ecological conservation; and provide the RFCA parties and stakeholders with a reference point for discussing the design for the final land configuration. Mitigation plans to address environmental impacts, such as potential loss of wildlife habitat, destruction of wetlands, or protection or reconstruction of the threatened Preble's mouse habitat will not be provided in the CDR, except to note where mitigation may be required.

The LCDB Project results (i.e. the Final Land Configuration Design Basis and the Initial Conceptual Design) should prove useful in providing the technical basis for planning and estimating stewardship activities in the areas of funding, operations, maintenance, inspection, monitoring, physical controls, institutional / administrative controls, management (including records and information systems), periodic assessment, and other activities required to ensure that remedial actions remain effective.

The revegetation specification will be consistent with generally accepted environmental restoration principles, including the use of native plant species wherever possible, the blending of restoration vegetation into dominant local species and plant communities, and the avoidance of monocultures.

The life cycle cost estimate will include projections regarding the effective life of the erosion controls, drainages, soil covers, and vegetation.

The key materials for implementing the final land configuration are expected to be imported topsoil, fill material, and riprap. Material quantity estimates will be prepared to allow early construction planning, including decisions for the advance procurement of these materials to reduce cost and maintain overall Site closure schedules.

The implementation schedule will assist in the coordination of final land configuration with concurrent D&D, environmental restoration, monitoring, and characterization activities.

8.0 PROJECT INTERFACES

Several ongoing studies and data-gathering efforts will contribute vital information to the LCDB Project.

The AME Project Team is focused on understanding actinide mobility in the environment and has completed several studies to estimate the impacts of soil erosion and sediment transport on Site surface water quality. The scope of the AME efforts includes impacts associated with specific storm events, remedial actions, hydrologic modifications, and land uses on surface water quality. The AME Project Team will be utilized to predict actinide transport characteristics for each bounding scenario. This will include developing erosion and actinide migration maps and utilizing storm water routing to predict actinide concentrations at various locations within the drainage channels. With these results, the LCDB Project Team will formulate the initial conceptual design to capitalize on the advantages offered by the individual bounding scenarios. The LCDB Project Team, in conjunction with the AME Project Team, will then conduct a more detailed evaluation of the initial conceptual design to assess its effectiveness in achieving the RFCA surface water quality standards. Additional details regarding the evaluation and coordination efforts between the LCDB and AME Project Teams is provided in Appendix F.

The AME Project Team is also conducting a geochemical investigation to identify the potential source of the uranium detected in groundwater and the corresponding transport mechanisms. The results of this investigation will be incorporated into the design basis (see Appendix B, Section 2.5.4.7) and will be used to confirm that the current and/or planned groundwater remedial actions will be effective, in conjunction with the final land configuration, to maintain compliance with the surface water quality standards at the POCs.

The SWWB Project Team is responsible for developing a detailed, Site-specific hydrologic model (water balance) that addresses ground water, surface water, and their relationships. The SWWB model will be calibrated based on recent historical information and will be used to predict changes in the water balance due to Site closure, including changes to ground water flows, hydrology, seeps, wetlands, and habitats. The water balance model will be sequentially modified to predict the significance and impacts associated with individual changes (including cessation of imported water, removal of Site structures, and other closure activities) through a series of model runs (scenarios). The series of SWWB model runs will address the initial conceptual design presented in the CDR. Output from the SWWB model runs will be provided to the LCDB Project Team. The results will be used to:

1. Evaluate effects of groundwater on surface water at site closure.
2. Predict surface water flows and groundwater hydrology after completion of remedial actions (D&D and ER).
3. Evaluate/confirm that the proposed final topography of the IA is supportive of RFCA surface water quality standards, and

4. Provide input for evaluating wetland development and the sustainability of wetlands and habitat proposed by bounding scenarios.

Additional details regarding the evaluation and coordination efforts between the LCDB and SWWB Project Teams is provided in Appendix E.

The ET Covers Project is responsible for the development and design of the final configuration for the Original Landfill, Present Landfill, and Solar Evaporation Ponds. The final topography and drainage plans for these cover systems will be integrated into the initial conceptual design for the LCDB Project. Long-term geomorphic considerations and application of the Pond Reconfiguration Strategy to the Present Landfill Pond (if not eliminated to facilitate installation of the ET cover) will be coordinated between the two projects.

9.0 PROJECT DELIVERABLES AND SCHEDULE

The key deliverables and project milestones for execution of this work plan include:

- Begin Bounding Scenario Development and Evaluation — June 2001
- Begin Development of Initial Conceptual Design — August 2001
- Issue Land Configuration Design Basis - Preliminary — March 2002
- Issue CDR to DOE for Review — TDB
- Issue CDR to Regulatory Agencies/Stakeholders / Public — TDB
- Issue Final CDR — TDB

Comments from the regulatory agencies were received in August 2001. These comments raised concerns that could not be resolved at this time. After several meetings and discussions with the regulatory agencies, DOE decided to postpone the LCDB Project. The scope of the LCDB Project was adjusted to bring in-progress work to a reasonable point of completion while deferring the preparation of the CDR until such time when the required information is acquired. The above schedule will be revised when plans to complete the CDR have been finalized.

10.0 QUALITY ASSURANCE PLAN

This section addresses the quality assurance work procedures that will be followed during execution of the work plan. The quality assurance (QA) procedures and plans adopted for implementing the LCDB Project were developed using the format and criteria specified in 10 CFR 830.120, *Quality Assurance,* for nuclear facilities and services and DOE Order 414.1, *Quality Assurance,* for non-nuclear facilities and services. [Note: The provisions of 10 CFR 830.120 and DOE Order 414.1 are consistent with DOE Order 5700.6C, which has been superceded.]

This QA Plan presents the applicable procedures used to control the work process. Compliance with the QA procedures and plans will be verified by a QA organization that is independent of the LCDB Project. Specific procedures that are directly applicable to the execution of this work plan are summarized in the following subsections.

10.1 Preparation of Engineering Calculations

An engineering calculation is a document prepared to confirm or substantiate engineering design decisions based on equations, references, design inputs, assumptions, and conclusions. Engineering calculations will be developed and prepared in a planned, controlled, and documented manner per *Site Engineering Process Procedure, 1-V51-COEM-DES-210.* Each engineering calculation will be assigned a unique document control number for tracking and control of subsequent revisions. Each calculation will contain the following information:

- Objectives of the calculation (including reference to the applicable item or system);
- Method used to perform the calculation to achieve the stated objectives, including identification of computer programs used (i.e., program name and revision);
- Assumptions (including those requiring future verification) and technical basis;
- Design input document references; and
- Summary of conclusions.

The source of all equations, formulas, and inputs will be identified by reference. All calculations will be subjected to an internal check for conformance to project design criteria, assumptions, use of appropriate method, mathematical accuracy, adequacy of content, reasonableness of results, conclusions, and other possible errors.

10.2 Preparation of Conceptual Design Drawings

The purpose of design drawings is to graphically present the details of the project, depict the components, develop cost estimates, and facilitate construction. Design drawings are divided into sketches and engineering drawings. Sketches may only be used if the information on the sketch will not be required for use again and are used to establish design/technical concepts for transmitting basic ideas in an informal manner. Sketches will not be used for fabrication or construction purposes.

Engineering drawings will be prepared using computer-aided design and drafting (CADD) in a planned, controlled and documented manner per *Site Engineering Process Procedure, 1-V51-COEM-DES-210.* RFETS standard drawings will be adopted where available and appropriate. Additional standard drawings and details will be developed as required using available codes and standards, and good industry and engineering practice.

Each engineering drawing will be assigned a unique document control number for tracking and control of subsequent revisions. Drawing sizes, title blocks, symbols, and other formats will be consistent with *RFETS General Drafting Standard, SX-300.* At a minimum, the title block will contain:

- The project title and number;
- Drawing title;
- Drawing reference and revision numbers; and
- Sign-offs for the designer, discipline engineer, reviewer, and approver.

Drawing packages will have an index title sheet identifying the project and listing the drawing numbers, titles and revision status.

10.3 Preparation of Specifications

Project-specific specifications and data sheets will be developed per *Site Engineering Process Procedure, 1-V51-COEM-DES-210.* The specifications will be consistent with the format and content identified by the Construction Specification Institute (CSI) Divisions 1 through 16. RFETS standard specifications will be adopted where available and appropriate. Available codes and standards, good industry and engineering practice, and previous field experience will be used to develop other required specifications. The specifications will also incorporate the applicable objectives and provisions identified in the Design Basis.

10.4 Review and Checking

All design and technical documents, including calculations, will be checked in accordance with *Site Engineering Process Procedure, 1-V51-COEM-DES-210.* The extent of the checking will be commensurate with the complexity, risk, and uniqueness of the design. The checker will be technically qualified and will not be the author or originator of the design or technical document. At a minimum, design and technical output documents will be checked for:

- Use of sound methods and approaches;
- Inconsistencies in methods and approaches;
- Technical adequacy and accuracy;
- Errors and omissions;
- Interferences and discrepancies;
- Technical coordination between discipline interfaces;
- Conformance to and inclusion of all FDOs;
- Completeness and understandability;
- Reasonableness of assumptions, results, and conclusions; and

- Identification and incorporation of appropriate references.

Design drawings and engineering specifications will contain "Prepared By" and "Checked By" spaces for initials and dates of the author or originator and the checker to verify that these documents have been properly checked.

10.5 Computer Software Verification

Computer programs used for or in support of design and technical analysis will be verified. The extent of verification checking will be commensurate with the complexity, risk, and uniqueness of the design. Acceptable means of verification include comparison of computer program results with:

- Hand calculations;
- Sample problems documented in the software manufacturer's published manuals;
- The results of previously verified computer programs; or
- Empirical data and information from technical literature.

Changes or revisions to computer codes will be controlled to assure that changes are documented, re-verified, and approved by authorized personnel as required.

10.6 Document Control and Records Turnover

During the implementation of the work plan, project documents will be appropriately filed for storage and retrieval. A file index will be developed and maintained to organize project records. Records within a particular file category will normally be filed in chronological order. Sign-out cards will be used when files are removed from the storage area. All materials, records, and documents will be returned to the storage area upon completion of the project.

All design documents will be controlled and dispositioned in accordance with *Site Engineering Process Procedure, 1-V51-COEM-DES-210.*

Quality records include all project documents, correspondences, records, and electronic deliverables that have been executed, completed, or approved, and which furnish evidence of the quality and completeness of data (including raw data) and activities affecting quality. All quality records will be turned over to Kaiser-Hill upon project completion.

10.7 Audits

At least one internal audit will be conducted to verify that the appropriate procedures are being followed. Where deficiencies are identified, follow up audits will be performed to confirm close out/compliance.

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Table 1
Scope and Status of the LCDB Project Tasks

Task	Task Description	Status
Review Site information and develop the design basis	See Section 2.0	Site information and design basis compiled to date is provided in Appendix B (see Tab 2, Appendix B).
Identify data gaps and assumptions	See Section 3.0	The data gaps and assumptions that have been identified during the development of the work plan are identified in Appendix C (see Tab 2, Appendix C).
Identify potential land configuration options	See Section 4.0	Potential land configuration options are presented is Section 4.0.
Gather remaining Site information	See Section 5.1	Gathering and reviewing Site information will continue throughout the development of the initial conceptual design. (Updated information has been included in the Design Basis, see Tab 2, Appendix B).
Evaluate the anticipated conditions at completion of active remediation	See Section 5.2	Erosion and hydraulic results are presented in Tab 3, Attachment B-2.
Develop bounding scenarios	See Section 5.3	Development of the bounding scenarios is presented in Tab 3, Attachment A.
Develop initial conceptual design	See Section 6.0	Description of the components included in an initial conceptual design are described in Tab 3, Attachment C.
Develop pond reconfiguration strategy	See Section 6.1	The Pond Reconfiguration Strategy is provided in Tab 3, Attachment D.
Develop sector (sub-area) reconfiguration strategy	See Section 6.2	This task is in progress.
Prepare conceptual design report	See Section 7.0	Task has not been initiated.

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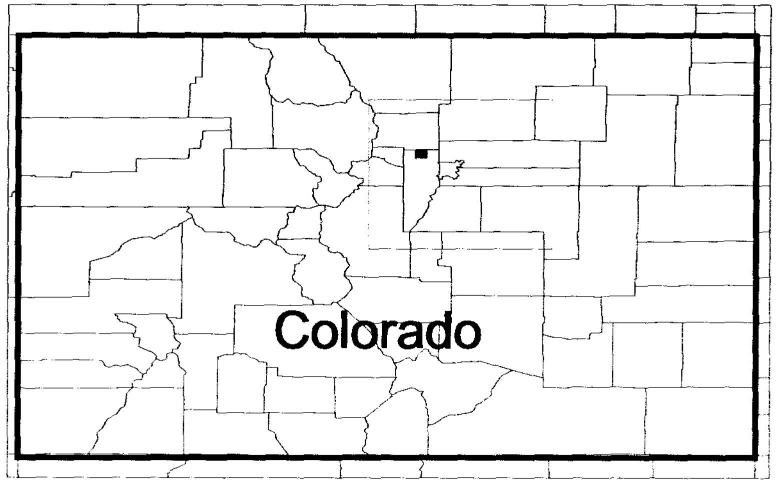

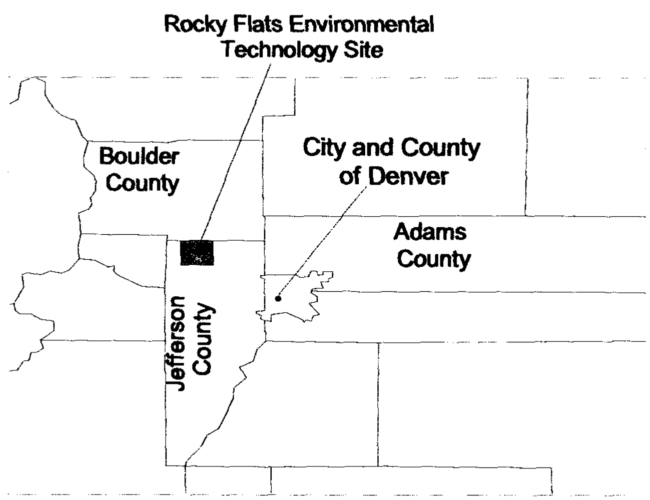

Figure 1

Site Location Map

Rocky Flats Environmental Technology Site

Jefferson County, Colorado, USA

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State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

Prepared by:

PARSONS

Parsons, Inc.
1700 Broadway, Suite 900
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303-831-8100

Feb 5, 2002

Preface

The purpose of the LCDB Project is to develop the design basis for final land configuration at RFETS. This design basis would be utilized to guide, integrate, and develop individual remediation and closure projects to place RFETS in a final configuration that would maintain compliance with the RFCA surface water quality standards after Site closure.

The work plan for the LCDB Project dated May 2001 was issued to DOE and FWS for review and comment. This document provides the final responses to DOE and FWS comments. Except where noted, responses to these comments were incorporated into the July 2001 revision that was issued the regulatory agencies and other stakeholders for review and comment. The remaining comments were deferred until after receipt of regulatory agency comments.

Based on the regulatory comments, completion of the LCDB Project is being postponed until additional data are available. The work developed by the LCDB Project Team was compiled into the *Land Configuration Design Basis – Preliminary* for retention and later use. The *Revised Draft Work Plan* (see Tab 1) and its associated appendices (see Tab 2) incorporate the previously deferred DOE/FWS comments and contain updated information to reflect the current progress of the LCDB Project.

Incorporation of responses to Comments 33 and 34 have been deferred and, therefore, have not been incorporated into the *Revised Draft Work Plan* contained in Tab 1 and/or its associated appendices provided in Tab 2.

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Comments from Rick DiSalvo

Comment 1: Section 1.0 – Will there be an opportunity for public review and comment on various critical aspects of the design basis? For example, the Introduction says various scenarios will be evaluated and then the most appropriate scenario selected for developing a conceptual design. Water POC's are also area where I think we will benefit from discussion.

Response: Work Plan has been revised to indicate that the CDR will be issued in January 2002 to stakeholders (including easement, mineral, and water right holders), natural resource trustees, and local community representatives for review concurrent with review by EPA and CDPHE. The work plan has also been provided to these parties.

Comment 2: Section 1.0 – Last sentence says that the CDR is expected to be completed in March 2001. I think it's 2002.

Response: Date has been corrected.

Comment 3: Section 1.2 – Last paragraph refers to POC location in Appendix B, Section 2.5.1 (see 2.5.1.3). That section says if the ponds are removed, the POC will only be at Indiana St, but RFCA says we will need to negotiate this with CDPHE and EPA. I think we will need to evaluate whether there are areas that may present themselves as "natural points" POC's upstream of Indiana St. as the conceptual design develops. See Comment 1, above.

Response: Agreed. Section 2.5.1.3 indicates that if the terminal ponds are removed, new POCs would be established. Because this has not occurred, an assumption regarding the location of the POCs was made to allow development and evaluation of potential scenarios that involve the removal of the terminal ponds. Section 2.5.1.3 has been clarified to state that, "For the purpose of developing and evaluating LCDB Project scenarios that involve removal of the terminal ponds, it is assumed that only the Walnut Creek (GS03) and Woman Creek (GS01) monitoring points at Indiana Street will be POCs. The appropriateness of the monitoring locations will be evaluated during the initial conceptual design to determine if any POC should be relocated."

Comment 4: Section 1.3 – The design basis needs to consider possible impacts to third party water rights for water flowing across site or that may be expressed from groundwater as surface water based on the final configuration. (I note that Appendix B, Section 2.3.9 does discuss water rights – I may have some comments on this section next week. I have not been able to talk with those who know more about this that I do.) It also needs to consider impacts to any existing easements to identify whether changes to easements may be required. (I note that Appendix B, Section 2.8.2.4 does discuss and list easements.) Finally, subsurface mineral rights also need to be considered and in particular, whether any interference with access to minerals by a rights holder could be posed by a particular configuration. (I note that Appendix B, Section 2.7.4.4. addresses one

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potential issue in that we may not be able to freely use onsite subsurface soils for borrow sources.)

Response: ***The following bullet has been added to Section 1.3 and to the annotated outline for the CDR Appendix D).***

- ***"Providing information to further identify the potential affects on operation of third party onsite water supply ditches, easements, and mineral rights."***

Comment 5: Section 1.4 – Again, point out that we will consider possible impacts to third party water rights (quantity and quality). Mineral rights also need to be considered. This means the Project Boundary may need to be expanded if we need to reconfigure water flows, or we need to constructively restrict access to mineral rights holders anywhere on the site. These factors need to be identified and considered in relevant portions of Appendix A as well.

Response: ***The project boundaries for the final land configuration are consistent with the AME and SWWB Project studies and are dictated by those areas that may result in an exceedence at a POC. As such, areas of the Site that do not drain to a POC are not included. In this respect, the LCDB Project is not comprehensive. The need for institutional controls to maintain the performance of the initial conceptual design will be addressed in the CDR. Other stewardship activities that are necessary to maintain the Site, as a whole would be better addressed in a long-term stewardship plan.***

Comment 6: Section 2.0 – Again, I think we need to plan on public review and comment. Over and above regulatory consultation, we need to have a good idea about public acceptability issues that need to be considered in developing the design basis and the conceptual design. (I note in Section 5.4, last bullet on page 15 states, "Regulatory, stakeholder and public acceptance). We especially want to let easement holders and water rights and mineral rights holders about our design basis and conceptual design plans so we won't be blindsided in the future. Also, the regulatory consultative process must include the Natural Resource Trustees.

Response: ***See response to Comment 1.***

Comment 7: Section 5.4 – I suggest that we add consideration of those NEPA values not already on the list. In particular, the short term impacts during construction to air quality (I note that it's listed in the Functional Design Criteria in Appendix A) and water quality, transportation impacts, irreversible and irretrievable commitments of resources and cumulative impacts must be considered in the design basis and the conceptual design.

Response: ***It is intended that short-term impacts during construction (including air and water quality considerations) be included in the evaluation process. Under CERCLA guidance, these items are covered under short-term effectiveness. Thus, no change to the list in Section 5.4 is required. Separate evaluation criterion will be included for air and water quality considerations during construction.***

Other NEPA criteria (including transportation impacts, irreversible and irretrievable commitment of natural resources, and cumulative impacts) are not specifically addressed because it is intended that the CDR not be the decision document for the final land configuration, but to provide a tool to facilitate discussions, planning, and management decisions. Furthermore, detailed NEPA analysis may be premature at this time given the level of detail and changes that may occur to the initial conceptual design.

Comment 8: Section 5.5.1 – The pond reconfiguration strategy should include as a factor the need to remediate the sediment in the existing ponds if the ponds are to be removed or reconfigured. Although this touches on the condition of the site after all remedial actions are complete, I think the design basis should consider that remediation and reconfiguration would likely happen at the same time.

Response: ***The following has been added to this section (Now Section 6.1). "The management of sediments from ponds that are proposed to be breached will be considered in the decision making process."***

Remediation and reconfiguration schedules will be integrated in the future. However, reconfiguration is being evaluated separate from remediation activities to identify and develop the appropriate scope and cost estimate for the CDR.

Comment 9: Section 6.0, penultimate bullet – This mentions life cycle costs. It occurred to me that a specific "life" of the design and design elements needs to be discussed as part of the basis. Is that in the FDOs?

Response: ***Bullet has been revised to change "life cycle" to "operations and maintenance" cost estimate. The design life is considered to be indefinite and that the final land configuration would need to be maintained until it can be demonstrated that controls are no long required. The design basis includes provisions that the final land configuration needs to demonstrate compliance with the surface water quality standards at the POCs for a 100-year, 6-hour storm event. In addition, long-term erosional and other geomorphic processes will be evaluated over a 1,000-year period as discussed in Appendix G, Section 6.0 (see Tab 2) to identify potential adverse impacts to the initial conceptual design.***

Comment 10: Section 7.0 – Following my previous comments on public input, etc., the CDR should include a section on public participation results in relation to public acceptability criteria. I do not advocate a specific response to every public comment, but rather a summary approach to identify key issues that go to public acceptability, data gaps, assumptions, etc. that should be considered in taking the CD to a final design in a RFCA decision document.

Response: ***The following bullet has been added to Section 7.0.***

- ***"Summary of regulatory agency, stakeholder, public, and other review comments."***

Comment 11: Section 9.0 - Include in schedule the anticipated public review periods.

Response: ***Provision to issue CDR to stakeholders and public has been added to the summary schedule presented in Section 9.0 of the work plan.***

Comment 12: Section 11.0 – I may have missed it, but the Prebbles Meadow Jumping Mouse Protection Plan is not included. Please consider whether it's a relevant reference tool.

Response: ***The following text has been added to Appendix B, Section 2.6.2. "Any necessary work that may cause significant disturbance, destruction, or other impacts to Protection Areas or Contiguous Wetlands identified on Figure B-12 must be approved in advance of any work per the requirements of Preble's Meadow Jumping Mouse Protection Plan (DOE, 2000f)."***

The definitions for Protection Areas or Contiguous Wetlands were also provided in Appendix B, Section 2.6.2 and a reference for the Protection Plan has been added to Section 11.0.

Comments from Cliff Franklin

Comment 13: Section 2.8.3.1, line 2: There hasn't been any discussion that Jefferson county would take over management of RFETS as an Open Space. The communities have expressed desires that Rocky Flats remain in Federal ownership and management. This idea should be removed.

Response: Comment incorporated. Reference to open space being administered by Jefferson County has been deleted.

Comment 14: Section 2.8.3.1, line 14: Jefferson County Policy and Procedures Manual for Open Space management would not apply on RFETS. This is Federal property, and county regulations do not supercede federal regulations.

Response: Comment incorporated. Reference to Jefferson County regulations has been deleted.

Comment 15: Section 2.8.3.2, page B-65, line 11: I think the scenario of a Refuge Worker is already being considered for soil action level determination.

Response: The refuge worker scenario is being considered. However, the current action levels in RFCA, Attachment 5 have not been revised to include refuge worker action levels. As such, the statement contained in Section 2.8.3.2 is correct and does not need to be revised at this time.

Comment 16: Section 2.8.3.2, page B-65, line 19: Refuge management plans are not developed "in conjunction with" DOE, adjacent governments, etc. They are developed with input and comments from these entities, not in conjunction with.

- ***Response: Comment incorporated. See response to Comment 138.***

Comment 17: Section 2.8.3.2, page B-65, line 27: Under the Refuge management, the natural resources are the first priority, providing the "maximum fish and wildlife oriented public uses" is generally not the objective of a refuge. For example, hunting would probably not be allowed on RFETS, even if it became a refuge.

- ***Response: Comment incorporated. See response to Comment 139.***

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Comments from Gail Hill

Comment 18: The plan needs to more focused towards issues involved with natural resource damages and possible mitigation actions that could be taken to minimize those damages. It also needs to be more focused on long-term stewardship impacts and objectives. DOE has not fully informed K-H and its contractor about its vision and ideas in these areas, and will more fully delineate its proposed plans before this work plan is finalized.

Response: ***The Introduction to the work plan has been revised to address mitigation and long-term stewardship.***

Comment 19: Page 2, line 8: This states that the expected completion date for the design basis and CDR is March 2001. Please change date to current proposed completion dates.

Response: ***Date has been corrected.***

Comment 20: Page 2, line 28: "....surface water are based on a single...."

Response: ***Comment incorporated.***

Comment 21: Page 5, line 18: DOE does not anticipate that the ponds will remain as-is in their current configuration. (See long-term stewardship report). The anticipated condition for the existing ponds are that they will be flow-through ponds. Please change this statement to "The existing ponds will be reconfigured to be flow-through ponds, with wetlands established in the bottoms for filtration and sediment control."

Response: ***Text has been added to clarify the assumptions regarding the reconfiguration of the existing ponds.***

Comment 22: Page 9, Section 4.1: Question the value of looking at an option that is inconsistent with long-term stewardship and natural resource damage objectives. In addition to the cost with constructing dams large enough to handle a 100-year storm event, the costs involved with buying additional water to discharge downstream to handle depletion issues would encumber the federal government indefinitely for large sums of money. If this draft is to define the bounding conditions, this should be considered outside the bounding conditions of the plan.

Response: ***The points raised above will be considered during the development of the bounding scenarios (see Tab 3, Attachment A) and initial conceptual design. The intent of Section 4 is to identify potential approaches that would be considered in developing the bounding scenarios. The process to develop and evaluate bounding scenarios has been clarified in the work plan.***

Comment 23: Page 10, line 10: Question why a pond to hold a 100-year storm event for settling purposes would be needed. As seen during the May 1995 flooding incident, the volume of water becomes much more of an issue than the amount of sediment contained in that water. This option points out the value of converting the ponds to flow-through, with wetlands in the ponds to allow for natural filtering.

Response: ***The design basis is the 100-year storm event as stated in Section 4.2. If this scenario option is included in the initial conceptual design, then the calculated runoff and sediment loading from the 100-year storm event would be used to size the flow-through basin and outlet to achieve the settling needing to meet surface water quality standards at the POCs.***

Comment 24: Page 11, Section 4.4: Again, instead of building wetlands upstream of the POCs, the ponds would be a logical place to build them, unless wetland acreage greater than the amount that would be constructed in the ponds is required to add wetland credits to the wetlands bank. Additionally, to test the option of using wetlands within the ponds, as a pilot project, Pond C-1 should be converted to flow-through and planted with wetland vegetation inside to help determine the viability and usefulness of pond wetlands to do natural filtering of surface waters.

Response: ***Comment noted. The existing ponds are upstream of the POCs and would be considered as potential locations if the ponds can be adequately modified to serve this function. Under the LCDB Project, the wetlands would be sized to meet the specific settling and management characteristics to maintain compliance with the surface water quality standards at the POCs, not to add wetland credits as part of mitigation. This would be evaluated with developing the final design when other factors including availability of future water supply have been determined. These factors have a significant impact on the amount of wetland acreage that can be sustained after Site closure, which in turn impacts their effectiveness as an option to maintaining surface water quality standards at the POCs. Revisions to the work plan are not required. Although, using Pond C-1 for pilot testing is not currently within the scope of the LCDB project, confirmation of the performance of artificial wetlands has been added as a data gap to Appendix C.***

Comment 25: Page 11, line 26 and 27: Redirecting runoff from one drainage to another would also need approvals by local entities and water rights holders. Although the local cities are currently not exercising their water rights on Walnut or Woman Creeks, they may wish to do so in the future, which could make this option problematic.

Response: ***Agreed, the option to direct runoff from one drainage into another has many concerns that were factored into developing the bounding scenarios (see Tab 3, Attachment A). Listing drainage diversion in the work plan was only intended to identify potential options for consideration. Revisions to the work plan are not required.***

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Comment 26: Page15, Section 5.4: An additional criteria to add would be: "Minimization of natural resource damages, and mitigation for existing damages as possible". Do not know why implications for off-site water management operations would be included. Since the local communities have not been telling the Site what their long-term plans for water management are, the Site cannot be responsible for changes the local communities may make in surface water management between now and Site closure.

Response: ***The minimization of natural resource damages will be covered in the evaluation of the bounding scenarios as part by the "Ecological Preservation" criterion. Also, see Appendix E for further details associated with this evaluation criterion.***

Off-site water management is a significant factor in determining the final land configuration for the Site. For example, if maintaining downstream diversion of water were required, scenarios involving flood control would be important. In addition, the current configuration of the Woman Creek and West Diversion Dams and McKay By-Pass Canal is highly dependent on the long-term plans of the local communities. In order to proceed with the LCDB Project, assumptions regarding long-term water management plans had to be made. If these assumptions are incorrect, the design basis would need to be adjusted prior to developing the final land configuration. The intent of the CDR is to provide the framework to discuss long-term off-site water management plans with the local communities. Revisions to the work plan are not required.

Comment 27: Page 17, line 11: RFFO plans to keep the landfill pond and use it in their refuge management plans. At this time, keeping the pond is the default option; removing it is an option only if the cost/benefit analysis shows the cost of keeping it outweighs the natural resource damages DOE may incur with its removal.

Response: ***Other factors including the feasibility and stability of placing the ET Cover over the Present Landfill are significant in determining the fate of the Landfill Pond. The design of the ET Cover is currently being performed. To be consistent with the preliminary information developed under the ET Covers Project, the working assumption for the LCDB Project is that the Present Landfill Pond would be eliminated. If this working assumption is not correct, then the fate of the Present Landfill Pond would be determined through the application of the Pond Reconfiguration Strategy, which includes consideration of ecological benefits.***

Comment 28: Page 20, line 35: The results from the AME, SWWB, and LCDB basis will be used iteratively with each other to refine their respective conceptual designs. The timing of all of the projects should be coordinated so an iterative process is used for all three, not just the LCDB. It is still unclear whether or not the hierarchy for the three projects are equal, or if two of them (AME and SWWB) are expected to "flow-up" to and support the LCDB. (pyramidal hierarchy)

Response: ***An integrated schedule has been developed.***

Comment 29: Page 21, Section 9.0: It appears that the schedule for the LCDB is not in sync with the other two studies. The SWWB is not to be completed until January 2002. If the SWWB is to feed information into the LCDB, it would seem this study should not be completed until some time after the SWWB is finished.

Response: ***All significant data gaps will be resolved and assumption verified prior to completing the final design.***

Comment 30: Page 21, line 10: Should be "developed" rather than "developing".

Response: ***Comment incorporated.***

Comment 31: Page 35, Table 2, Option 1: Relative cost should include potential natural resource damage estimate (will need to work with RFFO to do potential cost). Zero discharge will not minimize impact to wetlands. Some wetlands could dry up as a result of trying to detain all water on-site. A disadvantage would include water rights damages as a result of trying to detain all water on-site. An additional consideration would be that zero discharge is inconsistent with long-term stewardship strategies.

Response: ***Relative costs are not based on any specific items. Cost estimate details will be developed for the initial conceptual design. Revisions to the work plan are not required.***

"Minimize impacts to wetlands" has been deleted as an advantage for Option 1.

The first disadvantage listed under Option 1 has been revised to read, "Elimination of offsite water flow would restrict downstream water rights/uses and could require water augmentation to supplement losses."

The first disadvantage listed under Option 1 has been revised to read, "O&M, ~~and~~ inspections, and long-term stewardship for the dams/ponds would be required."

Comment 32: Page 35, Table 2, Option 3: An advantage would be that downstream water rights would not be restricted. Also, water depletion issues would also be minimized by removal of the ponds.

Response: ***Comment incorporated.***

Comment 33: Page A-4, #2, Site Structure, Infrastructure, and Facilities: List include landfills. Since new landfill is not part of the LCDB, may need to specify only considering the original landfill and the present landfill (formerly OU-7).

Response: ***This comment will be incorporated when the Appendix A is revised in accordance with the DQO process established for the LCDB Project.***

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Comment 34: Page A-5, #3, Standards, Clean-up Levels & Action Levels, line 1: Interior should be deleted – should only say Surface Water Standard (at points of compliance). There are current legal issues regarding the application of rad standards in water above the points of compliance.

Response: ***This comment will be incorporated when the Appendix A is revised in accordance with the DQO process established for the LCDB Project.***

Comment 35: Page A-7, #5 Specific Evaluation Criteria for Conceptual Design Scenario: See Comment 8 above. [Renumbered as Comment 26.] Do not know why implications for off-site water management operations would be included. Since the local communities have not been telling the Site what their long-term plans for water management are, the Site cannot be responsible for changes the local communities may make in surface water management between now and Site closure.

Response: ***See response to Comment 26.***

Comment 36: Page A-7, #6, Final Design Basis: Since construction of any new dams on Site would result in extensive natural resource damages, the inclusion of construction requirements for new dams should probably be removed. Natural resource damage mitigation should be included as an item.

Response: ***See response to Comment 24. Mitigation of natural resource damages is outside the scope of the LCDB Project.***

Comment 37: Page A-8, #7 Conceptual Design: Under Environmental Performance Projections, include "Maximize mitigation of habitats".

Response: ***See response to Comment 24. Mitigation of habitats is outside the scope of the LCDB Project.***

Comment 38: Page B-4, Section 2.1.2 Anticipated Conditions and Physical Constraints, lines 15-21: The anticipated condition of the ponds at this time is that the dams will be breached, and pond bottoms converted to wetlands per the Long-Term Stewardship report for the Site. Also, see Comment 9. [Renumbered as Comment 27.] RFFO plans to keep the landfill pond and use it in their refuge management plans. This paragraph should be deleted.

Response: ***The work plan has been revised to indicate that the anticipated conditions for the existing ponds have not been determined. For developing the scope and cost estimate for the initial conceptual design, it is assumed that the ponds will remain in their current configuration except for the Present Landfill Pond, which will be eliminated (see response to Comment 27).***

Comment 39: Page B-14, line 4: The Woman Creek Reservoir is operated by the Woman Creek Reservoir Authority, not the City of Westminster.

Response: ***Comment incorporated.***

Comment 40: Page B-15, Section 2.3.6.3 South Interceptor Ditch, lines 15-16: It is NOT assumed that the SID and Pond C-2 will remain intact and unaltered. Delete this sentence.

Response: ***This sentence was deleted and replaced with the following.***

"The final configurations for the SID and Pond C-2 have not been determined. In order to develop and evaluate various scenarios and to bound the scope of the initial conceptual design, the anticipated conditions at the completion of active remediation will be based on retaining the SID, its associated check dams, and Pond C-2 in their current configuration."

Comment 41: Page B-15, Section 2.3.7 Ponds and Dams, lines 31-32: The Lindsay Ranch Pond and Ponds D-1 and D-2 are NOT actively managed as part of the Site's water management system. Please delete this sentence, or change accordingly.

Response: ***Comment incorporated.***

Comment 42: Page B-16, line 1: See Comment 9. [Renumbered as Comment 27.] RFFO plans to keep the landfill pond and use it in their refuge management plans. This sentence should be deleted.

Response: ***See response to Comment 27.***

Comment 43: Page B-16, Section 2.3.7.1 Pond and Dam Characteristics, lines 31-33: "Ponds A-1, A-2, B-1, and B-2 are maintained as off-channel, potential spill control ponds and may be discharged by pumping when necessary. Bypasses around these ponds have the capability to carry upstream waters around, or divert spills into them." The previous language conveys the impression that the ponds still are being used for spill control.

Response: ***Comment incorporated. Text has been revised as follows, "~~Ponds A-1, A-2, B-1, and B-2 are maintained as off-channel, spill control ponds and may be discharged by pumping when necessary. By passes around these ponds carry upstream waters around, or divert spills into them.~~ Bypasses are provided to divert run-off flow around Ponds A-1/A-2 and Ponds B-1/B-2. These by-passes have gate valves which can be positioned to direct any spills into these ponds if required."***

Comment 44: Page B-17, Section 2.3.7.2 Pond and Dam Operations, lines 32-33: The solar ponds were never used as part of the surface water management system. Delete this sentence!

Response: ***Comment incorporated.***

Comment 45: Page B-17, Section 2.3.7.2 Pond and Dam Operations, lines 35-41. See Comments 3 and 20. [Renumbered as Comments 21 and 38.] DOE does not anticipate that the ponds will remain as-is in their current configuration. (See long-term stewardship report). The anticipated condition for the existing ponds are that they will be flow-through ponds. Please change this statement to "For the purpose of the LCDB Project, it is assumed that the A-, B-, and C-Series ponds will be reconfigured to be flow-through ponds, with wetlands established in the bottoms for sediment control."

Response: ***See response to Comments 21, 27, and 38. Revisions to work plan are not required.***

Comment 46: Page B-18, Section 2.3.7.3 A-Series Ponds, line 8: See Comment 25. [Renumbered as Comment 43.] Change to: "Ponds A-1 and A-2 are reserved for possible spill containment."

Response: ***Comment incorporated. Text has been revised as follows, "Ponds A-1 and A-2 are ~~reserved for spill containment~~ currently off-channel and maintained to contain any spills that may occur."***

Comment 47: Page B-18, Section 2.3.7.3 A-Series Ponds, lines 26-28: Change to "When the analytical results confirm that the water quality meets or exceeds downstream water quality standards, the pond is discharged into North Walnut Creek. During discharge, the effluent is sampled by RFCA POC monitoring station GS11."

Response: ***Comment incorporated. Text has been revised as follows, "~~When the analytical results confirm that the water quality is compliant with downstream water quality standards, the pond~~ The accumulated water is batch-discharged into North Walnut Creek if the analytical results verify that the water is of acceptable quality. During ~~batch~~ discharge, ~~the discharge effluent is sampled by~~ samples are collected at RFCA POC monitoring station GS11."***

Comment 48: Page B-19, lines 1-4: See Comment 25. [Renumbered as Comment 43.] Change to: "Ponds B-1 and B-2 are reserved for possible spill containment. Ordinary runoff is diverted around them to Pond B-4 via a pipeline. Water also can be sluiced into the ponds from the pipeline to prevent ~~contaminated~~ sediments in the ponds from drying out and becoming windborne."

Response: ***Comment incorporated. Text has been revised as follows, "Ponds B-1 and B-2 are ~~used for spill containment~~ currently off-channel and maintained to contain any spills that may occur. Ordinary runoff is diverted around them to Pond B-4 via a pipeline. Characterization results indicate that a portion of Ponds B-1 and B-2 contain actinide-bearing sediments above Tier 1 action levels. Water also can be sluiced into the ponds from the pipeline to prevent ~~contaminated~~ the pond sediments ~~in the ponds~~ from drying out and becoming windborne."***

Comment 49: Page B-19, lines 12-18: Do we know for sure that we need to remove the sediments in these ponds? If the action levels change, this may not be a foregone conclusion.

Response: ***Per current RFCA requirements and ALFs, sediments from Ponds B-1, B-2, and B-3 are proposed to be removed. Also, see response to Comment 57.***

Comment 50: Page B-19, lines 30-35: See Comment 29. [Renumbered as Comment 47.] Change to: "When the analytical results confirm that the water quality meets or exceeds downstream water quality standards, the water is discharged into South Walnut Creek. During discharges, Pond B-5 effluent water is sampled by RFCA POC monitoring station GS08. A gate valve and standpipe were installed in Pond B-5 in 1996 to allow for direct ~~batch~~ releases."

Response: ***Comment incorporated. Text has been revised as follows, "~~When analytical results confirm that the water quality is compliant with downstream water quality standards, the water~~ The accumulated water is batch discharged into South Walnut Creek if the analytical results verify that the water is of acceptable quality. During ~~batch~~ discharges~~,~~ ~~Pond B-5 effluent water is sampled by~~ samples are collected at RFCA POC monitoring station GS08. A gate valve and standpipe were installed in Pond B-5 in 1996 to allow ~~for~~ direct discharge ~~batch releases~~."***

Comment 51: Page B-19, lines 37-38: Delete this sentence. The cost and effort in sampling and analysis is overshadowed by the expense of the water transfer itself, and this action would also greatly reduce the stormwater storage capability of Pond B-5.

Response: ***Comment incorporated.***

Comment 52: Page B-20, Section 2.3.8 Site Water usage and Treatment Plan Effluent, line 21. Change to: "...effluent ~~for~~ from the on-site wastewater treatment plant." Additionally, on page B-19, the term "sewage treatment plant" (line 12) is used. The terminology should be consistent: use wastewater treatment plant.

Response: ***Comment incorporated.***

Comment 53: Page B-21, Section 2.3.9 Water Rights, line 6: What about the Kinnear Ditch pipeline that DOE financed for the City of Westminster. Assume that is why Kinnear Ditch has not been used for several years.

Response: ***Comment incorporated. Text has been revised as follows, "Currently, ~~Last Chance Ditch is used to transfer~~ water rights associated with Kinnear Ditch are transferred directly to Standley Lake by other means (underground pipeline / Last Chance Ditch). As such, transfer of water through Kinnear Ditch has not occurred for the last several years.***

Comment 54: Page B-35, Section 2.5.1.1 Surface Water Use Classifications, lines 1-2: The Colorado Water Quality Control Commission does not determine the present and future beneficial uses of state waters per se. They set standards and classifications based on current uses. Per the state website: "The Colorado Water Quality Control Commission is the administrative agency responsible for developing specific state water quality policies, in a manner that implements the broader policies set forth by the Legislature in the Colorado Water Quality Control Act. The Commission adopts water quality classifications and standards for surface and ground waters of the state, as well as various regulations aimed at achieving compliance with those classifications and standards." Suggest using their own words for this statement.

Response: *Text has been revised as follows to match regulatory requirements specified in 5 CCR 1002-31.6. "The State of Colorado Water Quality Control Commission (WQCC) is responsible ~~to determine~~ for classifying the present and future beneficial use of State surface waters (see 5 CCR 1002-31.6)."*

Comment 55: Page B-37, Section 2.5.1.1.3 Walnut and Woman Creek Use Classifications, line 25-27: We should NOT assume that the standards will not be revised. The Site plans on using the latest EPA guidance to formulate a proposal to raise the Pu and Am surface water standards for the Site, and change the use classifications in the future consistent with downstream classifications. This statement should be revised to: "However, the Site may propose to the WQCC standards different from those currently in place, consistent with new guidance, and intends to pursue on-site stream classifications consistent with downstream use classifications at closure."

Response: *Comment incorporated. Text has been revised as follows, "~~As such, it is assumed (for the purpose of the LCDB Project) that~~ For the purpose of the LCDB Project, the current use classifications and associated standards for Walnut and Woman Creek (Segments 4a/4b and 5) ~~will not be revised.~~ specified in RFCA, Attachment 5 (21 March 2000) will be used to develop the initial conceptual design. However, the Site may submit a petition to the WQCC to revise the on-site use classifications and water quality standards to be consistent with downstream use classifications and the latest EPA guidance / technical data."*

Comment 56: Page B-38, lines 15-16: See Comment 36. [Renumbered as Comment 55.] The Site should not assume that the PPRGs for surface water will become enforceable standards.

Response: *Comment incorporated. Text has been revised as follows, "The decision to discontinue action levels or convert them to enforceable standards has not been made. For the purpose of the LCDB Project, ~~it is assumed that the PPRGs identified for surface water will become enforceable standards~~ PPRGs will be considered to develop the initial conceptual design."*

Comment 57: Page B-39, Section 2.5.1.3 Points of Compliance, lines 14-17: "Compliance at the POCs will be determined in accordance ~~will~~ with the monitoring methods...". Also, the Site is pursuing an annual moving average for the POCs at this time, so the last sentence (lines 16-17) should either be changed or removed.

Response: ***The term "will" has been changed to "with".***
In order to be consistent throughout the work plan, the LCDB initial conceptual design will be based on adoption of current requirements. It is recognized that DOE has undertaken several initiatives to revise these requirements, but have not received approval yet. Accordingly, these revisions cannot be adopted (at

this time) as the design basis for the LCDB Project. Furthermore, identifying items that could possibly change could lead to unnecessary confusion. As stated in the introduction to the work plan, the initial conceptual design would be appropriately modified to incorporate any changes to meet the closure requirements established for the Site identified in the CAD/ROD.

Comment 58: Page B-48, Section 2.5.5.4 Solar Ponds Plume Treatment System, line 25: Change to read: "The SEPs were used to store and evaporate process wastewater effluent from the IA."

Response: ***Comment incorporated.***

Comment 59: Page B-53, Section 2.6.3 Wetlands: The vision at this time is to create wetlands in the current ponds for natural filtering and sediment control. The SWWB will provide info regarding the amount of water that may be available to maintain wetlands in the ponds, but the concept should continue to be pursued.

Response: ***Comment noted.***

Comment 60: Page C-9, Table C-01 Data Gaps and Assumptions for the LCDB Project, ID GAP X057, Assumption of LCDB Project: Since it is indicated in many places in this document that the amount of water for wetlands maintenance may be limited, there would be little reason to keep the ponds in their current configuration. Therefore, wetlands in the ponds for natural filtration and sediment control appears to be more logical, and a better assumption for LCDB purposes.

Response: ***Comment noted. There is no assumed final configuration for the existing ponds. In order to bound the scope and cost estimate for the initial conceptual design, it is assumed that the ponds will remain in their current configuration at the completion of active remediation (not Site closure). The appropriate reconfiguration of the ponds will be addressed during development of the initial conceptual design.***

The availability of water is just one factor that will be used to determine the reconfiguration of the existing ponds. Flood control and settling of actinide bearing sediments are other factors that will be considered. If the water supply is inadequate to sustain wetlands, then converting the ponds to wetlands for natural filtration and sediment control would not be the logical choice.

Comment 61: Page C-12, Table C-01 Data Gaps and Assumptions for the LCDB Project, ID GAP X110, Assumption for LCDB Project: See Comment 41. [Renumbered as Comment 60.] Wetland acreage may not be reduced, but may be concentrated in the ponds for filtration and sediment control.

Response: ***Comment noted. This data gap has been combined with GAP-X108 and clarified to address the specific information required to assess potential wetland impacts under various configurations.***

Comment 62: Page D-3, Section 4.0 Conceptual Design, line 20: Change to: "Evaluate the adequacy of the current dams, or if converting dams to a flow-through configuration is the best scenario".

Response: ***This bullet has been revised as identified below. The best configuration for the existing ponds has not yet been determined.***

- ***"Determine a suitable reconfiguration for the existing ponds and evaluate the adequacy of the current dams,"***

Comment 63: Page D-3, Section 4.0 Conceptual Design, line 26: The purpose of the LCDB is NOT to assist in developing water management policy for the Site. The policy should be determined first (currently under development at RFFO), and the options that are selected from the LCDB should be consistent with that policy.

Response: ***In the absence of a final water management policy for the Site, the LCDB Project will proceed based on assumptions with the goal in mind to develop information that could be used to develop a water management policy for the Site if required.***

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Comments from John Stover

Comment 64: The document appears to be written by several different authors with minimal coordination.

Response: ***The document has been extensively coordinated between the authors through intra- and inter-discipline reviews. Re-review of its flow will occur prior to being finalized.***

Comment 65: I did not see evidence of high level of understanding of documented Endangered Species Act issues (South Platte depletions is missing) at the Site and present pond configuration and operations.

Response: ***A separate discussion of South Platte depletions has been added to Appendix B, Section 2.6. However, the intent of the work plan and associated design basis (Appendix B) was to provide accurate but summary level information and references for other documents that would be necessary to develop the initial conceptual design. Hence, current pond operations were not addressed in detail.***

Comment 66: Will the project look at stream stability (local or system instabilities or both)? Are we addressing local instabilities that will cause system problems?

Response: ***Appendix G, Section 5.0 has been clarified to indicate that the geomorphic evaluation will include consideration of the long-term evolution of the fluvial system at RFETS due to headward erosion, channel incision, and depositional processes.***

Comment 67: One of the pressing concerns within the Site and Big Dry Creek watershed is decreasing stream bank stability. In downstream agricultural areas, bank erosion is causing significant property loss and channel degradation. The variability of flow caused by increased impervious surface area upstream and fluctuating flows from wastewater treatment facilities contribute to this problem.

Response: ***Comment noted.***

Comment 68: Variable flows can cause increased bank erosion by not allowing the stream to settle to equilibrium (including sediment load equilibrium). At low flows, banks dry out and become less cohesive. As a higher flow comes down the channel, the previously dry bank is subjected to greater stream power and a flow that lacks sediment. Removing sediment from the banks allows the stream to reach a temporary high-flow equilibrium. Undercutting and sloughing also occurs. As the flow recedes, the banks dry again and the cycle repeats itself.

Response: ***Comment noted. However, the observations and conclusions presented above may not be dominant for conditions at RFETS.***

1H

Comment 69: The overall stability of the stream channels must be considered. If system-wide instabilities exist, they must be addressed before the design of local stabilization or habitat features can proceed. I saw only vague recognition of this fact in the document. One example is the discussion about problems with the Broomfield Diversion ditch capacity. Since the current configuration is so important and forms the basis for evaluation of different scenarios, the work plan should account/document the following existing conditions:

- Input from Solar Ponds Plume (approx. 3 to 4 million gallons/year)
- Make statements about the purpose of the ponds particularly A-1, A-2, B-1, & B-2; if they are to be kept after active remediation and they are still off-line.
- The Landfill Pond and its current operation of pumping water to the A-1 Bypass are not described.
- The document should the State Engineers Office (SEO) derived the drawdown rate.
- The work plan should note the current C-2 agreement with the SEO. (video taping outlet structure every 5 years, annual valve exercise)
- Current dam inspection agreement with FERC.
- Discuss outlet structures and dam safety problems (i.e. Rock/sand toe blankets, C-2 outlet structure,)

Response: Overall stability of the stream channels will be considered. The following responses are provided to each bullet.

- *When ITS water was pumped into the modular tanks for evaporation, the generation rate ranged from 1.9 to 4.7 MM gallons per year with an average of 3 MM gallons per year. However, the volume is predicted to be significantly less since some surface water sources contributing to the plume were eliminated during the Solar Pond Plume remedial action. Data to quantify the current plume contribution to North Walnut Creek is not available. This data is not required because the plume flow would be accounted for in discharge records for Pond A-4 and should not be treated differently than other seeps that contribute to flow in North Walnut Creek.*
- *The current purpose of each pond is provided in Appendix B, Section 2.3.7. Providing statements regarding the future use of the ponds after remediation in the work plan (without having performed the required evaluations, developed the initial conceptual design, or applied the Pond Configuration Strategy) is not appropriate.*
- *Additional information regarding the current operation of the Present Landfill Pond has been included in Appendix B, Section 2.3.7.*
- *Acknowledgement of draw down rate limitations has been added to Appendix B, Section 2.3.7.2.*

- ***Detailed discussion of SEO and FERC inspection requirements is not required for the work plan. These items would be addressed as part of the conceptual design when the reconfiguration requirements for the dam structures are developed.***
- ***The current configuration of the outlet structures and safety considerations are provided in Table B-06. Specific safety problems and actions required to modify the dam structures to meet reconfiguration requirements for the final land configuration will be addressed as part of the conceptual design through the application of the Pond Reconfiguration Strategy.***

Comment 70: How will they address the South Platte water depletion issue?

Response: The following steps will be taken to address South Platte water depletion.

- ***Discussion of South Platte water depletion requirements has been added to Appendix B, Section 2.6.***
- ***Potential impacts to downstream water uses (including South Platte water depletions) will be included in the evaluation of the bounding scenarios.***
- ***The South Platte water depletion associated with the initial conceptual design and mitigation recommendation will be included.***

Comment 71: There are differences in addressing hillslope versus stream channel processes. The work plan appears to focus on the channel processes.

Response: The work plan includes evaluation of both hillslope and channel processes. For the erosional transport of actinide bearing soils (see Appendix F), the WEPP computer code will be used to address hillslope erosion and the HEC-6T computer code will be used to address channel erosion. The long-term geomorphic evaluation (see Appendix G) will address landscape changes due to hillslope (including mass wasting, slumping, and landslides) and stream channel (including channel advancement, down cutting, and incision) processes.

Comment 72: The document is written as an Environmental Restoration document and does not fully consider long-term stewardship and Natural Resource Trustee concerns. My view is that this document is written to guide ER actions to get through active remediation, not a final pond configuration plan for DOE. DOE has long-term liabilities that are not addressed which could be significantly impacted the results of this work plan.

Response: Long-term stewardship will be discussed and the pond reconfiguration for the initial conceptual design will be presented in the CDR. Additional information regarding long-term stewardship considerations and application of the Pond Reconfiguration Strategy is provided in Tab 3, Attachments A and D.

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Comment 73: Please define who the regulators are. It appears that the Work Plan only considers the RFCA Parties (USEPA and CDPHE) as regulators. The final pond configuration does require review and concurrence beyond EPA and CDPHE. The U.S. Fish and Wildlife Service also should be recognized as a regulatory agency as well as the State of Colorado's Department of Natural Resources and the State Engineer's Office. Their involvement under the ESA with the Industrial Area remediation is reduced but they are heavily involved with the Natural Resource Trustees and dam safety.

Response: ***The planned distribution for the CDR has been further clarified in the work plan introduction (see Section 1.0). The actual distribution of the CDR to individual regulators, stakeholders, and local community members will be as directed by DOE.***

Comment 74: The document should look at the Use Classifications at Big Dry Creek Segment 1, which begins below Great Western Reservoir. An attempt should be made to integrate the Site into the rest of the watershed (Regional Setting) with the understanding of what contributions the Site makes to the watershed. A regional setting was provided for ground water but not surface water.

Response: ***Use classification for Big Dry Creek (Segment 1) has been added to Section 2.5.1.1. Regional hydrology information to address Big Dry Creek and South Platte River has been added to Appendix B, Section 2.3.***

Comment 75: The Table 2 Summary of Potential Land Configuration Options should be improved.

- I have concerns that viable options will not be given a critical assessment. The Work Plan appears to be written to justify the current conditions without a full evaluation of the different options/alternatives. There are additional alternatives that should be considered like low-head dams with meanders that could retain some water and create wetlands. The Actinide Migration Evaluation group is examining bacterial processes in wetlands as a mechanism to enhance sediment reduction. Low-head dams and wetlands would reduce water velocities. There could be a mixture of removing some ponds and retaining others. Several of the ponds (A1, A2, B1, & B2) are already offline because of the A1 and B1 bypasses and do not routinely contribute to contaminant control. They are used for emergency spill control. After active remediation is completed, does K-H expect to have spills that need emergency actions? There is only minimal recognition of ESA /natural resource impacts. This would create significant costs for DOE but are not listed in the Table.
- Table 2 under options 1 or 2A and 2C should note the need to upgrade existing dams for long-term operations.
- The options in Table 2 do not address if the upper ponds (A1, A2, B1, & B2) will be modified to have them function as part of the pond system under Options 1 or 2. Also what will happen to the bypasses.

Response: Table 2 is intended only to identify potential approaches for final land configuration. Various bounding scenarios will be developed based on these options and critically evaluated. The work plan is not intended to justify or support using the current conditions as the final land configuration without evaluation of the bounding scenarios. The work plan does utilize current conditions as the starting point to develop the scope and cost estimate for the initial conceptual design.

- *The use for low-head dams would be considered if wetlands are included as a component of the initial conceptual design.*
- *The reconfiguration of the existing ponds will be assessed during the initial conceptual design. Pond reconfiguration is not considered (by itself) a land configuration option, but could be a tool to implement the option.*
- *More detailed evaluation of ESA and natural resource impacts will be preformed as stated in Appendix E of the work plan during the evaluation of the bounding scenarios (see Tab 3, Attachment 3) and the initial conceptual design that will be presented in the CDR.*
- *The adequacy of the existing ponds and need to upgrade existing dams for long-term operations and the reconfiguration of the upper ponds and associated bypasses will be further assessed (regardless of the configuration option used) during development of the initial conceptual design through the application of the Pond Reconfiguration Strategy.*

Comment 76: Section 5.4 Scenario Evaluation that the scenarios will be screened for ecological preservation but does not look at utilizing options to enhance habitat for mitigation or offsets to reduce DOE's long term liabilities.

Response: The scenarios will be evaluated against ecological criteria to identify scenario components that achieve the best balance between maintaining compliance with surface water quality standards and minimizing disturbance to ecological resources. The CDR will contain information that will allow DOE to enter into consultations (including consideration of potential mitigation measures) with natural resource agencies to discuss the potential effects of the initial conceptual design and how to best manage any anticipated changes in ecological resources. See Appendix E for additional details.

Comment 77: Wetlands can take be many varieties - no net loss of function or value should be noted in Table B-17.

Response: No net loss of function or value of wetlands is not a restriction for the LCDB Project. If the initial conceptual design results in a net loss of wetland function or value, then the CDR will contain information that will allow DOE to enter into consultations (including consideration of potential mitigation measures). Revisions to work plan are not required.

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Comment 78: Section 1.1 Site Location and Background should include a description of where the Site sits in relation to the Big Dry Creek watershed and the South Platte basin.

Response: ***Additional regional information to address Big Dry Creek and South Platte River has been added to Appendix B, Section 2.3. Inclusion of this information in the introduction to the work plan would not be appropriate.***

Comment 79: Section 5.4 Scenario Evaluation – please better define what is meant by "Minimization of long-term stewardship provisions"

Response: ***A more complete definition of long-term stewardship has been added to the Introduction (Section 1.0) of the work plan. This bullet has been revised as identified below.***

- ***Minimization of long-term stewardship provisions for maintaining "post-cleanup" controls on residual hazards and safety concerns.***

Comment 80: Table 2 – States under Option 3, Disadvantages that there would be no contaminant reductions would be provided. It is my understanding that the Actinide Migration Evaluation group is looking at wetlands as.

Response: ***Option 3, Removal of Surface Water Controls, includes existing ponds and dams. Although some wetlands may survive, this option does not include any engineered long-term provisions to provide contaminant reduction. Other than existing conditions, AME has not evaluated the use of wetlands as a sediment capture and retention mechanism. AME has assessed the redox chemistry of the ponds and determined that Pu mobility does not increase.***

Comment 81: Letters were exchanged with SEO and FERC in April 1995 regarding dam toe rock/sand blankets for six dams (A1, A2, B2, B3, B4, and C1). Only the blankets for B2 and B4 have been completed. This is not recognized in the evaluations. How are existing dam maintenance problems factored into the scenario evaluations?

Response: ***Maintenance requirements will be factored into the evaluation of the bounding scenarios as a criterion under long-term stewardship. The specific activities that are required to upgrade the dams would be considered in the Pond Reconfiguration Strategy to support decisions to retain or breach the existing ponds.***

Comment 82: Water depletions are briefly noted Table B-17 but do not appear to be considered in the evaluations.

Response: ***The following bullet contained in Section 5.4 has been revised to include South Platte water depletions.***

- ***Ecological preservation (including consideration of wetlands, ~~and~~ habitats, and water depletions to the South Platte River).***

Comment 83: A better discussion about the A1 and B1 Bypasses is needed in Appendix B and the main body of the document to understand what role they play in pond operations. Memorandums (i.e. Hayes, 1994) do exist that identify problems with the A-1and B-1 Bypasses to accommodate high flow rates. The pipeline running from the Wastewater Treatment Plant (WWTP) to Pond B4 was not discussed. Central Avenue ditch extension not mentioned. The bypasses, Central Avenue ditch extension, and pipeline should be discussed under Section 2.2.3-Site Structures, Infrastructure, and Roads.

Response: ***Additional details for the A- and B-series bypasses and WWTP effluent pipeline to Pond B-3 have been added to Sections 2.3.7.1 and 2.3.7.2.***

Comment 84: Figures B-11 and B-12 cite different wetland acreages of 186 and 192.1 acres. There is a third different wetland acreage cited in the document. Which is the correct wetland acreage on Site? There is a reason why the acreage is different but it is not immediately clear to the reader. Please clarify for reader not familiar with the Site.

Response: ***The listing of acreages has been deleted from these figures. Also, see response to Comment 12.***

Comment 85: Section 2.3.6.3 South Interceptor Ditch, page B-15; add the length of the SID (approx. 5300 ft.) to the physical description of the SID.

Response: ***Comment incorporated. The measured length of the SID based on 1994 aerial topography GIS drawings is approximately 7,700 feet.***

Comment 86: Section 2.3.6.3 South Interceptor Ditch, page B-15, lines 15 and 16. Delete sentence that states, "It is assumed that the SID, and its associated check dams, and Pond C-2 will remain intact and unaltered."

Response: ***See response to Comment 40.***

Comment 87: Section 2.3.10, page B-22 and 23. The section is entitled Channel Hydraulics and Sediment Transport. It only presents the Manning's "n" values for various stream segments. The Manning's "n" provides an estimate of flow resistance. Were these values computed from field observations or estimated from table. Other parameters like the geometric properties (i.e. width, depth, slope) of the channel are missing. A more rigorous systems analysis must be performed. How will the work plan address the need for this analysis? Put some real information/approaches in section. There is no sediment transport information is contained in the section.

Response: ***Section 2.3.10 has been rewritten to describe the availability of hydraulic information for the channels. As such, the specific Manning's "n" values have been deleted.***

For reference, the Manning's "n" values were obtained from the <u>Report on Soil Erosion and Surface Water Sediment Transport Modeling for Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site</u>

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(August 2000). Other hydraulic information for the drainage channels (including channel cross-sections, channel slope) has been developed by the AME Project Team. This hydraulic information is based on a combination of field measurements / studies, values from published literature, analytical testing results, and GIS generated data from aerial topographic mapping of the Site. Sediment transport information (including particle size distribution, settling data) has also been compiled by the AME Project Team for use in the HEC-6T models developed for the Site. This information will be adopted for evaluation of the bounding scenarios and the initial conceptual design.

Comment 88: Pond C-2 cannot be a flow-through pond unless the dam's outlet works are upgraded.

Response: Comment noted. The need to upgrade the ponds will be considered during the initial conceptual design.

Comment 89: Page B-21. The Kinnear Ditch pipeline financed by DOE for the City of Westminster is not discussed. The pipeline is the principal reason why the Ditch has not been used in several years.

Response: See response to Comment 53.

Comment 90: Page B-35 Section 2.5.1.1, Surface Water Use Classifications, lines 1-2. Change to reflect wording in Gail Hill's comments.

Response: See response to Comment 54.

Comment 91: Page B-37, Section 2.5.1.1.3 Walnut and Woman Creek Use Classifications, line 25-27. The standard could be revised. The Site will use the latest EPA guidance to formulate a proposal to raise the Pu and Am standards for the Site, and change the use classifications with downstream classifications. The standards will probably be based on risk calculations.

Response: See response to Comment 55.

Comment 92: 10CFR 1022 – DOE Compliance with Floodplain/Wetlands Environmental Review Requirements should be acknowledged in Appendix B. 10 CFR 1022 establishes policy and procedures for discharging the Department of Energy's (DOE's) responsibilities with respect to compliance with E.O. 11988 and E.O. 11990.

- Executive Order (E.O.) 11988- Floodplain Management (May 24, 1977)
- Executive Order 11990 – Protection of wetlands (May 24, 1977)

Response: The following text has been added to Section 5.4 (Bounding Scenario Evaluation) of the work plan. "The DOE policy and procedure contained in 10 CFR 1022 for assessing actions to be taken that may impact floodplains or wetlands will also be considered during the evaluation process."

Comment 93: Page B-92, Table B-17 Functional Design Objectives for the Final Land Configuration: GEN-04 – has typo. "serve" should be "severe"

Response: ***Text has been corrected.***

Comment 94: Table C-01 Comments

- Under ID GAP-X065, X070, and X067: Why is the word "or" used instead of "and/or". The SW group are the SMEs for surface water.
- GAP-X066: Status of Kinnear Ditch – This should be discussed with City of Westminster but the document should recognize the existence the Kinnear pipeline and its role.
- Page C-8: The impacts of the gravel mining operations to the upper Walnut Creek reaches should be examined.
- GAP-X057: Assumptions of LCDB project. Since concerns about having sufficient water for wetland maintenance are mentioned several times in the document, why keep the ponds in their current configuration. There is no examination of water operations for the upper A-and B-series ponds where several viable wetlands exist.
- Page C-10: The potential impacts to downstream species in the middle South Platte through depletion losses due to Site activities should be examined.
- GAP-X108 and X110: The wetlands may not be reduced. The existing wetland functions should be examined to see if equivalent functions can be created in the ponds.

Response: ***The following responses are provided:***

- ***GAP-X065, X070, and X067: Based on review of available data, the proposed resolutions for these data gaps have been modified to indicate that assumptions consistent with the AME Project Team would be used.***
- ***GAP-X066: The phase "Kinnear pipeline" has been added to the assumption. Also, see response to Comment 53. Discussions with City of Westminster would occur prior to finalizing the design.***
- ***Gravel Mining: GAP-X078 has been expanded to include assessing impacts of potential gravel mining in upper Walnut Creek.***
- ***GAP-X057: See response to Comment 60. It is noted that the existing wetlands in the upper ponds (A1/A2 and B1/B2) are currently supported by manual transfers of water into the ponds from other sources (including WWTP effluent and transfers from the Present Landfill Pond). As such, the wetlands in these ponds may or may not be sustainable after Site closure.***
- ***South Platte Depletions: See responses to Comments 82 and 97.***
- ***GAP-X108 and X110: See response to Comment 61.***

Comment 95: Page D-3, Section 4.0 Conceptual Design, line 20: Change to "Evaluate the adequacy of the current dams/pond configuration or if converting dams/ponds to a flow-through system scenario is the best scenario"

Response: ***See response to Comment 62.***

Comment 96: Page D-3, Section 4.0 Conceptual Design, line 26: The purpose of the LCDB project is NOT to develop water management policy for the Site. The policy should be determined first.

Response: ***Agreed. See response to Comment 63.***

Comment 97: Appendix E, Ecological Evaluation for LCDB Project – The potential downstream impacts to the South Platte listed species and Ute Ladies Tress should be included in the evaluation. There was no discussion included in the Appendix.

Response: ***Appendix E, Section 5.0 has been expanded to address consultation requirements to mitigate potential water depletions to the Platte River basin that may result form the initial conceptual design.***

Comment 98: Appendix F, Erosion and Hydrologic Evaluation for LCDB: Page F-6, Section 4.2 Potential Scenarios for Final Land Configuration: The WEPP model can estimate the runoff, soil loss, and deposition for specified storm events. How will the LCDB translate this information to surface water quality standards. Potential risks can be assessed but how a direct relationship be established? The direct relationship is also implied in Section 4.6 Comparison of the Potential Scenarios.

Response: ***As indicated in Sections 4.4 and 4.5, the LCDB Project Team will be supported by and integrated with the AME Project Team. The WEPP results generated by the LCDB Project Team will be provided to the AME Project Team for further evaluation using HEC-6T, isoconcentration maps for predicted actinide concentrations, and actinide migration transformations to predict average actinide concentrations at various locations in the drainage channel for the modeled storm event (100-year, 6-hour). The predicted concentrations at the POC locations will be compared against the actinide standards listed in RFCA, Attachment 5. The approach identified in Appendix F is the same procedure that was previously used by the AME Project Team for the Erosion Study conducted for existing conditions.***

The commenter is correct that a direct comparison is not possible since the RFCA standards for actinides are based on a 30-day moving average and the modeled predictions would be for a single storm event. However, this information will be used to assess the performance of the bounding scenarios and the initial conceptual design in their expected availability to maintain compliance with the RFCA standards.

Comment 99: Appendix G, Geomorphic Evaluation: Page G-4, Section 6.0 Conceptual Design: What anthropogenic features (roads, dams, water conveyance structures, etc) will be in place when predicting the future landform conditions? Will there be alternative scenarios run or will only the current conditions be evaluated?

Response: ***Appendix G, Sections 3.0 and 5.0 have been clarified to indicate that anthropogenic influences (roads, dams, water conveyance structures, etc) associated with each bounding scenario will be considered to predict the scenario's ability to withstand long-term geomorphic changes relative to each other. The current geomorphic processes occurring at RFETS will form the basis for evaluating each bounding scenario.***

A more detailed evaluation of the initial conceptual design will be preformed as described in Appendix G, Section 6.0.

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Comments from Mark Sattelberg, U.S. Fish and Wildlife Service

Comment 100: Overall, the Draft Final Work Plan for Land Configuration Design Basis Project (LCDB) is clear and straightforward. A better description of what this document is trying to accomplish should be added at the beginning. It is a plan that should reduce time in determining the final land configuration, when all the data is available.

Response: ***Comment noted.***

Comment 101: There is a great amount of information that needs to be incorporated into the LCDB; most is listed in Appendix C. A tracking system should be instituted to make sure all of the information is included in the final document.

Response: ***Comment noted. The table and procedures described in Appendix C serve to track resolution of these data gaps.***

Comment 102: It is hard to plan for the final land configuration without knowing what the final site usage is going to be. If the final land usage is determined to be a National Wildlife Refuge, the Service's preferred final land configuration for the site would be restoration of the native topography, hydrology, and vegetation, to the maximum extent allowed by required remedial actions. This would include the removal of all man-made structures, landforms, "improvements", etc. and return to pre-industrial conditions that existed before the mid 19th century.

Response: ***In the absence of designating RFETS as a National Wildlife Refuge and to be consistent with the current goals and visions identified in RFCA, the LCDB Project is being developed consistent with a final land use of open space. If this changes, the design basis will be re-evaluated prior to developing the final design.***

The rationale for basing the LCDB Project on open space is further explained in the first paragraph of the Introduction and Appendix B, Section 2.8.

Comment 103: Page 1, line 13 – Another stated objective could be the possible reduction of long-term stewardship responsibilities for DOE.

Response: ***Minimizing long-term stewardship is a goal for the LCDB Project, is covered as an FDO (see Appendix B, Table B-17, FDO GEN-03), and included in the evaluation criteria (see Work Plan, Section 5.4). However, it is not considered a project objective.***

Comment 104: Page 2, line 8 – The completion date should be updated.

Response: ***Comment incorporated.***

Comment 105: Page 2, line 28 – "base*d*", use past tense.

Response: ***Comment incorporated.***

Comment 106:Page 2, line 32 – Is the statement true - that the interim cleanup levels are equal to the Tier I action levels? RSAL Tier I levels are being recalculated, how will this change the cleanup levels? How is ALARA being accounted for?

Response: ***The statement is correct. Should the interim action levels be changed, remedial action decisions will be appropriately modified. The appropriateness of all interim remedial actions will be addressed during the final CAD/ROD for the Site. Also, see response to Comment 57.***

ALARA is addressed during the development of individual interim remedial action decisions.

Comment 107:Page 3, line 25 – Is the purpose of this work plan to "develop" the information or to "gather" the information

Response: ***The objective is correct as stated.***

Comment 108:Page 4, line 37 – After "monocultures"... add, "unless preferred to minimize wildlife usage."

Response: ***The goal of LCDB Project is to ensure the long-term survival of vegetation that is established to stabilize the Site and to preclude erosion of actinide bearing soils that could cause exceedence of surface water quality standards. Revisions to work plan are not required.***

Comment 109:Page 4, line 38 – Change to "open space/wildlife refuge designations".

Response: ***See response to Comment 102.***

Comment 110:Page 5, line 18 – Does keeping the ponds in the current configuration take into account the removal of contaminated sediments? What about the bypass system that is currently in place?

Response: ***The decision process to keep or breach the existing ponds will be determined during the development of the initial conceptual design through the application of a Pond Configuration Strategy that will be prepared as part of the LCDB Project (see Section 6.1). Sediment management has been added to Section 6.1 as a consideration and will be incorporated into the Pond Reconfiguration Strategy. The reconfiguration of the bypasses will also be addressed during the initial conceptual design.***

Comment 111:Page 8, line 33 to 38 – Language should be added concerning the priority for resolution of the data gaps, as presented in Appendix C.

Response: ***The significance of each data gap is adequately covered in Appendix C.***

Comment 112: Page 10, line 3 to 5 – Although zero discharge provides a high degree of confidence in achieving surface water quality standards at point of compliance, the accumulation of mineral salts, metals, and radionuclides may cause the evaporation ponds to become an attractive nuisance for wildlife. Sediment and groundwater contamination may also become a long-term management issue.

Response: ***Comment incorporated. The following sentence has been added, "The need for long-term sediment management and the potential accumulation of salts within the retention basis due the evaporation process would need to be considered."***

Comment 113: Page 10, line 26 to 32 – If surface water quality standards can be met without any treatment or retention, the removal of existing ponds and controls with eventual return to natural, pre-RFETS conditions would be the choice of the U.S. Fish and Wildlife Service (Service). Issues dealing with Preble's Meadow Jumping Mouse (PMJM) habitat would have to be discussed between the Service and Department of Energy (DOE).

Response: ***Comment noted.***

Comment 114: Page 11, line 1 to 13 – Management of sediment needs to be taken into account, eventually the sediments would have to be removed and disposed, as they build up in the treatment wetlands.

Response: ***Comment incorporated. The following sentence has been added, "Long-term sediment management would need to be considered."***

Comment 115: Page 15, line 16 – Compliance with RFCA closure and post-closure should also include the ARARs.

Response: ***The appropriate RFCA requirements are listed as FDOs for the LCDB Project (see Appendix B, Table B-17). A list of ARARs is not being developed at this time.***

Comment 116: Page 17, line 15 to 22 – Pond reconfiguration strategy should also include routine removal of accumulated, "contaminated" sediments.

Response: ***Comment incorporated. The following sentence has been added, "The management of sediments from ponds that are proposed to be breached will be considered in the decision making process." The contaminant concentrations (if any) in the sediment will be considered.***

Comment 117: Page B-7, line 1 – Roads on the routes for wildlife surveys should remain.

Response: ***Although maintaining roads for wildlife surveys is not a primary goal of the LCDB Project, this need would be considered as an "other legitimate purpose" as currently defined in this section. Please identify access requirements for wildlife surveys.***

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Comment 118:Page B-7, line 9 – A discussion of possibilities should be added for the buildings, slabs, tunnels, other structures and associated soils when the concentrations are < Tier I but > Tier II. A statement that the RSALs, therefore the tiered system, may change is also needed.

Response: ***The decisions regarding the disposition of buildings, slabs, tunnels, other structures, and associated soils is outside the scope of the LCDB Project. However, options to protect surface water based on anticipated closure conditions will be addressed under the LCDB Project. Also, see response to Comment 57.***

Comment 119:Page B-7, line 19 to 25 – Does DOE see a need to retain some buildings for support of long-term stewardship responsibilities or at the request of the future land managers?

Response: ***Comment incorporated. The following sentences have been added:***

"However, it is recognized that some building and structures may be required for long-term stewardship activities (including facilities for Site management, maintenance, and monitoring) and to facilitate future land usage. During the course of Site closure, utilizing existing buildings and structures will be considered when these long-term requirements are more clearly identified."

Comment 120:Page B-7, line 30 to 35 – Will holes be punched through the walls and floors of foundations to return the groundwater flow to a more "natural" state?

Response: ***Text has been clarified to indicate that reconfiguration of subsurface structures to facilitate groundwater flow is outside the scope of the LCDB Project. These items are being assessed under the SWWB Project. However, returning the Site to natural groundwater flow conditions is not a RFCA closure requirement.***

Comment 121:Page B-8, line 3 – "wasted" should be "wastes".

Response: ***Comment incorporated.***

Comment 122:Page B-8, line 17 – See comment 2 for Appendix B. [Renumbered as Comment 118.]

Response: ***See response to Comment 118.***

Comment 123:Page B-19, line 5 - See comment 2 for Appendix B. [Renumbered as Comment 118.]

Response: ***See response to Comment 118.***

Comment 124:Page B-19, line 17 – "Also" should be lower case.

Response: ***Comment incorporated.***

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Comment 125: Page B-22, line 39-41 – Describe what a Manning's "n" value of ..., really means.

Response: ***Discussion of Manning's "n" values has been deleted from Section 2.3.10 (See response to Comment 87).***

For reference, Manning's "n" is an empirical value to account for resistance to fluid flow including physical roughness of the drainage channel, irregularity of the channel cross-section, channel alignment and bends, vegetation, silting and scouring, and other obstructions within the channel. Higher values indicate an increased resistance to flow.

Comment 126: Page B-38, line 21 – The Comprehensive Risk Analysis should be looked at for screening purposes once the RSAL Working Group completes setting the new levels. This should ensure that the levels are protective of human health and the environment.

Response: ***Comment noted. The text has been modified to indicate that this activity is outside the scope of the LCDB Project.***

Comment 127: Page B-39, line 11 to 17 – If flow-through, low-head wetlands are installed [land configuration option 4 (Table 2 of the Work Plan)], the point of compliance will need to be modified. This will be unknown until the final decision is made.

Response: ***Comment noted. However, the POCs may not need to be modified for this option.***

Comment 128: Page B-40, line 31 to 33 – If soils with levels between Tier I and Tier II remain in place, will there be any management or institutional/engineering controls for those areas?

Response: ***Institutional controls will be further evaluated prior to closure. The LCDB Project scope currently includes only those controls to maintain compliance with surface water quality standards.***

Comment 129: Page B-43, line 22 to 28 – EPA/CDPHE at the Rocky Mountain Arsenal required the concrete for the biota barrier meet pressure and degradation criteria. Those criteria may need to be met on Rocky Flats.

Response: ***Comment noted.***

Comment 130: Page B-44, line 1 – Is RFETS alluvium considered topsoil quality? The soil must meet specifications to support the vegetative cover.

Response: ***Based on current information, the RFETS alluvium should be suitable to support vegetative growth and the proposed plant communities to be used for the vegetative cover already grow in this material.***

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Comment 131: Page B-56, line 16 to 22 – Topography, specifically slope, may have a large effect on the type of vegetative composition that may be used and whether it will survive.

Response: ***Comment incorporated. Topography has been added to the list.***

Comment 132: Page B-57, line 31 – Black-tailed prairie dogs are considered warranted but precluded by the Service for the Endangered Species Act, meaning they should be treated as listed by Federal Agencies. If BTPD reestablish themselves on RFETS, vegetation development may require additional management controls on the BTPD.

Response: ***Text has been added to Section 2.7.3 to indicate that a vegetation management plan may be developed to identify the inspection, maintenance, and control activities that are required after Site closure for those areas where vegetation cover is a critical component to maintain compliance with surface water quality standards or the effectiveness of other remediation systems.***

Comment 133: Page B-59, line 31 to 33 – If soil is disturbed or removed, it would increase the odds of vegetative success if soil amendments were added to the soils, to increase the fertility of the soils.

Response: ***The revegetation specification that will be prepared for the CDR will include consideration of soil fertility and address the need to add soil amendments. This can be accomplished by requiring testing of soil materials prior to planting to determine fertility characteristics. Soil amendments would be added to the soil based on the fertility test results.***

Comment 134: Page B-60, line 6 – Elk could become a constraint to maintaining a protective ground cover, if the Flats becomes open space/wildlife refuge, with limited human visitors, and a herd of elk moved into the LCDB area. The expected impact would be a fraction of cattle grazing, but there may be some limited disturbance to the vegetative cover.

Response: ***Elk or mule deer grazing is not expected to constrain vegetation development at RFETS for the following reasons:***

- ***Conditions that cause vegetation problems associated with elk grazing include 1) herd confinement, 2) availability of nutritious forage due to regular watering and fertilization, or 3) large elk population that is concentrated in a limited area for a sustainable period of time. These conditions are not expected at RFETS.***
- ***Areas where vegetation cover is a critical component to maintain compliance with surface water quality standards and other remediation systems would be inspected. Management actions would be taken to correct any identified problems associated with elk grazing before it becomes a widespread problem. See response to Comment 132.***

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- ***Elk herds under non-confined conditions typically move away from grazed areas before the ground cover becomes permanently damaged or impaired.***

Comment 135:Page B-64, line 1-16 – Determination of land manager for the open space scenario has not been determined. Was Industrial/Commercial development was also part of the open space scenario?

Response: ***Industrial/commercial development was not considered.***

Comment 136:Page B-64, line 33 – Mechanisms for determining what, if any, lands at Rocky Flats may eventually be transferred to the Department of the Interior for inclusion in the National Wildlife Refuge System have not been finally determined. Regardless of the final land ownership configuration, DOE and DOI ownerships could be managed in a compatible and complimentary fashion.

Response: ***Comment incorporated. This bullet has been revised to:***

- ***"Land ownership for all or certain portions of RFETS would be transferred from the Department of Energy to the Department of Interior."***

Comment 137:Page B-65, line 11-13 – The refuge worker scenario is being added to the ALF calculations.

Response: ***See response to Comment 57.***

Comment 138:Page B-65, line 18 – The "refuge master management plan" is call the Comprehensive Conservation Plan (CCP). Service Policy requires that CCPs are prepared with an extensive public involvement process, in compliance with NEPA and in consultation with states, neighboring landowners, and local jurisdictions. The provisions for public participation in the proposed legislation is unnecessary, since the Service CCP Policy insures that all interested parties will be fully involved in the planning process. The Service does not wish to have a different planning process for Rocky Flats, but much prefer to manage and plan a RF NWR in accordance with the National Wildlife Refuge Improvement Act of 1997, as part of the refuge system.

Response: ***Comment incorporated. This bullet has been revised to:***

- ***"The refuge fish and wildlife resources would be managed in a manner consistent with the goals and objectives to be established in a Comprehensive Conservation Plan. Input received from consultation with State and local agencies and public participation is typically considered in developing these plans. ~~by a refuge master management plan. Such plans are typically developed in conjunction with the state wildlife resource management agency (Colorado Division of Wildlife (CDOW), local governments adjacent the refuge, and interested public parties.~~"***

Comment 139: Page B-65, line 22 to 35 – Management goals and objectives for the proposed RF NWR would be determined through the CCP planning process, and are undetermined at this time. The Service would manage the refuge to achieve the mission of the Refuge System, as established in statute, in accordance with the National Wildlife Refuge System Administration Act (as amended), for the purposes set forth in legislation establishing the refuge. The purposes of the refuge, as proposed in the current legislation, are A) restoring and preserving native ecosystems. B) providing habitat for and population management of native plants and migratory and resident wildlife. C) conserving threatened and endangered species. D) providing opportunities for compatible, wildlife dependant environmental scientific research. E) providing public with opportunities for compatible outdoor recreational and educational activities.

Response: Comment incorporated. This bullet has been deleted and replaced with:

"The FWS would manage the refuge to achieve the mission set forth in legislation establishing the refuge in accordance with the National Wildlife Refuge System Administration Act. The purposes of the RFETS refuge, as listed in the proposed legislation, are: (1) restoring and preserving native ecosystems, (2) providing habitat for and population management of native plants and migratory and resident wildlife, (3) conserving threatened and endangered species, (4) providing opportunities for compatible, wildlife dependant environmental scientific research, and (5) providing public with opportunities for compatible outdoor recreational and educational activities."

Comment 140: Page B-66, line 21 – The Service would prefer the wells be removed or partially removed (>3 feet below soil surface) and closed to the state engineer's specifications.

Response: Comment noted.

Comment 141: Page B-66, line 27 – Some ATVs do serious damage to vegetative areas. Preference is for multi-axle ATVs with low-pressure tires (e.g. Gator or Argos).

Response: Sentence has been revised as follows, "It is assumed that lightweight all-terrain vehicles designed for minimal ecological impact will be used to access monitoring locations to minimize disturbance on vegetated areas." Specification of the type of vehicle should be included in the Long-Term Stewardship Plan or the Integrate Monitoring Plan, which is outside the scope of the LCDB Project.

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Comments from Laura Brooks

Comment 142: Consider adding "Conceptual Design" to title of document since it does include both steps and an outcome of the project is a "Conceptual Design Report."

Response: ***Comment noted.***

Comment 143: Page 2 last sentence above Section 1.1 states that the expected completion date for the design basis and CDR is March 2001.

Response: ***Comment incorporated.***

Comment 144: Page 2 Section 1.1, 2d paragraph: Technically, OUs 1,3, 7 and portions of 5 and 6 exist. (See RFCA Attachment 1.)

Response: ***Comment incorporated. Sentence has been change as follows, "The Site is primarily divided into …"***

Comment 145: Page 2 3d paragraph: More correct to state that "The Site is currently undergoing cleanup with a goal for completing physical completion by 2006." Rather than stating "Site Closure" by 2006. After physical completion, there will still be much regulatory work to complete before the site is "closed."

Response: ***Comment incorporated.***

Comment 146: Page 5 1st bullet: Check with Susan Serreze RE: cleanup of subsurface soil contamination. This statement may not be consistent with the RIDD or the ER RSOP…. *Per Susan, delete "all"*

Response: ***Text was reviewed with Susan Serreze and appropriately revised.***

Comment 147: Page 13, Section 4.11. I thought the purpose of the NA Alternative was to evaluate whether any of the engineering options are even necessary.

Response: ***Section 4.11 describes a no action option that would be applied to a specific sector or drainage. The "No Action" alternative would need to be considered as part of a decision document such as the CAD/ROD.***

Comment 148: Page 24, Section 11.0: This document will need to be submitted to the AR; all references that are not legal, textbooks, etc., need to be in the AR file for the project or cross-referenced to the this projects AR file.

Response: ***Since this is not a RFCA required document, neither this document nor the associated references will be submitted to the Administrative Record.***

Comment 149: Page B-1, Section 2.0, 2d paragraph, 2d sentence: delete "is operated by" and replace with "the integrating management contractor is the Kaiser-Hill Company, LLC."

Response: ***Comment incorporated.***

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Comment 150: Page B-3, 1st bullet: Check with Susan Serreze: consistent with the ER RSOP? Also, see Section 1.3, page 5. *Per Susan, "this is an incorrect statement and is undecided"*

Response: ***Text was reviewed with Susan Serreze and appropriately revised.***

Comment 151: Page B-3, 2d bullet: Check with Susan Serreze: consistent with ER RSOP? *Per Susan, OPWL will not be flushed: Pipes left in place will be grouted. NPWL will be removed or flushed re: RCRA Sanitary Sewers/Storm Drains, this statement is covered.*

Response: ***Text was reviewed with Susan Serreze and appropriately revised.***

Comment 152: Page B-7, Section 2.2.3.2, 1st paragraph, 2d sentence: Check with Susan Serreze: consistent with ER RSOP? *Per Susan, delete, "regardless of depth"*

Response: ***Text was reviewed with Susan Serreze and appropriately revised.***

Comment 153: Page B-8, Section 2.2.3.3, 3d and 4th paragraphs: Check with Susan Serreze: consistent with ER RSOP?

Response: ***Text was reviewed with Susan Serreze and appropriately revised.***

Comment 154: Page B-35-B-38, Section 2.5.1.1: I still think this is superfluous information for the purpose of this document.

Response: ***Comment noted.***

Comment 155: Page B-39, Section 2.5.1.3, last sentence: I thought this sentence was to be deleted. Value in keeping? The section should specify that the POCs are for surface water.

Response: ***The last sentence is required to identify the basis to demonstrate / verify that the initial conceptual design complies with the surface water quality standards at the POCs. This demonstration/verification is to be included in the CDR. The first sentence has been changed to "... the POCs for surface water will be ..."***

Comment 156: Page B-39, Section 2.5.1.4, 2d paragraph: Delete sentences 5 and 6. This document does not need to commit KH to these possibilities.

Response: ***Comment incorporated.***

Comments from Michael Coriden

While generally correct, the Study's description for all of these areas [water rights, mineral rights, and easement right holders] contain inaccuracies and poorly worded statements. Steve Schiesswohl will write a memorandum with his detailed comments on these problems.

Comment 157: Section 2.3.9 entitled "Water Rights" should actually be entitled "Water Conveyance Easements." The majority of the section describes the various water supply ditches in and near Rocky Flats. These are not "water rights", but rather easements to convey water from one location to another across the Rocky Flats property. Actually, since the purpose of this section appears to be the discussion of the impact of the water supply ditches upon the hydrology on and in the vicinity of Rocky Flats, the brief discussion of water rights ownership should probably have its own section.

Response: ***Comment incorporated.***

Comment 158: The last paragraph of Section 2.3.9 that actually mentions water rights is poorly worded. A simple statement could be made that the DOE does not have any water rights for use at Rocky Flats. All water used by the Department of Energy at Rocky Flats is purchased from the Denver Water Board. This paragraph also refers to "onsite water rights". There is no such thing as an "onsite" water right versus an "offsite" water right. The water rights owners have the right to take their water from the various streams that flow across Rocky Flats, but can take and use that water at any point along the stream either on or off the Rocky Flats site.

Response: ***Comment incorporated.***

Comment 159: The Study does not contain a detailed list of legal water rights on and around Rocky Flats. Within RFFO's own files, sufficient information exists to determine the status of water rights of the Rocky Flats property. However, Kaiser-Hill or its subcontractor can easily obtain an updated list of legal water rights and their owners from the State Engineer's Office for inclusion as a Table in Appendix B.

Response: ***A listing of water rights is not required for the work plan.***

Comment 160: While the discussion of mineral rights is substantially correct, it is poorly worded and confusing. Steve and I confirmed that Table B-14 "List of Mineral Rights Holders" is correct, but not as detailed in its description of the Owners as is possible.

Response: ***The list of Mineral Rights Holders (Table B-14) was deleted.***

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Comment 161:The last sentence of Section 2.8.2.3 states, "It is assumed that mineral rights within the LCDB Project will not be exercised or rescinded by the State." This sentence is a misstatement. The State of Colorado does not have any mineral rights within the LCDB Project area. I think that the author is referring to permits issued by the State for mining and reclamation activities. If so, this sentence should be changed.

Response: ***Comment incorporated.***

Comment 162:I have not had the opportunity to discuss the Study's statements with Wood Rigsby in the context of the McKay OU-11 litigation. I will update this memorandum in the event that my discussion with Wood brings anything new to light.

Response: ***Comment noted. Since an updated memorandum has not been provided, it is assumed that the work plan statements do not need to be revised.***

Comment 163:Steve Schiesswohland I reviewed Table B-15, "List of Private Easement Holders" and concluded that the table does not list all of the easement holders. Attached to this memorandum is Steve's list of easement holders.

Response: ***Comment incorporated. List of Easement Holders has been updated.***

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Preface

The purpose of the LCDB Project is to develop the design basis for final land configuration at RFETS. This design basis would be utilized to guide, integrate, and develop individual remediation and closure projects to place RFETS in a final configuration that would maintain compliance with the RFCA surface water quality standards after Site closure.

The work plan for the LCDB Project dated July 2001 was issued to the regulatory agencies and other stakeholders for review and comment. Because of these comments, completion of the LCDB Project is being postponed until additional data are available. The work developed by the LCDB Project Team was compiled into this *Land Configuration Design Basis – Preliminary* for retention and later use. The *Revised Draft Work Plan* (see Tab 1) and its associated appendices (see Tab 2) incorporate most of the regulatory agency comments and contain updated information to reflect the current progress of the LCDB Project.

These revisions are not intended to resolve all issues raised by the regulatory agencies or to be final documents. Specifically, responses to or the incorporation of the proposed responses for Comments 5, 7, 20, 22, 23, 24, 27, 28, and 45 have been deferred and, therefore, have not been incorporated into the *Revised Draft Work Plan* contained in Tab 1 and/or its associated appendices provided in Tab 2.

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Comment 1: Section 1.0 - It seems implicit that this document serves to integrate various individual efforts that relate to elements of the design basis. If so, this should be explicitly stated.

Response: ***Section 1.0 was clarified to indicate that the LCDB Project Team will be coordinating with other closure project efforts throughout the execution of the LCDB Project to develop an integrated Design Basis and Initial Conceptual Design for the RFETS final land configuration that is effective and acceptable to the RFCA parties.***

Comment 2: Section 1.0, 2nd par: 1st Sentence - RFCA's intent is to achieve surface water quality standards everywhere on site. What mechanism(s) will replace RFCA after closure?

Response: ***It is agreed that the RFCA remedial actions are to be protective of surface water and that RFCA requires compliance with the surface water quality standards at the designated Points of Compliance (POCs). Revisions to the work plan are not required.***

Per Part 28 of RFCA, all Parties are required to commence negotiation of an appropriate modification within 60 days after the Federal Register notice that removes RFETS from the NPL.

Comment 3: Section 1.0, 4th par - It is unclear for the SWWB process that it will achieve all the expectations placed on it in this document. This comment applies throughout the document.

Response: ***The expectations are consistent with the SWWB Work Plan dated August 2000 and coordination meetings between the LCDB and SWWB Project Teams. Revisions to the work plan are not required.***

Comment 4: Section 1.1, Page 3, 4th par - The introductory sentence uses "insoluble" to modify a list of contaminants, some of which are soluble. The points is made later in the paragraph that it is plutonium and americium which are considered insoluble. The first use of "insoluble" is confusing and should be removed. The conclusion in the last sentence needs a reference. It is unclear that this statement is accurate.

Response: ***The word "insoluble" was deleted from the first sentence and the last sentence was deleted.***

Comment 5: Section 1.1, Page 4, 1st par - RFCA requires protection of surface water onsite, so if this assumption is accurate, water quality standards will already have been achieved before any land reconfiguration occurs.

Response: ***Agreed. The intent of the LCDB Project is not to be a separate remedial action or closure activity, but to be incorporated into on-going closure activities as a planning document. To be an effective planning document, the LCDB Project has adopted the scope of planned remedial and closure actions as the initial starting point (referred to as the "Anticipated Conditions at the Completion of Active Remediation") for evaluation purposes. Once the final***

land configuration has been identified, specific LCDB components will be incorporated into specific remedial and closure actions to provide an integrated approach to the final land configuration for the Site.

In addition, the LCDB Project documents would be appropriately modified to incorporate any changes to meet the closure requirements established for the Site identified in the CAD/ROD as stated in Section 1.0 of the Work Plan. Hence, the final land configuration will become part of the overall RFCA closure. As such, the Anticipated Conditions at the Completion of Active Remediation may or may not be representative of the efforts that will be included within RFCA decision documents or actually completed.

Comment 6: Section 1.2, Page 4, last par - What is the last sentence trying to say? What does this mean?

Response: ***The last sentence is referring to establishing risk-based (human health and ecological) remediation levels in the CAD/ROD derived from the Comprehensive Risk Assessment that are lower than the surface water quality standards that are specified in RFCA that would significantly alter the LCDB Project. The text of the Work Plan was revised as follows:***

"For the purpose of the LCDB Project, it is assumed that these surface water quality standards will be protective of the human health and ~~the environment~~ ecological risk-based remediation levels derived from the Comprehensive Risk Assessment and include in the CAD/ROD."

Comment 7: Section 1.3 - Project scope needs to be revised and cleaned up after the purpose of the document is defined.

Response: ***Response to this comment is deferred.***

Comment 8: Section 1.3 - The list of anticipated conditions does not mention the IA plume. Does this imply that no action is anticipated?

Response: ***For developing the LCDB Project, it is assumed that only the Mound, East Trenches, and Solar Pond Plume Systems will be present. However, this does not imply that no action will be taken for the IA VOC plume. Also, see response to Comment 5. Revisions to the work plan are not required.***

Comment 9: Section 1.4, Project Boundaries - This description seems inconsistent with Figure B-02, which excludes the west spray field and westernmost reaches of the Walnut Creek drainage.

Response: ***The LCDB Project boundary shown on Figure B-02 was corrected to be consistent with the description.***

Comment 10: Section 2.0 - This section describes in detail the site's failure to use the consultative process in scooping this project or in information gathering.

Response: ***This section does not present any information related to the Site's failure to use the consultative process in scooping this project or in information gathering. Furthermore, this document is not bound by the consultation provisions stipulated in RFCA. Revisions to the work plan are not required.***

Comment 11: Sections 4.0, 5.0 and 6.0 - Throughout these sections and elsewhere, the general comments above render the development of options and scenarios an unproductive exercise. Clean-up objectives are not achieved by most options, long-term management of plutonium-bearing wastes is considered lightly, and there is little identification of post-closure restrictions on land access or site uses.

Response: ***Clean-up objectives are already stipulated in RFCA and would be incorporated into individual decision documents. The options presented in the LCDB Project work plan are intended to supplement and integrate these individual remedial actions to develop the design basis for the final land configuration. The development of the options and scenarios are intended to allow meaningful discussions to plan for the eventual closure of the Site. Long-term management, long-term stewardship, and land use would be addressed during the evaluation process as identified in Section 5.4 of the work plan. Revisions to the work plan are not required.***

Comment 12: Section 4.0, Page 10-2nd Par - As it is necessary to achieve water quality standards everywhere on-site, any option using streams, ponds or wetlands – which are waters of the State, for the purposes of removing contaminants will be reviewed very carefully and may not be acceptable. It appears that several of the options that have been laid out in concept in following sections are likely to be in conflict with RFCA and State Water Quality Regulations.

- 4.1 Surface Water Retention (Zero Discharge)
- 4.2 Surface Water Detention
- 4.4 Wetland Filtering and Treatment

Response: ***See response to Comment 2. Revisions to the work plan are not required.***

Comment 13: Section 4.0 - What are the objectives that these options would satisfy? Would stream standards within the impoundments and wetlands – which would be/are waters of the State, be attained? With respect to water augmentation - where would water be put into the hydrologic system and where would it come from? What amount of water would need to be augmented?

Response: ***The FDOs for the final land configuration are presented in Appendix B, Section 3.0. Surface water quality standards would be met at the designated POCs. Since the need for water augmentation has not been***

established, specific details cannot be provided in the work plan. Identifying the source, amount, and point of entry would be developed during the design process. Revisions to the work plan are not required.

Comment 14: Section 4.0 - The proposed retention or detention options are likely to increase ground water levels in the stream alluvium and weathered bedrock. Ground water impacts for these options must be considered.

Response: ***Based on current surface monitoring results there is no reason to suspect that groundwater underlying the any proposed retention or detention ponds would be impacted. Although future impacts are unlikely, the following statement was added to the "Additional Considerations" column of Table 2 for each retention and detention option (Option 1, 2A, 2B, 2C, and 4) to consider the potential interaction between surface and groundwater during the design process.***

"Interaction between surface water and groundwater."

Comment 15: Section 4.10, Infiltration - Increase infiltration and flushing contaminants through a treatment system requires a fully functioning treatment system. In the case of the SPPTS, we would not want to see increases in water levels that were still insufficient to provide the head required to drive the system. Also, because uranium is adsorptive to soils the secondary source at the SPP should be well understood before using this option.

Response: ***Comment noted. The following statement was added to the "Additional Considerations" column of Table 2 for Option 10 – Infiltration.***

"Possible mobilization of subsurface soil and groundwater contaminants.

Ability and effectiveness of existing plume treatment systems to accommodate increased infiltration/contaminant flux."

Comment 16: Section 4.10, Infiltration - Any new seeps resulting from the promotion of infiltration would likely be NPDES point source discharge points.

Response: ***Any new seeps resulting from the promotion of infiltration would be managed in accordance with RFCA. Revisions to the work plan are not required.***

Comment 17: Section 6.1 - The need for pond reconfiguration is not clearly explained.

Response: ***The work plan does not indicate that the existing ponds need to be reconfigured, but addresses the development of a strategy that will be used to determine the final configuration for the existing ponds. Final configuration includes the option of leaving the existing ponds in their current configuration or to be reconfigured (including breaching of the pond). The Pond Reconfiguration Strategy will identify the factors, considerations, and information that will be used to make the final configuration determinations. The need to reconfigure individual ponds will be determined during the design***

process through the application of the Pond Reconfiguration Strategy. Section 6.1 was clarified to incorporate the above response.

Comment 18: Section 6.2, Page 19 – How and when will problem sectors be identified?

Response: Problem sectors would be identified throughout the closure of RFETS as additional characterization data and other information are obtained. The Sector Reconfiguration Strategy would be applied to these problem sectors to allow consistent identification of design solutions. Section 6.2 was clarified to incorporate the above response.

Comment 19: Section 8.0, Page 22 – The AME Project is also providing information on uranium geochemistry and transport.

Response: Section 8.0 was revised to acknowledge that AME is also performing uranium geochemistry and transport studies.

Comment 20: Section 9.0 - The failure to clearly identify the purpose of this document, to resolve controversial issues in advance and to utilize the consultative process renders this schedule completely unrealistic.

Response: Revision of the LCDB Project schedule is deferred.

Comment 21: Table 2, Page 36 - Previous comments apply to these tables and are not repeated here. More thorough comments will be offered after general comments are resolved. However, operational costs of options collecting plutonium-bearing sediments will be high rather than low. Some additional option-specific comments are:

- Options 1, 2, and 4: Infiltration is an additional consideration for all ponding options.
- Option 3: 2nd Advantage - Consideration needs to be demonstrated, rather than speculated.
- Option 4: Has the long-term effectiveness of this technology been shown?
- Option 7: Erosion controls are compatible with most open space land use.
- Option 8: Only the short-term effectiveness is impacted by prairie fires. Prairie fires are a normal mechanism to keep prairie vegetation healthy.
- Option 9: Include the disadvantages from Options 5, 6, 7 and 8. Should consider the need for a burrowing mammal barrier in the ET cover.
- Option 10: It is unclear how this is different from other options.

Response: Operational costs for wetlands was changed from "low' to "low to moderate". Because sediment removal for Options 1, 2, and 4 would occur infrequently, the identified relative cost for these options is appropriate. The following responses are provided to the option-specific comments:

- ***Infiltration was added as a consideration to Options 1, 2, and 4. See response to Comment 14.***

- *The second advantage listed for Option 3 was deleted.*
- *Wetlands have been used effectively for many years for stormwater management. Proper maintenance would extend the life and performance of the wetland indefinitely. Additional information for stormwater wetlands is available from EPA, USDA, and Center for Watershed Protection.*
- *"Compatible with open space land use" was added to the list of advantages for Option 7.*
- *The term "long-term" was deleted from the disadvantage listed for Option 8.*
- *ET provisions are not intended to be an ET cover. Under Option 9, specific sectors would be reseeded to alter the vegetation mix to increase the ET rate. This would be accomplished by reseeding specific sectors. Section 4.9 was revised to clarify the intent of ET provisions. The disadvantages listed in Options 5, 6, and 7, as well as, consideration of a burrowing mammal barrier are not applicable to Option 9. However, the disadvantage listed in Option 8 was added to Option 9.*
- *The infiltration option could be used to increase the amount of infiltration within specific sectors, thus reducing the amount of runoff and associated sediment load transported into surface water. Infiltration could also be used to flush subsurface and groundwater contaminants in conjunction with groundwater treatment systems. Section 4.10 was revised to clarify the intent of infiltration provisions.*

Comment 22: Appendix A - The general comments directly relate to this section. What is The Problem? The existing statement implies that the problem is that there is no LCDB.

Response: *Response to this comment is deferred.*

Comment 23: Appendix A, Page A-5 - Plans and assumptions regarding endstate should consider the impact to ground water flow of plugging foundation drains and subsurface impermeable "bathtubs" that receive recharge but inhibit lateral ground water flow. The bullets under "Standards, Clean-up Levels & Action Levels" in the Uncertainties and Constraints section list "Inferior Surface Water Standard". Does this imply Segment 5 or have some other meaning?

Response: *The following sub-bullet will be added under D&D End-States/Demolition Plans & Assumptions when the LCDB Project DQOs are formally revised.*

"- Groundwater flow impacts due to remaining subsurface features."

The text was revised as follows: "~~Inferior~~ Changes to Surface Water Standards".

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Comment 24: Appendix A, Page A-6, Item 4 - For modifications to groundwater, include subsurface piping and utility trenches.

Response: ***The following sub-bullet will be added when the LCDB Project DQOs are formally revised.***

"- Modification of subsurface piping and utility trenches."

Comment 25: Appendix A, Page A-7, Item 6 - What is DOE's Water Management Policy? Why would it apply after closure? Does the USF&W have a water management policy?

Response: ***DOE's Water Management Policy describes how water is managed onsite to comply with various requirements and agreements. The management policy is a living document and would be appropriate revised to reflect the final land configuration, requirements, and agreements that are applicable at the time of closure. It is not known if USF&W would have a water management policy. However, any specific water management requirements that are needed to maintain compliance with surface water quality standards after closure would need to be included. Revisions to the work plan are not required.***

Comment 26: Appendix A, Page A-8 - It is unclear why one option can be picked during this project. It is recommended that the top three (?) options be selected for conceptual design, and compared.

Response: ***The LCDB Project is chartered with developing one initial conceptual design to provide a reference point to facilitate discussions on the final land configuration. Additional alternatives may be developed at a later date for consideration or inclusion in a decision document. Revisions to the work plan are not required.***

Comment 27: Appendix A, Page A-9, Decision Rules - If it is determined that this document is an ER decision document, CERCLA Guidance on remedy selection will need to be included. To be complete, the first decision rule should end with, "otherwise the LCDB is incomplete and must be further optimized."

Response: ***Response to this comment is deferred.***

Response: ***The first decision rule will be revised when the LCDB Project DQOs are formally revised to add, "otherwise, the LCDB is incomplete and must be further optimized."***

Comment 28: Appendix A, Page A-10 Synergistic or antagonistic effects should be considered in the optimization of the design.

Response: ***The following item will be added when the LCDB Project DQOs are formally revised.***

"3. Consideration of synergistic and antagonistic effects."

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Comment 29: Appendix B, Section 2.1.1 - Previous comments on boundaries apply to this section. Bullet 2 is inconsistent with other discussions.

Response: ***See response to Comments 9. The second sentence was deleted from bullet 2.***

Comment 30: Appendix B, Section 2.1.2, Page B-7 - Second bullet – the site has not yet provided a plan to characterize the intact portions of the PWL.

Response: ***See response to Comment 5. Section 2.1.2 was revised to clarify that the LCDB Project documents would be appropriately modified to incorporate any configuration changes to the anticipated conditions resulting from implementation of on-going closure and remediation projects based on approval of RFCA decision documents.***

Comment 31: Appendix B, Section 2.1.2 - Bullet 3 should note that these will be removed to three feet below **anticipated final** grade.

Response: ***Bullets 3, 4, and 5 were revised to utilize the phase "anticipated final grade".***

Comment 32: Appendix B, Section 2.1.2, Page B-8, Bullet 1 and elsewhere - Capping of the original landfill will require significant buttressing and accommodation for the PMJM habitat at the toe of the landfill. Final configuration to accommodate this option may be significant and on a scale unrelated to the other cap projects.

Response: ***See response to Comment 30. The specific issues identified in this comment would be addressed in the decision document being developed for the original landfill. Interface with the ET Covers Project was added to Section 8.0 of the Work Plan.***

Comment 33: Appendix B, Section 2.1.2, Page B-8 - First and second bullets – Serious consideration should be given to remedies other than the ET covers for the Original Landfill and the SEP. The SEP plume collection system is likely to be adversely impacted by the ET cover.

Response: ***See response to Comment 30. The specific issues identified in this comment would be addressed in the decision documents being developed for the original landfill and SEPs. Revisions to the work plan are not required.***

Comment 34: Appendix B, Section 2.2.3.2, Page B-12 - Utility corridors should be broken up with backfilled plugs as well as the structures listed.

Response: ***See response to Comment 30. The specific issues identified in this comment would be addressed in the decision documents being developed for closure of the IA. Revisions to the work plan are not required.***

Comment 35: Appendix B, Section 2.2.3.3, Page B-13 – For process waste lines that are left in place, would there be any "long-term care" – e.g. through land use restrictions – so no-one ends up digging these up?

Response: ***See response to Comment 30. The specific issues identified in this comment would be addressed in the decision documents being developed for closure of the IA. Revisions to the work plan are not required.***

Comment 36: Appendix B, Section 2.2.3.3, Page B-13 – When and how will data to characterize the decision to leave PWL in place be collected?

Response: ***See response to Comment 30. The specific issues identified in this comment would be addressed in the decision documents being developed for closure of the IA. Revisions to the work plan are not required.***

Comment 37: Appendix B, Section 2.2.3.3 and elsewhere - Studies at the site have shown the likelihood of leakage from sewers to the groundwater where pipes are above groundwater and leakage of groundwater to the sewers where they are below groundwater. Therefore, it is likely that on the western end of the site, sewers leak to the groundwater, but on the eastern end, groundwater leaks to the sewers. All the statements referring to post-water shutoff effects on groundwater and seeps need to either allow for this or await the SWWB results on this analysis.

Response: ***Agreed. As stated in Sections 1.0 and 8.0 of the work plan, the SWWB results will be incorporated into the LCDB Project when available. Revisions to the work plan are not required.***

Comment 38: Appendix B, Sections 2.2.3.3 (3rd par) and 2.2.3.4 - Should mention the possibility of infiltration of contaminated groundwater into the systems.

Response: ***Comment incorporated.***

Comment 39: Appendix B, Section 2.3.8, 3rd par - See comment 2.2.3.3 and elsewhere. This statement does apply to the drainage receiving sewage treatment plant effluent.

Response: ***Agreed. Section 2.3.8 was revised to clarify.***

Comment 40: Appendix B, Section 2.3.9 - Please provide more information about on-site water rights owned by the Cities of Broomfield and Westminster – year, amount, and use type. Have these rights been exercised? When?

Response: ***References to on-site water rights were either deleted or appropriately revised.***

Comment 41: Appendix B, Section 2.3.10 - How were Manning's "n" values determined?

Response: ***Section 2.3.10 was rewritten to provide a more general description regarding the availability of hydraulic information for the drainage channels and the specific Manning's "n" values were deleted. For reference, the Manning's "n" values and other hydraulic information (including channel cross-sections, channel slope) were developed by the AME Project Team and is***

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presented in the Report on Soil Erosion and Surface Water Sediment Transport Modeling for Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site (August 2000). These values are based on a combination of field measurements / studies, published literature, analytical testing results, and GIS generated data from aerial topographic mapping of the Site.

Comment 42: Appendix B, Section 2.4.3.1, Page B-32 - The Arapahoe Sandstones have been characterized in the Site Geologic report as low sinuosity braided stream deposits, the terms point bar and floodplain deposit are not commonly associated with this stream morphology.

Response: The term "point bar" was changed to "bar". The remaining portions of the description are consistent with the Geologic Characterization Report (EG&G, 1995).

Comment 43: Appendix B, Section 2.4.3.1, Page B-33 - The discussion of fracturing from the Vertical Migration White paper is much better information than what is summarized here. Lack of lateral ground water transport of contaminants in fracture zones needs to be demonstrated in some areas of the site.

Response: Section 2.4.3.1 was revised to provide a reference to the Vertical Migration White Paper.

Comment 44: Appendix B, Section 2.5.5.5, Present Landfill Seep Collection System - The current surface water standard for benzene is 1.2 ug/l. The maximum results are 2 ug/l. Need to explain where the samples were collected from – the treatment pond, or waters of the State? We need to make sure that surface water standards are being met in waters of the State everywhere on Site.

Response: Section 2.5.5.5 was revised to clarify that the effluent samples are collected from the discharge area (SW00196) between the gravel bed and landfill pond. Current compliance with the surface water action levels is addressed in the Reports for the Groundwater Plume Treatment Systems. Maintaining compliance with the surface water quality standard after closure will be factored into the final land configuration taking into account planned actions for the Present Landfill.

Comment 45: Appendix B, Section 2.5.6.1, 881 Hillside French Drain - Even if concentrations of organic chemicals are below surface water standards, any discharge of groundwater to the SID with detectable organics will be considered to be a "point source discharge of pollutants". These drains and others developed for remediation need to be included in Figure B-04.

Response: Response to this comment is deferred.

Comment 46: Appendix B, Section 2.6.3, Page B-58 - The State would like to review these aerial photographs. Were they evaluated for seep related vegetation? What about the impact of grazing on the vegetation conditions at that time?

Response: *Only the aerial photographs form 1951 were used. These photographs are available for purchase from Colorado Aerial Photo Service. The specific photographs used are Frames DV34-18, DV34-19, DV34-20, DV34-31, DV34-32, and DV34-33.*

Section 2.6.3 was revised to clarify that the photo interpretation was restricted to stream wetlands, which would be minimally affected by grazing. Additional evaluation of the aerial photographs is planned to address riparian habitats and seep related vegetation. Additional details regarding the evaluation of the aerial photographs are provided in Appendix E of the Work Plan. The commenter is correct and as noted in Appendix E, this evaluation will be limited by the influence of grazing that occurred at the Site when the photographs were taken.

Comment 47: Appendix B, Section 2.7.2.3, Page B-62 - What about tree rooting depths?

Response: ***The majority of the Site consists of prairie grassland and was conservatively the only component used in the evaluation of the bounding scenarios. The onsite trees that typically found at RFETS are cottonwoods that are associated with riparian zones along the drainages. Rooting depths of mature cottonwood trees are similar to the upland shrub rooting depths; the majority of the root biomass typically occurs within the top 72 inches of the soil profile. As such, presenting data for tree-rooting depths is not warranted. Revisions to the work plan are not required.***

Comment 48: Appendix B, Section 2.7.4.4 - A major concern from a cost management standpoint is the need to balance cut and fill volumes to minimize the amount of imported fill. Where is this discussed?

Response: ***Agreed. Section 7.0 of the work plan was revised to indicated that cut and fill calculations would be developed as part of the initial conceptual design and included in the CDR. The conceptual grading plan for the IA will be the initial starting point to balance cut and fill volumes on a Site-wide basis (including consideration of the ET Covers Project and D&D) to minimize the amount of imported fill.***

Comment 49: Appendix B, Section 2.8.1 - The Jefferson Center has been withdrawn from planning considerations. The development on the Rocky Flats south boundary is called Vauxmont.

Response: ***Text was revised to incorporate this comment.***

Comment 50: Appendix B, Section 2.8.2.3, 2^{nd} par and elsewhere - Unclear what last sentence means.

Response: ***This sentence was revised to clarify.***

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Comment 51: Appendix B, Sections 2.8.3.1 and 2.8.3.2 - Merge sections to clarify.

Response: ***The first paragraph of Section 2.8.3.2 was revised to clarify the intent of the two sections. Although RFETS will likely become a National Wildlife Refuge, the work plan was not revised at this time to remove the assumption of open space until more definite plans are developed.***

Comment 52: Appendix B, Section 2.8.3.2, Page B-70, 5th bullet - Is the CCP developed by the USF&W? When?

Response: ***This bullet was revised to indicate that the CCP is prepared by the USF&W. The USF&W will determine when the CCP is prepared, but would likely occur after RFETS is transferred to the USF&W.***

Comment 53: Appendix B, Section 2.8.3.2, page B-70 - This sixth bullet in this list suggest that RFCA Attachment 5 may need to be modified to be based on a refuge worker scenario. A further implication of this modification is that more extensive remediation may be required.

Response: ***Speculation that additional remediation or any other action would be required is not appropriate until the scope and extent of any changes to the RFCA Attachment 5 action levels can be fully assessed and discussed between the RFCA Parties. Revisions to the work plan are not required.***

Comment 54: Appendix B, Section 2.8.3.2, Page B-70, 7th bullet: - RFCLOG has passed a resolution proposing a transportation corridor through the eastern edge of the refuge. The Colorado Department of Transportation Executive Director proposes to study several highway alignments through the refuge.

Response: ***This bullet was clarified to indicate that once designated as a National Wildlife Refuge, local governments are prohibited from annexation of the property. However, existing right-of-ways and easements may be maintained or new ones permitted at the discretion of the USF&W, if the right-of-way or easement serves greater interest of the community and is consistent with the purpose of the National Wildlife Refuge (see 50 CFR 29).***

Comment 55: Appendix E, Page E-4, Section 3.1.3 - It is doubtful that the SWWM model, as currently discretized, will be accurate to 18 inches, especially on the slopes containing wetlands.

Response: ***The SWWB is just one of the tools that would be used to predict long-term changes to wetlands. Appendix E, Section 3.1.3 was revised to indicate that the SWWB results would be assessed, in conjunction with the other evaluation tools, to determine the value and limitations of the results in supporting long-term predictions for the survival of wetlands.***

Comment 56: Appendix F, Page F-4, Section 2.2 - If the LCDB project team does not assess the quality of information obtained from other project teams then those other teams have a responsibility to provide uncertainty information related to their project both to the LCDB and to the regulators.

Response: ***As stated in Section 2.2, the LCDB Project Team has evaluated the reasonableness of the information obtained from other project teams (including AME) and has identified and resolved potential discrepancies in the information for use in the LCDB Project. The evaluation process and use of the erosion modeling information previously completed by the AME Project Team would be discussed in further detail in Appendix E (Erosion and Actinide Evaluation Report) of the CDR.***

The statement, "The LCDB Project Team will not will not validate, verify, or assess the quality of the information utilized and provided by the other RFETS Project Teams" was intended to only indicate that the LCDB Project Team would not peer review documents generated by other RFETS Project Teams since such peer reviews are being performed by others.

APPENDIX A
DATA QUALITY OBJECTIVES
FOR THE
LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This appendix has not been revised since its last issuance dated July 2001. To complete this appendix, responses to DOE/FWS Comments 33 and 34, and regulatory agency Comments 23, 24, 27, and 28 need to be incorporated (see Tab 1).

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LAND CONFIGURATION DESIGN BASIS PROJECT DATA QUALITY OBJECTIVES

INTRODUCTION

The DQO process (EPA/600/R-96/055, 9/94) is a series of planning steps designed to ensure that the type, quantity and quality of work performed for decision-making, including information acquisition, design development, and design evaluations, are appropriate for the intended purpose. EPA has issued guidelines to help decision makers develop site- and project-specific DQOs. The process is intended to:

- Clarify the project's objectives;
- Define the decision making inputs;
- Determine evaluation criteria; and
- Specify acceptable levels of decision error for data/information used to support the design.

The DQO process also specifies project decisions; the information required to support those decisions, and the quantity and quality of information needed. The DQO process consists of seven steps. Each step influences choices that will be made later in the process. These steps are as follows:

- Step 1: State the Problem;
- Step 2: Identify the Decision;
- Step 3: Identify the Inputs to the Decision;
- Step 4: Define the Study Boundaries;
- Step 5: Develop the Decision Rules;
- Step 6: Specify Tolerable Limits on Decision Errors; and
- Step 7: Optimize the Design

The following discussion presents the output from applying the DQO process to the LCDB project.

THE PROBLEM

A final land configuration design has not been developed that will ensure (with acceptable confidence) control of water runoff, erosion, & residual contaminant migration from the RFETS (via all possible pathways, e.g., water and air).

- The current configuration of RFETS has many features that compromise control of infiltration, runoff, erosion and sedimentation, such as the industrial infrastructure and topography. For example, features impact the quality as well as the quantity of water leaving the Site.

- The LCDB must be consistent with future land use scenarios and must protect human health and the environment after remediation has been completed and the Site has been closed. Human health must be protected from direct, on-site exposures as well as indirect, off-site exposures (via contaminant migration).

DECISIONS

The decisions that will be made are as follows:

- Are the collective inputs and outputs to the design within acceptable uncertainties to venture further decisions that depend on the LCDB (e.g., is the resulting risk to human health acceptable, and are resulting surface water concentrations below water quality standards)?
- Does the LCDB ensure, within acceptable confidence that any concentrations on and from the Site will be below applicable standards and action levels?
    - Human Health Risk Scenarios
    - Surface Water Quality Standards
    - Water Quantity
    - Ecological Risk Scenarios (Preble's Meadow Jumping Mouse, wetlands, tall grass prairie)

INPUTS TO THE DECISION

The information necessary to make the LCDB decisions specified above include the following:

1. **Functional Design Criteria** - The function design requirements are the functions (regulatory or performance) that must be performed or accomplished by the final land configuration design. Requirements and related information needs are listed.

    - Protection of Human Health & Environment
        - RFCA Surface Water Quality Standards at Closure
        - Other ARARs/TBCs (e.g., air quality standards during and after implementation
        - Human Health Risk Assumptions (10E-4 to 10E-6) -- during and after implementation
        - Pond Operation
        - Long Term Performance
        - Storm Event Scenario
        - Life Cycle Design Basis
        - Climatological Cycle
        - Seismic History and Related Performance Criteria
        - Prairie Fires (Impacts on Erosion and Contaminant Migration)
    - Post Closure Stewardship and Cost: minimize operation and maintenance
    - Reconfiguration to Pre-RFETS conditions is not a requirement

2. **Relevant Design Basis Factors** - The relevant design basis factors include information about the current site conditions that must be incorporated into the development of the final land configuration design. This information includes:

   - Physical Factors (intrinsic)
     - Physical Boundaries of the Project
     - Current Topography (Surface Elevation)
     - Current Surface Water Drainage System (Drainage Morphology)
     - Meteorological History
     - Geological/Geophysical (Seismic/Geomorphic, etc.)
   - Site Structures, Infrastructure and Facilities
     - Buildings
     - Parking Lots/Building Slabs
     - Roads
     - Infrastructure and Landfills
     - Storm Water Systems, Footing Drains, ditches
     - Drainage Control Dams
     - Waste Water Impoundments
     - Monitoring Wells
   - Biological Factors & Ecological Resources
     - Sensitive Species
     - Habitat, Wetlands, Riparian
     - Local Vegetation
   - Plans & Assumptions Regarding Endstate
     - Land Use Assumptions (Open Space, Wildlife Refuge, Residential, Industrial)
     - D&D End-States/Demolition Plans & Assumptions
     - Remediation Systems Plans & Assumptions
       - Soil remediation
       - Process Waste Lines
       - Buried Utilities
       - Landfills & Solar Pond Closures
     - Roadway Assumptions at Closure
     - Monitoring Well Abandonment Plans & Assumptions
   - Residual Contamination
     - Soil, near surface
     - Surface Water and Sediments
     - Vadose
     - Groundwater
   - Contaminant Mobility & Migration Modeling Results
     - Actinide Migration
     - Groundwater Contaminant Migration

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    - Vadose Zone Contaminant Migration
    - Air Transport & Dispersion
    - Soil Erosion Potentials

3. **Uncertainties & Constraints** - This information includes information that is currently unknown or decisions regarding the design that have not been finalized. It also includes constraints that have been placed on the final land configuration design.

    - RFETS Restoration Plan Assumptions
        - Assumptions regarding D&D
        - Final Design of Remediation Systems (e.g., ET Covers, Process Sewers)
    - Standards, Clean-up Levels & Action Levels
        - Interior Surface Water Standard (at points of compliance)
        - Final Clean-up Levels
        - Soil Action Levels
    - Extent & Movement of Contamination: Final Modeling Results
        - Actinide Migration
        - Groundwater Contaminant Migration
        - Vadose Zone Migration
        - Air Transport & Dispersion
    - Budgets
        - Project Budget
        - RFETS Closure Budget
    - Community/Regulatory Acceptance
        - Stakeholder Position
        - Natural Resource Damage Assessment
        - Regulatory Agency Position
    - Final Land Use
        - Open Space
        - USF&W, Wildlife Refuge
    - Water Flux at Closure
        - Site-Wide Water Balance
    - Erosional Models Accuracy & Results
    - Time Frame

4. **LCDB Reconfiguration Options** - These options are changes to the existing configuration, or site features, that may be considered for inclusion in the final design for land configuration.

    - Topographical modifications
        - Recontouring, including grade control
        - Road closures
    - Modifications to groundwater or surface water hydrology
        - Engineered drainages

  - Culvert removals
  - Cover soil material specifications and depth
  - Cover evapotranspiration characteristics
  - Infiltration provisions
  - Modifications to groundwater or surface water hydrology
  - Run-on and run-off controls
- Erosion resistance, erosion controls, erosion mitigation
  - Vegetation
  - Armoring
- Ponds reconfiguration
  - Pond conversion
  - Pond settling
  - Pond detention time

5. **Specific Evaluation Criteria for Conceptual Design Scenarios -** This information will be used to evaluate the relative acceptability or favorableness for each of the scenarios considered.

   - Wetlands Changes---Habitat Ledger
   - Surface Water Runoff
   - Durability
   - Effect on Remedial Systems
   - Implications for off-site water management operations
   - Implications for DOE Water Management Policy
   - Final Design Basis

6. **Final Design Basis** - The final design basis is the final set of guidance, information, assumptions and requirements upon which the final land configuration design will be developed.

   - Parameters for Risk, Geological, Geophysical, Actinide, Biological, Meteorological, Hydrological/Fate & Transport Models and Evaluations
   - Rationale and Logic for disposition or building of dams
   - Construction Requirements for any new dams
   - Required Type, Quality and Availability of Soil Import
   - Required Type & Distribution of Vegetative Cover
   - Remediation Requirements/End States (e.g. necessary to remove deep contamination)
   - No Change in DOE's Water Management Policy
   - No Change in Off-Site Water Management Operations
   - Sensitive Species & Habitat Trade-Off

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7. **Conceptual Design -** One of the potential scenarios will be developed further in order to generate preliminary information and estimates as to the attributes of a final land configuration, based on the information currently available.

    - Surface Configuration and Reconfiguration
        - Surface Configuration of the Industrial Area, Inner Buffer Zone
        - Configuration of the Walnut Creek & Woman Creek Drainages & Dams
        - Monitoring Well Access
        - Site Roads & Access
        - Material quantity estimates
    - Biological Balance
        - Preble's Meadow Jumping Mouse
        - Wetland Ledger
    - Environmental Performance Projections
        - Evapotranspiration -- maximize
        - Evaluations & Modeling (Computer/Numerical) Results
        - Erosional Modeling
    - Cost
        - Long-term post-closure stewardship costs
        - Initial annual operation & maintenance costs (associated with reclamation; 1st 5 yrs)
        - Capital costs by phase and area
    - Schedule (time required to design and construct)
    - Presentation Materials
        - Topographical maps, models, slides

8. **Design Basis Data Gap Analysis -** This information is a summary of information that needs to be developed or determined at some point in the LCDB project before the final land configuration design can be finalized.

    - Current Data Gaps
    - Data Needed to Develop Conceptual Design
    - Data Needed for Final Design
    - Data Acquisition Plan

STUDY BOUNDARIES

There are three boundaries applicable to this project; they include:

1. Geographical:
    - North: McKay Ditch Drainage (including Walnut Creek Watershed)
    - South: Woman Creek Watersheds (including Mower Ditch)
    - East: Indiana Street
    - West: Spray Fields

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2. Z component
   - f(air models)
   - Groundwater table (post closure)
3. Temporal
   - Periodic (e.g., 100-year) flood events
   - Long term performance (life cycle design)

DECISION RULES

The LCDB decision rules will be used to evaluate the design basis. The decision rules are:

1. If uncertainties are clearly defined, reviewed, and approved for inputs and outputs of the design basis, then LCDB results may be used in future Site decisions related to human health, impacts on the environment, and/or exceedances of standards and action levels (e.g., water quality standards).
2. If the LCDB indicates adequate control of surface water runoff and erosion to prevent (with acceptable confidence) contamination levels from exceeding applicable standards and action levels, then the LCDB is adequate; otherwise, it is inadequate and must be further optimized.
3. If the LCDB indicates adequate protection of other environmental media and natural resources (during and after implementation), then the LCDB is adequate; otherwise, the LCDB is inadequate and must be further optimized.

TOLERABLE LIMITS ON DECISION ERROR

Errors in the design basis will be controlled through the following specifications:

1. Quality controls of engineered designs and data, per DOE requirements and EPA Guidance (e.g. PARCC parameters).
2. Probabilistic errors will apply in sampling & analysis scenarios, and are typically with errors <10%.
3. Errors and tolerance will be defined for each modeling/design basis scenario, for both inputs and outputs (as related to model calibrations and sensitivity analyses), and as early in the process as possible.

OPTIMIZATION OF THE DESIGN

The LCDB will be optimized by evaluating and/or implementing the following criteria:

1. Quantity of data needed for each component of the design (i.e., ID and fill data gaps).
2. Data Quality -- breadth and compatibility of data between models and professional disciplines.
3. Optimization of designs by balancing indicated performance (quality) with costs (budgetary constraints).

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APPENDIX B
DESIGN BASIS FOR
THE FINAL LAND CONFIGURATION

Note:

The Design Basis has been revised since its last issuance dated July 2001 to incorporate responses to DOE/FWS Comments 3, 12, 40, 54, 65, 69, 70, 74, 81, 83, 84, 85, 86, 87, 90, 119, 120, 125, 131, 132, 136, 157, 158, 160, 161, and 163, and Regulatory Agency Comments 6, 9, 29, 31, 38, 39, 40, 41, 42, 43, 44, 46, 49, 50, 51, 52, and 54 (see Tab 1). To complete this appendix, response to Regulatory Agency Comment 45 needs to be incorporated.

The following sections have also been revised to incorporate additional information that is new or has been updated since July 2001.

- **Information for McKay Ditch (see Section 2.3.1.1),**
- **Information for RFCA Surface Water Monitoring results and findings and conclusions from the Source Evaluation Reports (see Section 2.5.1.4 and Table B-08),**
- **Information for Sediment characterization and additional findings and conclusions from the AME investigations (see Section 2.5.2), and**
- **Information from recent Quarterly Groundwater Plume System Reports (see Section 2.5.5).**

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1.0 INTRODUCTION

The purpose of this appendix is to present the design basis that will be used to identify the scope, objectives, and other design criteria for the final land configuration. Specifically, this appendix identifies:

- The anticipated conditions and other physical constraints of the Site that will be present at the completion of active remediation (see Section 2.1),
- The Site information and other design criteria that the engineer/designer needs to know in order to complete the detailed design (see Sections 2.2 through 2.8),
- The set of objectives (including RFCA requirements), conditions, limitations, aspects, and other provisions that bound the scope for the final land configuration (see Section 3),
- The balancing performance functions / criteria that the design is to achieve (see Section 3), and
- The engineering codes, standards, guidelines, and other design criteria that will be followed to produce the design and develop the associated specifications (see Section 4).

This appendix also incorporates the assumptions listed in Appendix C that were established for the identified data gaps. As the LCDB Project progresses and additional information becomes available, this appendix and associated assumptions will be revised accordingly. The design basis presented in this appendix is diverse in nature to accommodate a wide-range of potential scenarios. The pertinent design basis information will be applied to develop an initial conceptual design for the final land configuration.

2.0 SITE INFORMATION

This section summarizes information relevant to implementing the LCDB Project relative to the Functional Design Objectives (FDOs) listed in Section 3.0.

The Rocky Flats Environmental Technology Site (RFETS or Site) is located 16 miles northwest of Denver, Colorado, in Jefferson County as shown on Figure B-01. The Site, which encompasses approximately 6,500 acres, is owned by the United States Department of Energy (DOE), and the integrating management contractor is the Kaiser-Hill Company, LLC (Kaiser-Hill). Before its current closure mission, RFETS was part of the nationwide nuclear weapons research, development, and production complex. The Site is currently undergoing aggressive cleanup with a goal for physical completion of active remediation by 2006. This cleanup is required and guided by the Rocky Flats Cleanup Agreement (RFCA) signed by the DOE, United States Environmental Protection Agency (EPA) and Colorado Department of Public Health & Environment (CDPHE).

2.1 Anticipated Conditions after Active Remediation

This section identifies the anticipated conditions that will exist at RFETS following the completion of active remediation, such as planned deactivation and decommissioning (D&D) and environmental restoration activities. In accordance with the current schedule, active remediation will be completed in Year 2006. The anticipated conditions after active remediation is the starting point for conducting hydraulic evaluations, identifying the bounding scenarios, and developing the scope and associated cost estimate for the initial conceptual design.

The activities associated with historical operations, D&D, erosion and infiltration controls, storm water and pond management, culvert removal, road closure, and environmental restoration that have affected or may affect topography, hydrology, and contaminant transport will be considered in developing the initial conceptual design.

2.1.1 Project Boundaries

The LCDB Project boundaries are graphically shown on Figure B-02 and are consistent with the boundaries used for the AME erosion study. The boundaries encompass the Walnut and Woman Creek drainage basins that may have been impacted by Site activities as follows:

- The northern project boundary is the surface water hydraulic divide between the Rock Creek and Walnut Creek drainage basins. Rock Creek runs through the northwestern portion of the outer BZ and discharges into Coal Creek approximately 9.5 miles downstream of RFETS. Coal Creek hydrogeologically separates the foothills from RFETS and limits the amount of run-off that flows through RFETS. Drainage in this basin is considered to be unaffected by activities that were conducted at RFETS. As such, the Rock Creek basin is not included within the scope of the LCDB Project.
- The eastern project boundary is Indiana Street, which also defines the points of compliance (POCs) for surface water leaving the Site.
- The southern project boundary is the surface water hydraulic divide between the Upper Big Dry Creek and Woman Creek drainage basins. Smart Ditch I, a natural tributary to Woman Creek, is currently diverted to Upper Big Dry Creek. Smart Ditch I is also used to convey water rights from Rocky Flats Lake for irrigation and filling two ponds (D-1 and D-2) located in the southeast corner of the Site. Most of the water from Smart Ditch eventually flows into Standley Lake via Upper Big Dry Creek. Some of the overland runoff that is intercepted and conveyed by Smart Ditch joins Woman Creek and eventually enters Woman Creek Reservoir. The drainage into the Smart Ditch and Upper Big Dry Creek basins is considered to be unaffected by activities that were conducted at RFETS. As such, these basins are not included within the scope of the LCDB Project. However, storm water overflow from Smart Ditch I, which empties into Woman Creek, will be considered.

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- The western project boundary is the RFETS boundary. However, upstream portions of Woman Creek west of the RFETS boundary will be included as part of the erosion and hydrologic evaluations (see Appendix F) to estimate the flow entering the project boundary from offsite areas. Although historical stream gauging data at the western RFETS boundary is available, this data is not adequate to support the erosion and hydrologic erosion evaluation on the specified storm-event (100-year, 6-hour) basis.

Figure B-02 also shows the property boundary of RFETS, the watershed boundaries for Walnut and Woman Creeks upstream of Indiana Street, and the erosion modeling boundary used for the AME study. The hydraulic watershed boundaries are discussed in Section 2.3. The AME erosion modeling boundary was adopted for the LCDB erosion and hydrology evaluation as described in Appendix F of the work plan.

2.1.2 Anticipated Conditions and Physical Constraints

The anticipated conditions and physical constraints that are assumed to be present at RFETS following active remediation are shown on Figure B-03 and include the following:

- Underground buildings, structures, and utilities that do not meet the unrestricted criteria and associated soils in excess of the RFCA Tier I action levels will be removed or stabilized (see Section 2.2.3.2).
- Soils above Tier I action levels and associated pipe in areas where leaks occurred will be excavated. Intact sections of the process waste lines and sanitary sewers will either be removed, cleaned in-place using water flushing, or sealed with grout, cement, or foam (see Section 2.2.3.3).
- Aboveground buildings, structures, utilities, and other components will be removed to 3 feet below the anticipated final grade (see Section 2.2.3.2). Telephone, alarm and electrical systems are not considered utilities.
- Uncontaminated structures including foundations and slabs more than 3 feet below the anticipated final grade will be abandoned in-place (see Section 2.2.3.2).
- Excavations within the Industrial Area (IA) will be backfilled with clean soil, rough graded to match the anticipated final grades, dressed with 6 to 8 inches of topsoil, and revegetated (see Section 2.2.3.2). Backfill will consist of clean soil or recycled clean concrete as per the Concrete Recycling RFCA Standard Operating Protocol (RSOP). If recycled concrete is used, 2.5 feet of clean fill dirt and 0.5 feet of topsoil will be placed over the concrete to facilitate final grading of the Site.
- Buildings and surface features, such as parking lots, electric / light poles, posts, and fences will be removed (see Section 2.2.3.1).
- Paved roads will be removed except for the West Entrance Road, East Entrance Road, and North Perimeter Road (see Section 2.2.3.1).

- Open unpaved roads are assumed to remain in the BZ unless erosion analyses or other considerations indicate that closure of the road is required (see Section 2.2.3.1).
- The Original Landfill, Present Landfill, and Solar Evaporation Ponds will be covered with evapotranspiration (ET) covers (see Section 2.5.3).
- The Mound Area, East Trenches, and Solar Evaporation Ponds groundwater plume collection and treatment systems will be operated and maintained after closure if sufficient groundwater exists for operation of these systems (see Section 2.5.5).
- Current surface water diversion ditches and structures, including the West Diversion Ditch/Dam, South Interceptor Ditch, and Woman Creek Diversion Ditch/Dam, will not be altered. The LCDB Project will evaluate the current configuration of the surface water diversion ditches and structures to identify appropriate changes to facilitate the selected final land configuration for the Site (see Section 2.3).
- Current surface water supply ditches, including the Kinnear Ditch, McKay Ditch, McKay Bypass Canal, Upper Church Ditch, South Boulder Diversion Canal, Smart Ditch, and Mower Ditch, will not be altered and will continue to be used to convey water across the Site to the extent described in Section 2.3.8.
- Drainage control structures located within the IA will be removed or plugged in place. These control structures include curbs, catch basins, and culverts associated with removed roads and parking areas (see Section 2.2.3.4).
- Drainage control structures that are within drainage channels (e.g., Walnut Creek and South Interceptor Ditch) will remain intact and unaltered. These drainage control structures include check dams, uncontaminated culverts under retained roads, and hill slope erosion/drainage features (see Section 2.2.3.4).
- For the purpose of the LCDB Project, it is assumed that active mining will not occur within the LCDB Project area (see Section 2.7.6.3).
- Current and planned easements will need to be maintained after closure (see Section 2.7.6.4).

The final configurations for the A-, B-, and C-series ponds and the Present Landfill Pond have not been determined. This final pond configuration will be influenced by required remedial actions (such as removal of pond sediments) and the approach taken to achieve the FDOs established for the final land configuration. A Pond Reconfiguration Strategy is being developed under this work plan to aid in decisions regarding the final disposition of the ponds. In order to develop and evaluate various scenarios and to bound the scope of the initial conceptual design, the anticipated conditions at the completion of active remediation will be based on retaining the A-, B-, and C-series dam structures and associated ponds in their current configuration. [Note: The reconfiguration of the ponds will be evaluated during the LCDB Project.]

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To prevent sloughing and accelerated deterioration of the evapotranspiration (ET) cover being planned for the Present Landfill, it may be necessary to extend the cover well into the Present Landfill Pond. Although the design of the ET cover is ongoing, for the purpose of the LCDB project, the anticipated conditions at the completion of active remediation are based on the Present Landfill pond and dam having been covered and eliminated to accomplish the required remedial actions. The design work and costing to support a decision are ongoing and a final decision will be made later (see Section 2.5.3).

The LCDB Project will also evaluate the current configuration of the surface water diversion ditches and structures to identify appropriate changes to facilitate the final land configuration for the Site (see Section 2.3.6).

The anticipated conditions and physical constraints that are listed above and elsewhere in this design basis are assumed to be present following the completion of active remediation. These anticipated conditions that were used to formulate the LCDB Project are subject to change if the final scope of on-going closure and remediation projects as approved in RFCA decision documents is substantially different from the anticipated conditions. The LCDB Project documents (including the design basis) would be appropriately modified to incorporate any changes to meet the closure requirements established for the Site identified in RFCA decision documents for individual remedial actions and the final CAD/ROD. [Note: The contours shown on Figure B-03 are based on existing (1994) topographical information for illustrative purposes only. Final grading plans would be developed in conjunction with the initial conceptual design.]

2.2 Site Characteristics

2.2.1 Topography

The surface topography for RFETS and the surrounding area shown on Figure B-03 is based on 1994 aerial fly-over data. RFETS is located on a broad eastward-sloping plain of coalescing alluvial fans on the western margin of the Colorado Piedmont section of the Great Plains Physiographic Province. The Colorado Piedmont terminates abruptly on the west at the Front Range section of the Southern Rocky Mountain Province and gives way to lower, gently rolling terrain of the High Plains section of the Great Plains Physiographic Province on the east (EG&G, 1995; DOE, 1996b and 1996c).

The Colorado Piedmont represents an old erosional surface along the edge of the Front Range and is characterized by dissected topography (EG&G, 1995). While the alluvial fan surface west of RFETS has a general slope that falls from west to east at approximately 2.5 percent, more recent processes have incised drainages and removed portions of the alluvial cover. Drainage swales passing through RFETS have slopes up to 5.5 percent, resulting in significant topographical relief along the eastern portions of the Site (EG&G, 1992).

The IA is located on the relatively flat surface of the Rocky Flats Alluvium pediment. The pediment surface has been eroded by Walnut Creek on the north and east side of the IA and by Woman Creek on the south of the IA. Terraces along these streams range in

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height from 50 to 150 feet (DOE, 1996b and 1996c) and comprise the majority of the BZ. It is assumed that the topography will not change significantly prior to the completion of active remediation.

2.2.2 Climate and Meteorology

Soil erosion due to runoff is identified as a significant transportation mechanism in the migration of surface soil contaminants to surface water (Kaiser-Hill, 2000a). Erosional processes depend on meteorological factors (storm intensity, frequency, duration, and season), as well as physical factors (slope, soil types, run and vegetation). Extreme weather events, such as floods, generate the majority of the erosion expected to occur (Kaiser-Hill, 2000a). However, evaluation of typical weather patterns is also necessary to determine long-term impacts on geomorphic process rates. Meteorology information is also important from a design prospective to determine infiltration, evaporation, and transpiration rates.

Meteorological information has been collected at RFETS since 1952. The first data were collected from the roof of Building 991. In 1953, the monitoring station was relocated to the roof of Building 123. In 1975, the monitoring station was relocated to the West BZ where a 61-meter tower was erected. A backup 10-meter monitoring station was erected in 1989 about 50 meters northeast of the 61-meter primary tower. The location of the 61-meter tower is provided on Figure B-03. Several other temporary precipitation or wind monitoring stations have been established throughout the Site to support various projects.

Measurements of wind and temperature at 10, 25, and 60 meters above ground surface, as well as ground-level measurements of precipitation and other parameters, are collected from the 61-meter tower. Since 1989, all meteorological data have been collected on a real-time basis and are recorded as 15-minute averaged values (DOE, 2000c).

Site meteorological data collected between 1953 and 1993 were summarized by AeroVironment, Inc. (Aero, 1995). Since 1992, all data have been validated in accordance with a formal quality assurance program. Additional data collected between 1984 and 1993 were validated as part of preparing the historical summary report. The summarized meteorological data are as follows (Aero, 1995; DOE, 1995a; and EG&G, 1990):

- The climate at the Site is continental and semiarid, which is typical of locations along the Rocky Mountain Front Range. The shadow effect produced by the Rocky Mountains to the west is the primary reason for the semiarid climate at the Site.
- Table B-01 summarizes the monthly temperature data for RFETS. The average winter temperature is a high 41 degrees Fahrenheit (°F) during the day to a low of 21°F at night. The average summer temperature ranges from a high of 81°F during the day to a low of 60°F at night.

- Table B-02 summarizes the monthly precipitation quantity data for RFETS. The Site receives approximately 15 inches of precipitation per year. Snow is the primary form of precipitation from October through April. It is estimated that average annual snowfall at the Site is about 90 inches.
- The expected intensity of storm events occurring at RFETS is summarized in Table B-03. High-intensity, localized, convective storms are typical of the Denver metropolitan area.
- The frequency of monthly precipitation is summarized in Table B-04. About 40 percent of the precipitation falls as rain during April through June.
- The late summer and autumn months are marked by large centers of high pressure that build over the Rocky Mountains and produce very dry, sunny weather, which can make the area susceptible to wildfires.
- Table B-05 summarizes the monthly wind speed data for RFETS. The Site is prone to strong westerly winds. These winds can exceed 70 miles per hour (mph) at a height of 10 meters a few times in a normal year. Gusts exceeding 100 mph are experienced every 3 or 4 years. Very sudden temperature changes of up to 60°F can be caused by these westerly winds.
- Tornados at the Site are unlikely because of its location adjacent to the foothills.

2.2.3 Site Structures, Infrastructure, and Roads

This section addresses the anticipated configuration of the Site within the LCDB Project boundary after completion of active remediation with respect to the existing structures, infrastructure, and roads.

2.2.3.1 Roads and Parking Lots

For purpose of the LCDB Project, it is assumed all of the paved roads except for the East Entrance Road, West Entrance Road, and North Perimeter Road, and all of the existing paved parking lots will be removed (see Data GAP-050). All areas where roads and parking lots are removed will be rough-graded and revegetated to minimize soil erosion. The three roads that will be left in place may be minimally redesigned.

It is assumed that the existing unpaved roads within the BZ will remain in their present configuration at the completion of active remediation (see Data GAP-060). A reconfiguration plan for the roads in the BZ will be developed based on the need to maintain the road to gain access to remediation systems (groundwater plume systems and ET covers), maintain ponds/dams (if any), collect environmental samples, provide a firebreak, or serve some other legitimate purpose. The potential for the road to facilitate the transport of actinide bearing soils to surface water by erosion will also be considered. It is intended that roads in the BZ would be closed and revegetated if they are not required for access or other legitimate use. A list of roads that can be abandoned or replaced with footpaths will be developed as part of the initial conceptual design.

2.2.3.2 Buildings, Slabs, Tunnels, and Other Structures

For purpose of the LCDB Project, it is assumed that all buildings, slabs, tunnels, and other structures will be removed to a minimum depth of 3 feet below anticipated final grade regardless of contamination (see Data GAP-070). However, it is recognized that some building and structures may be required for long-term stewardship activities (including facilities for Site management, maintenance, and monitoring) and to facilitate future land usage. During the course of Site closure, utilizing existing buildings and structures will be considered when these long-term requirements are more clearly identified. In addition, some structures may be retained to support other missions.

Buildings, slabs, tunnels, and other structures that exceed the unrestricted release criteria will be removed. Associated soils in excess of Tier I Action Levels are to be removed or stabilized. When closure of each building area is completed, the current plan is to backfill and rough grade the excavated area to match the anticipated final grade. The disturbed areas will be covered with topsoil and seeded with a temporary groundcover to minimize erosion. Establishment of permanent native vegetation will be initiated after the entire IA is closed, subsequent to the end of active remediation. Backfill will consist of clean soil or recycled clean concrete meeting the requirements specified in the RFCA Standard Operating Protocol (RSOP) for Concrete Recycling. If recycled concrete is used, three feet of clean fill dirt/topsoil will be placed over the concrete to facilitate final grading of the Site.

It is assumed that the topography after closure of the IA will resemble the existing contours. Alternate contouring of the IA may be developed for the initial conceptual design. These alternate contours may be adopted as the final configuration of the IA. Evaluation of the closure conditions of the IA will be based on fully established vegetative coverage; not the temporary vegetative cover.

Non-contaminated buildings, foundations, and other structures that are more than 3 feet below the anticipated final grade may remain in place. Underground structures that could provide a conduit for groundwater contaminant migration, such as tunnels, will be backfilled, grouted, or otherwise sealed or plugged in place.

Some underground structures may restrict or enhance groundwater flow. The need to reconfigure subsurface structures to address potential impacts to groundwater flow and mitigation of plumes may be assessed under the SWWB Project. The reconfiguration of subsurface features or existing groundwater remediation systems is not included within the scope of the LCDB Project since the extent of such modifications (if required) cannot be assessed at this time. It is further assumed that such modifications (if required) would be implemented prior to completion of active remediation (see Data GAP-070).

2.2.3.3 Process Waste Lines and Sanitary Sewer

The process waste lines (old and new) are a network of tanks, pipelines, and valve vaults used to transfer process wastes primarily to the liquid waste treatment facility in Building 374. Process wastes may have included acids, bases, solvents, radionuclides,

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metals, oils, polychlorinated biphenyls (PCBs), biohazards, paints, and other chemicals (DOE, 1994a).

The sanitary sewer system has been used for the transport, storage, and treatment of sanitary wastes since 1952. Waste streams that may have been discharged to the sanitary sewer system include a variety of chemical and radioactive wastes from laboratories, process buildings, and laundries. These wastes may have contained acids, bases, beryllium, chromic acid, chromium, film processing chemicals, nitrates, oils, paint, radionuclides, solvents, sulfuric acid, and tritium (DOE, 1992a). Additionally, hazardous and radioactive liquids from spills and accidental discharges have entered the sanitary sewer system. It is assumed that portions of the sanitary sewer connected to non-process buildings are not contaminated and, therefore, will qualify for No Further Action and will be abandoned in place. The locations of the process waste lines and sanitary sewers are identified on Figure B-04. Additional details regarding the process waste lines and sanitary sewers are provided in the *Industrial Area Characterization and Remediation Strategy* (RMRS, 1999b).

It is believed that portions of the process waste lines and sanitary sewers have leaked or allowed groundwater to infiltrate into the lines/sewers. Soils above Tier I action levels and associated pipe in areas where leaks occurred are to be excavated. Because the precise locations where pipelines may have broken or leaked are poorly defined, characterization efforts will focus on identifying contaminated soil, rather than on the integrity location of each pipeline (RMRS, 1999b). Excavations will be backfilled to the anticipated final grade with clean dirt.

Intact sections of the sanitary sewers will be cleaned in-place using water flushing and plugged with grout, cement or foam. It is assumed that any remaining process waste lines and sanitary sewers will be adequately severed and plugged/sealed in a manner that will not interfere (i.e., subsurface pathways will be eliminated) with the LCDB Project or achieving the project objectives (see Data GAP-070). For the purpose of the LCDB Project, it is further assumed that capping, long-term care, or monitoring for any remaining portions of the process waste lines and sanitary sewer is not required.

2.2.3.4 Storm Drains and Culverts

The existing storm drains at RFETS are shown on Figure B-04. Current inventory indicates that there are 239 drains. A few of the storm drains may have been exposed to contaminated liquids because of spills, fires, contaminated surface water runoff, and contaminated sediments. Wastes that potentially were discharged to storm drains include silver paints (DOE, 1992a). Storm drains will be evaluated as part of the closure activities for the IA. Any contaminated portions will be decontaminated or removed. It is assumed that non-contaminated portions will be handled as follows:

- For roads that will be eliminated, the associated culvert crossings will also be removed. If necessary, the crossing will be converted to an open channel that has the same bottom width, longitudinal slope, side slopes, and surface covering as

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the adjacent portions of the stream. However, final Site regrading may eliminate the need for the channel.

- For roads that will remain after closure, all associated culvert crossings will remain intact and unaltered.
- Culverts and check dams within the principal and minor drainage channels and hillslope erosion control structures will remain intact and unaltered. These structures will be evaluated as part of the initial conceptual design to verify that they are consistent with long-term performance objectives for the LCDB Project.
- All other structural storm water controls within the IA will be removed, plugged, or otherwise made non-functional. These controls include, but are not limited to, street curbs and gutters; storm sewers, inlets, catch basins, manholes and outlets; diversion / containment dikes and berms; and subsurface drains.

2.2.3.5 <u>Other Underground Utilities</u>

There are numerous underground utilities located throughout the IA including building footing drains, water and gas supply pipelines, and steam lines. Sources of information on buried utilities include the following:

- The Rocky Flats Closure Site Services (RFCSS), Utility Division (located in Building 124) is the custodian for utility system drawings and data sheets for the various utility systems.
- The *Site Safety Analysis Report (SAR)*, Chapter 3, Section 3.3 provides both descriptions and drawings.
- The Remediation Industrial and Site Services Project Management Plan for Site Closure, particularly including Section 5.1.2.1, Utility Projects.

It is assumed that all utilities will be removed to at least 3 feet below the anticipated final grade at the building foundation and capped at the vertical footprint of the building (see Data GAP-070). Remaining portions of the utility will be sealed to prevent water intrusion via the utility conduit or corridor.

Building footing drains will be characterized as part of the closure activities for the IA. Footing drains that are above the unrestricted release criteria will be removed. All other footing drains will be severed and plugged to eliminate any direct subsurface migration pathways.

2.3 *Hydrology*

The principal and minor drainages that flow out of the LCDB Project boundary are shown on Figure B-02. The principal drainage features are Walnut and Woman Creeks. Minor drainage features include Mower Ditch, and three unnamed features.

Both Walnut and Woman Creeks lie within the Big Dry Creek basin, which is an 86 square mile tributary of the South Platte River. The confluence of Big Dry Creek with the South Platte River is near Brighton, which is approximately 42 miles downstream of

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RFETS. The portion of the Big Dry Creek drainage basin that lies west of Indiana Street is approximately 12.9 square miles, which is comprised of the Walnut, Woman, and Upper Dry Creek basins. The Walnut Creek basin encompasses approximately 3.7 square miles with an average basin slope of 0.027 foot per foot and an existing impervious surface of 14 percent. The Woman Creek basin encompasses approximately 4.5 square miles with an average basin slope of 0.028 foot per foot and an existing impervious surface of 2 percent. The Upper Dry Creek basin encompasses approximately 4.7 square miles with an average basin slope of 0.031 foot per foot and an existing impervious surface of 2 percent (EG&G, 1992).

The runoff associated with Walnut and Woman Creeks upstream of Indiana Street are primarily diverted around the Great Western Reservoir and Standley Lake, which are located downstream of RFETS. Runoff from Upper Dry Creek currently flows into Standley Lake. Walnut Creek flows into Big Dry Creek near the intersection of the Boulder Turnpike (US36) and 104th Avenue, which is approximately 5.3 miles downstream of RFETS.

Each principal and minor drainage feature leaving RFETS flows beneath Indiana Street within a culvert. Indiana Street acts as a hydraulic barrier that precludes overland flow and redirects the runoff to the culverts. Flows within the drainages are generally negligible except during precipitation or snowmelt events.

For the purpose of the LCDB Project, the locations where surface water leaves the LCDB Project boundary via a drainage feature are considered to be stream egress locations (SELs). There are seven distinct SELs situated along the LCDB Project boundary. These SELs and their associated upstream drainage basins are shown on Figure B-02. Drainage within these basins is mainly by natural ephemeral streams that generally flow from west to east. Additional hydrological information related to each SEL and associated basin is presented in the following subsections.

2.3.1 Walnut Creek (SEL-01)

Walnut Creek is part of the Big Dry Creek drainage basin and receives almost all of the drainage from the IA, the Inner BZ north of the East and West Entrance Roads, and the northeastern portion of the Outer BZ. The tributaries (No Name Gulch, North Walnut Creek, and South Walnut Creek) combine to form Walnut Creek about 4,000 feet west of Indiana Street. The SEL for this drainage basin, designated SEL-01, is located where Walnut Creek crosses Indiana Street (see Figure B-02). The current point of compliance (POC) sample collection point (GS03) is located approximately 100 yards west of Indiana Street.

The natural discharge point for Walnut Creek is into the Great Western Reservoir approximately 0.5 miles downstream of SEL-01. However, the RFETS portion of the Walnut Creek drainage basin is currently diverted around the Great Western Reservoir via the Broomfield Diversion Ditch under the control of the City of Broomfield, which starts just downstream of Indiana Street. The capacity of the Broomfield Diversion Ditch is limited to approximately 40 cfs and could be overtopped if runoff from a large storm event is not controlled.

The infiltration rates and predicted 100-year erosion rates for the Walnut Creek watershed are depicted in Figures B-05 and B-06, respectively. The infiltration and erosion characteristics can be divided into three primary geographical sections, as follows:

- The eastern portion of the watershed consists of relatively broad floodplains with a channel slope of about 2 percent and side slopes of about 5 percent. The soil has low to medium infiltration characteristics with the low infiltration rates occurring in the channel bottoms (see Figure B-05). The area has a predicted 100-year erosion rate that is low to moderate (see Figure B-06).
- The central portion of the watershed consists of relatively steep channels (4 percent) and channel side slopes (20 percent). This portion of the Site transitions from the younger Rocky Flats Alluvium on the western section of the Site to the older Arapahoe formation on the eastern part of the Site. The majority of this area has channel side slopes and bottoms with relatively moderate infiltration rates, but the upland portions of the watershed, consisting of alluvial material, are characterized by high infiltration rates (see Figure B-05). The predicted 100-year erosion rates are relatively high in the steeper sections of the watershed and relatively low in the flatter parts (see Figure B-06).
- The western section of the watershed is relatively flat with a grade of about 2 percent. There are no defined channels in this area to convey flow, and the infiltration rate is relatively high (see Figure B-05). Very little overland runoff is expected to flow onto RFETS from the western portions of the Walnut Creek watershed due to the relatively flat topographic gradient. The predicted 100-year erosion rate in this area is very low (see Figure B-06).

The Walnut Creek basin within the LCDB Project boundary and upstream of SEL-01 is approximately 1,544 acres. However, the basin extends further west to its headwaters near the mouth of Coal Creek Canyon, which encompasses approximately 2,370 acres upstream of SEL-01. Walnut Creek flows across Indiana Street through a round corrugated metal pipe (CMP) culvert that is approximately 128 inches in diameter. The calculated peak flow and volume at GS03 associated with a 25-year, 6-hour storm event (assuming all ponds are filled to capacity) are 1,400 cubic feet per second (cfs) and 183 acre-feet, respectively (EG&G, 1992). The Walnut Creek drainage basin upstream of SEL-01 contains the following tributaries:

2.3.1.1 McKay Bypass Canal and West Diversion Ditch

Originally, McKay Ditch flowed into North Walnut Creek. In September 1974, the Walnut Creek Diversion Dam and McKay Bypass Canal were constructed to route the McKay Ditch flow north of the Present Landfill. The McKay Bypass Canal is comprised of an inlet at the West Diversion Dam that consists of three 60-inch diameter corrugated metal pipe (CMP) culverts, 2 miles of engineered channel, and 26 rock grade control structures (used to reduce the velocity of the conveyed water to prevent scour of the canal). Most of the rock structures are located along the downslope portion of the canal where it turns away from Upper Church Ditch and heads to the east (see Figure B-03). Two other culvert crossings are located along the route of the canal. These road crossing include twin 66-inch diameter CMP culverts just east of the West Diversion Dam and twin 48-inch diameter CMP culverts located to the North of Pond A-4.

The McKay Bypass Canal flows eastward paralleling the Upper Church Ditch for about 8,000 feet. The McKay Bypass Canal is downslope of the Upper Church Ditch and, therefore, will intercept any overflow. Water in the upper reaches of the North Walnut Creek watershed (west of the IA) is intercepted and diverted by the West Diversion Ditch, which also discharges into the McKay Bypass Canal. The drainage area is estimated to be approximately 550 acres. Drawings 27165-251 through 27165-299 provide additional design and construction details for the McKay Bypass Canal.

An investigation of the McKay Bypass Canal was conducted in 1993 (Mangeot). This report indicates that although the McKay Bypass Canal can still handle the design flow resulting from a 100-year, 6-hour precipitation event (estimated to be 210 cfs), its capacity has been reduced over the years due to erosion, sedimentation, and encroachment of vegetation. The capacity of the canal is likely to have been further reduced since the 1993 investigation in which the calculated capacity ranged from 284 to 368 cfs, but does not account for flow obstructions due to vegetative growth within the canal. The twin 48-inch diameter culvert crossing is a bottleneck in conveying peak flows. The 1993 investigation estimates the capacity of this crossing to be only 125 cfs and does not account for obstructions.

The 1993 investigation also indicates that all but two of the 26 rock check dams were damaged and eroded during a large storm that occurred in May 1981. The damage is likely caused by the accumulation of vegetation and debris depositing on the upstream face of the dams, which results in clogging and build-up of head causing the rock riprap to wash out. The riprap may also be undersized to handle the resulting flow velocity.

The confluence of North Walnut Creek and West Diversion Ditch is at the inlet to the McKay Bypass Canal. The West Diversion Dam was constructed to divert these flows into the canal. The diversion of flow includes several 90-degree bends. The 1993 report indicates that the configuration of the West Diversion Dam and associated ditches would require significant long-term maintenance and recommended that the 90-degree bend be removed to allow a more natural flow of North Walnut Creek into McKay Bypass Canal.

In 1999, an underground (UG) pipe running west to east was installed across the northeast portion of the BZ to allow the McKay Ditch flow to reenter Walnut Creek on the east side of Indiana Street. The inlet structure is located approximately 1,000 feet upstream of the confluence of the McKay Bypass Canal and Walnut Creek. The inlet consists of a concrete wall with a slide gate to divert runoff into the UG pipe via a drop structure. The UG pipe is equipped with a trash grate and slide gate valve and has a design capacity of 110 cfs. Water flows in excess of 110 cfs will spill over the concrete wall into the downstream portion of the McKay Bypass Canal. In addition to the spillway, a 1-inch diameter PVC pipe is located approximately 4 inches from the base of

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the wall to maintain a minimum base flow into the downstream portion of the McKay Bypass Canal.

Operation of the UG pipe and position of the slide gates are controlled by the City of Broomfield. When the slide gate along the concrete diversion wall is closed and the slide gate to the pipe entrance is open, water flow in excess of the 1-inch diameter PVC pipe and seepage around the gate would be diverted into the UG pipe. For the purpose of the LCDB Project, it is assumed that the slide gates will normally be positioned to divert flow into the UG pipe (see Data GAP-080). As such, storm water runoff intercepted by the West Diversion Ditch and the McKay Bypass Canal upstream of the inlet structure will be sent to Great Western Reservoir while runoff from Walnut Creek is simultaneously diverted around the Great Western Reservoir via the Broomfield Diversion Ditch. The water diverted into the UG pipe will be excluded from the erosion and hydrologic evaluation for SEL-01 and its corresponding POC (GS03).

2.3.1.2 No Name Gulch

No Name Gulch receives drainage from a limited portion of the north-central BZ, east of the Present Landfill. The direct runoff from the Present Landfill and an associated seep are collected and retained in the adjacent Landfill Pond. When required, the accumulated waters are pumped to Pond A-3. Additional details regarding the seep and Landfill Pond are provided in Section 2.5.3.2. Currently upgradient overland flow is intercepted and diverted around the Landfill Pond. When the Present Landfill is closed, it is assumed that the seep and Landfill Pond will be eliminated and run-off from the ET cover will flow into No Name Gulch without detention (see Data GAP-130). Additional details regarding closure of the Present Landfill are provided in Section 2.5.3.2.

2.3.1.3 North Walnut Creek

North Walnut Creek receives surface water runoff from the northern portion of the IA. The flow through North Walnut Creek is controlled by four detention ponds that are constructed in series (known as the A-Series Ponds). Additional details regarding the construction and operation of the A-Series Ponds are discussed in Section 2.3.6.3.

2.3.1.4 South Walnut Creek

South Walnut Creek receives surface water runoff from the eastern and central portion of the IA, including the Central Avenue Ditch and a portion of the 903 Pad Area. The natural channel of South Walnut Creek has been significantly altered by construction of the IA. For example, Central Avenue Ditch provides drainage for approximately 79 acres of the south central portion of the IA. A diversion box located at the eastern inner gate controls the flow direction. Runoff is normally conveyed along the eastern inner fence to South Walnut Creek via a concrete-lined engineered channel. During high flow conditions, runoff can be diverted into Central Avenue Ditch Extension, which runs along the top of the pediment, directly to Pond B-05 (see Figure B-03). Runoff diversion into Central Avenue Ditch Extension occurs infrequently (once every couple of years).

The flow through South Walnut Creek is controlled by five detention ponds that are constructed in series (known as the B-Series Ponds). Additional details regarding the construction and operation of the B-Series Ponds are discussed in Section 2.3.6.4.

2.3.2 RFETS Gate #25 Drainage (SEL-02)

A small watershed located in the eastern portion of the BZ flows offsite through a 36-inch diameter CMP culvert under Indiana Street near the RFETS access gate #25. This drainage is hydraulically separated from Walnut Creek by the access road into the BZ. The Broomfield Diversion Ditch intercepts and diverts the offsite flow around the Great Western Reservoir. The basin upstream of SEL-02 is approximately 21 acres.

2.3.3 East Entrance Drainage - North (SEL-03A/B)

The East Entrance Drainage – North is a part of the Walnut Creek drainage basin. Within the LCDB Project boundaries, this drainage basin is hydraulically separated from Walnut Creek and flows directly off-site across Indiana Street through a set of two culverts. The culvert locations are designated as SEL-03A and SEL-03B (see Figure B-02). The basin upstream of SEL-03A is approximately 58 acres and flows into a 56-inch diameter CMP culvert. The basin upstream of SEL-03B is approximately 117 acres and flows into a 36-inch diameter CMP culvert. Off-site runoff from these basins is intercepted by the Broomfield Diversion Ditch and diverted around the Great Western Reservoir.

2.3.4 East Entrance Drainage - South (SEL-04)

The East Entrance Drainage - South is a part of the Woman Creek drainage basin. Within the LCDB Project boundaries, this drainage basin is hydraulically separated from Woman Creek and flows directly off-site across Indiana Street through a 24-inch diameter CMP culvert. The culvert location is designated as SEL-04 (see Figure B-02). The basin upstream of SEL-04 is approximately 194 acres. This basin receives some of the flow from the eastern portion of the dispersion areas containing low-level actinide activity (see Section 2.5.2).

2.3.5 Mower Ditch (SEL-05)

Mower Ditch is a part of the Woman Creek drainage basin. In the past, the Woman Creek base flow was diverted into Mower Ditch, which flowed off site into Mower Reservoir. The diversion of water was stopped when the Site constructed a concrete cut-off wall with a gate-valve on the inlet to Mower Ditch in 1997. However, the overland run-off that enters into Mower Ditch flows directly off-site across Indiana Street through a 36-inch diameter CMP culvert. The bottom 6 inches of the culvert is filled in with soil. The culvert location is designated as SEL-05 (see Figure B-02). The Mower Ditch Creek basin upstream of SEL-05 is approximately 175 acres. This basin receives a flow from the eastern portion of the dispersion areas containing low-level actinide activity (see Section 2.5.2). Approximately 20 yards east of Indiana Street, the natural channel of Mower Ditch is blocked by an earthen dike to direct flow into a diversion ditch that is routed to Woman Creek Reservoir.

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2.3.6 Woman Creek (SEL-06)

Woman Creek is part of the Big Dry Creek drainage basin and receives drainage from the southern most potion of the IA and almost all the drainage from the BZ south of the east and west entrance roads. The SEL for this drainage basin (SEL-06) is located where Woman Creek crosses Indiana Street. The basin extends to its headwaters near the mouth of Coal Creek Canyon (see Figure B-02). The current POC sample collection point (GS01) is located approximately 50 yards west of Indiana Street.

Woman Creek once discharged into Standley Lake approximately 1.5 miles downstream of SEL-06. However, the off-site flow from Woman Creek is currently diverted to the Woman Creek Reservoir located on the east side of Indiana Street and flow to Standley Lake is precluded. The Woman Creek Reservoir is operated by the Woman Creek Reservoir Authority. All upstream drainage from Woman Creek is detained in the reservoir until analytical results from GS01 indicate that the water quality is acceptable for discharge. The accumulated water is pumped to the northeast via a buried pipeline into Walnut Creek downstream of the Great Western Reservoir.

The Woman Creek watershed has the same slope, infiltration, and erosion characteristics as the three sectors (eastern, central, and western) previously identified for Walnut Creek (see Section 2.3.1). The infiltration and predicted 100-year erosion rates are depicted in Figures B-05 and B-06, respectively. The characteristics of the Woman Creek watershed are as follows:

- The eastern part of the watershed has a moderate slope, and low to moderate infiltration rates and erosion rates.
- The central portion is relatively steep, has erosion rates that vary between moderate to high depending on the steepness, and has infiltration rates that range from low in the channel bottoms to high on the upland areas.
- The western area is flat, has low erosion rates, and has high infiltration rates. Very little overland runoff is expected to flow onto RFETS from the western portions of the Woman Creek watershed due to the relatively flat topographic gradient. However, it is possible that some overland flow into Woman Creek may occur during the summer months due to flood irrigation on the McKay property just west of the RFETS property boundary (Kaiser-Hill, 2000a).

The Woman Creek basin within the LCDB Project boundary and upstream of SEL-06 is approximately 1,334 acres. However, the basin extends further west to its headwaters near the mouth of Coal Creek Canyon, which encompasses approximately 2,870 acres upstream of SEL-06. Woman Creek flows across Indiana Street through an elliptical CMP culvert that is 46 inches high by 64 inches wide. The calculated peak flow and volume at GS01 associated with a 25-year, 6-hour storm event (assuming all ponds are filled to capacity) is 830 cfs and 162 acre-feet, respectively (EG&G, 1992). The Woman Creek drainage basin upstream of SEL-06 contains the following tributaries:

2.3.6.1 North and South Woman Creek

Woman Creek is formed by two branches (known as North and South Woman Creeks) that converge at the western edge of the IA. The flow in North and South Woman Creeks are intermittent. A seep area (known as the Apple Orchard Seeps) is located within the South Woman Creek watershed.

2.3.6.2 Antelope Springs Gulch

Antelope Springs Gulch is a perennial feature that carries water from Antelope Springs, a large seep to the south of Woman Creek. The seep is likely caused and influenced by Rocky Flats Lake. Because of this seep, Antelope Springs Gulch normally has base flow most of the year. Antelope Springs Gulch flows into Woman Creek just upstream of Pond C-1.

2.3.6.3 South Interceptor Ditch

The South Interceptor Ditch (SID) is a manmade structure that was constructed in 1980 to divert surface water runoff from the southern portion of the IA (including the 881 Hillside and 903 Pad Area) to Pond C-2. The SID is approximately 8,000 feet in length and flows beneath Woman Creek through a siphon pipe. The drainage basin associated with the SID is approximately 190 acres. Design drawings 27165-251 through 27165-299 provide design and construction details for the SID. The SID was originally designed to handle a 100-year, 6-hour precipitation event. However, erosion, sedimentation, and encroachment of vegetation have reduced the SID's flow velocity and capacity (EG&G, 1992).

The SID and Pond C-2 are considered a separate drainage since flow does not directly enter into Woman Creek (i.e., all runoff is retained in Pond C-2). However, Pond C-2 is batch (pump) discharged, usually once a year, to Woman Creek. The final configurations for the SID and Pond C-2 have not been determined. In order to develop and evaluate various scenarios and to bound the scope of the initial conceptual design, the anticipated conditions at the completion of active remediation will be based on retaining the SID, associated check dams, and Pond C-2 in their current configuration. The need to retain the SID to meet the LCDB Project objectives will be evaluated during the development of the initial conceptual design.

2.3.7 Ponds and Dams

The following 12 ponds shown on Figure B-02 are used to manage surface water at RFETS. This series includes:

- North Walnut Creek: Ponds A-1, A-2, A-3, and A-4.
- South Walnut Creek: Ponds B-1, B-2, B-3, B-4, and B-5.
- Woman Creek: Pond C-1.
- South Interceptor Ditch: Pond C-2.

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- Present Landfill Pond.

Pond C-2 lies in the valley of Woman Creek, but is hydraulically isolated from the creek itself. Ponds A-4, B-5, and C-2, the newest and largest ponds in their respective watersheds, are downstream from the other ponds and are known as the terminal ponds. The other, smaller ponds are known as the interior ponds.

These 12 ponds were constructed at various dates between 1952 and 1980 to manage surface water runoff from the Site. Between the 1952 and 1962, the pond network consisted of Ponds A-1, B-2, B-3, B-4, and C-1 (Dow, 1972 and 1973a). Pond B-1 was added in 1962. Ponds A-2, A-3, and the Present Landfill Pond were added and existing dams for Ponds A-1, B-1, B-2, B-3, B-4, and C-1 were raised between 1972 and 1974 to increase the overall detention capacity. The construction of the terminal Ponds A-4, B-5, and C-2, including the SID, was completed in 1980.

For the purpose of the LCDB Project, it is assumed that the A-, B-, and C-Series ponds will remain intact and unaltered upon completion of active remediation (see Data GAP-160). The need to retain the ponds to meet the LCDB Project objectives will be evaluated during the development of the initial conceptual design. If the ponds are required to meet surface water quality standards, the need to modify the design and operation of the ponds will be considered. Replacement of the ponds with engineered wetlands or other structures will also be considered. If the ponds are not required, the initial conceptual design will consider removal of the ponds. Maintaining wetlands and ecological habitats will be factored into the decision process for reconfiguration of the ponds.

Although the landfill pond is likely to be eliminated as part of the closure action for the Present Landfill as discussed in Section 2.5.3, information regarding the construction and operation of this pond is provided in Table B-06 and summarized in Section 2.3.7.6.

Other ponds located at RFETS include, but not limited to, the Lindsay Ranch Pond, Ponds D-1 and D-2 in the Smart Ditch Drainage, the quarry ponds, and the Walnut Creek flume pond at Indiana Street. These ponds are not the primary features of the Site's water management system or are outside the LCDB Project boundary. As such, detailed information regarding these ponds is not provided.

2.3.7.1 Pond and Dam Characteristics

Mr. Richard Morris, P.E., of the LCDB Project Team, reviewed design and inspection records for the ponds. The purpose of the review was to assess the safety and adequacy of the ponds for flood control, storm water detention, and sediment storage after closure of the Site. During the week of 26 February 2001, Mr. Morris visually observed the dam and appurtenant structures at each pond. The design and construction information for each dam, as well as the safety considerations and long-term performance issues that should be considered in developing the reconfiguration strategy for the ponds, are summarized in Table B-06.

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Each pond is retained by a dam that is regulated by a spillway and, in most cases, an outlet works. The dams are earthen embankments having unzoned or simple zoned embankments. At the terminal ponds, Present Landfill Pond, and Pond A-3, the embankments are keyed into bedrock; at Pond A-2, the embankment is keyed into firm soil. It is not known if the remaining interior dams were built with keys. Rock riprap, usually of small size, protects the upstream slopes from erosion. Except at Pond A-1, the downstream slopes have toe or interior drains of various types and designs to intercept seepage.

With two exceptions, the spillways are ungated open channels cut into native ground on one of the dam's abutments. The exceptions are at Ponds B-4 and the Present Landfill Pond. The Present Landfill Pond has a concrete box culvert through the embankment crest, and Pond B-4 has a gated concrete box culvert through the embankment crest discharging to a concrete chute. The spillway at Pond C-1 is partly paved with a concrete slab, while that at Pond A-3 has a concrete sill across the spillway crest. Most spillways are protected from erosion by rock riprap, except for those at the terminal ponds and at Ponds B-3 and B-4. The spillways at Ponds A-1, A-2, and B-2 have only isolated "bands" of riprap placed across the downstream channels and are otherwise unprotected.

All dams, except at Pond B-4, have an outlet works to discharge water in the normal course of operations. Discharge flow from Pond B-4 is via the concrete-lined spillway. The remaining interior ponds have conduits of ductile iron pipe or corrugated steel pipe passing through or under the embankments, while the terminal ponds have conduits of reinforced concrete pipe. In at least one case (at Pond B-2), the old conduit has been lined with a smaller-diameter pipe of high-density polyethylene.

The outlet works for Ponds A-1 and B-1 were permanently sealed and the outlet works for the Present Landfill Pond is non-functional. Pond A-2 had both high- and low-level outlet; however, the low-level outlet is closed off with a blind flange. Pumping is typically used to remove water from the reservoirs without a functional outlet works.

The valves at Ponds A-3, B-2, and C-2 are at the downstream end, so that the outlet conduits are pressurized within the embankments. The outlet structures at Ponds A-4 and B-5 were modified in 1996, which included adding gate valves within the ponds at the upstream end of the discharge pipe to allow manual batch gravity draining.

Bypasses are provided to divert run-off flow around Ponds A-1/A-2 and Ponds B-1/B-2. The bypasses are buried and are constructed from corrugated metal pipe (CMP). These bypasses have an upstream concrete headwall with two sets of gates valves. One gate valve directs flow into Pond A-1/B-1 and other gate valves allow flow into the bypass pipe. The gate valves are normally positioned to divert runoff into the bypass but can be manually closed to direct any spills into these ponds if required. The bypass for Ponds A-1/A-2 is 42 inches diameter and has an approximate capacity of 60 cfs (WWE, 1994a). The A-1/A-2 bypass outlet discharges downstream of Pond A-2 into a riprap energy dissapator. The inlet into Pond A-1 from the headwall consists of 24-inch diameter CMP. The bypass for Ponds B-1/B-2 is 48 inches diameter and has an approximate capacity of 100 cfs (WWE, 1994a). The B-1/B-2 bypass outlet discharges

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downstream of Pond B-3 into a riprap energy dissapator. The inlet into Pond B-1 from the headwall consists of 24-inch diameter CMP. The headwalls allow flow in excess of the bypass capacity to enter into Pond A-1 or B-1.

The available records do not indicate what design standards or criteria were used for the dams. The dams for Ponds A-2, A-3, A-4, B-5, and C-2 and the Present Landfill Pond appear to conform generally to the standards of practice that existed when they were built. Such standards would include the then-current regulations of the Colorado State Engineer and the practices in such design manuals as the U.S. Bureau of Reclamation's Design of Small Dams. The original parts of Ponds A-1, B-2, B-3, B-4, and C-1, in contrast, appear to have been designed and built in a less-formal, *ad hoc* manner. Available documents suggest that these original structures were irregularly shaped, poorly compacted, and without effective seepage control measures.

Per the design drawings, the terminal ponds were designed to store runoff from a 100-year, 3-day storm event. The estimated runoff for the design storm was determined to be 70, 71, and 42 acre-feet for Ponds A-4, B-5, and C-2, respectively. Several drainage studies have been conducted to reflect changes to the Site drainage features since the terminal ponds were built (ASI, 1991d and EG&G, 1992). Runoff results in acre-feet from various design storms are summarized below and vary significant because the drainage analyses were preformed by separate entities using different techniques and assumptions. It is noted that the runoff will be significantly altered after Site closure with the removal of impervious surface located in the IA. The estimated amount of runoff resulting from a 100-year, 6-hour storm event after Site closure predicted using WEPP (see Tab 3, Attachment B.2) is summarized below. The predicted runoff values should be verified by other methods prior to being adopted for design of the final land configuration.

	Original Design	**Zero Discharge Study ASI, 1991d**			**Master Plan EG&G, 1992**	**Predicted Runoff After Site Closure**
Pond	**(100-yr, 72-hr)**	**(100-yr, 6-hr)**	**(100-yr, 24-hr)**	**(100-yr, 72-hr)**	**(100-yr, 6-hr)**	**(100-yr, 6-hr)**
A-4	70	73	130	160	64	56
B-5	71	65	100	130	71	29
C-2	42	45	220	240	28	26 1/ / 107 2/

1/ Predicted runoff for SID drainage basin only.

2/ Predicted runoff for combined SID and Woman Creek drainage basins upstream of Pond C-2.

A topographic survey and capacity study was performed in 1990/1991 to determine changes to dam and spillway elevations and pond capacities (Merrick, 1992). This information is summarized in Table B-06 and forms the basis for current pond operations in determining capacity of the ponds.

The hydrologic criteria for sizing the spillways likewise vary from structure to structure. This likely reflects the changes in dam-safety standards and flood hydrology techniques that have occurred over the years. Apparently, no records exist that document the

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hydrologic design of spillways at Ponds A-1, A-2, B-1, B-2, B-3, B-4, and C-1. Analyses by the Corps of Engineers in 1984 indicate that these spillways can pass the equivalent of a 50-year flood. In 1998, Wright Water Engineers concluded that the spillways could pass the flood from a 25-year, 6-hour storm, which is the design criterion set by the Colorado State Engineer for dams of this classification. The spillway at Pond A-3 has a similar capacity. At the terminal ponds, the spillways have much greater capacities. According to the Corps of Engineers, the spillway for Pond B-5 can pass the flood resulting from a 6-hour probable maximum precipitation (PMP) event. The spillway for Pond A-4 can pass 50% of the PMP flood. The spillway for Pond C-2 can pass 80% of the PMP flood. These capacities exceed the Colorado State Engineer's design criteria for dams of this type.

2.3.7.2 Pond and Dam Operations

Since 1989-1990, most of the ponds have been operated to retain all Site runoff with manual batch-release to surface water following verification through analytical results that the NPDES discharge limits and water quality standards are met. Prior to 1992, accumulated water from several interior ponds was spray-irrigated in lieu of batch discharge to the surface water. The ponds are interconnected by channels, pipes, valves, and pumps to facilitate water transfers and releases in response to Site needs.

The current pond operations are documented in the *Ponds Operations Plan: Revision 2* (RMRS, 1996). In general, the terminal ponds are operated in a batch-release mode. Pre-discharge sampling is initiated when the water level reaches the pre-determined, pond-specific elevation specified in the *Pond Operations Plan.* The pre-discharge sample analyses typically takes about two weeks to complete. The accumulated water is batch-discharged from the terminal pond if the analytical results verify that the water is of acceptable quality. The batch discharge operations are terminated when the water level is reduced to the pre-determined, pond-specific elevation specified in the *Pond Operations Plan.* During pre-discharge sampling/analyses and discharge, flow into the pond is minimized to the extent practical to isolate the sampled pond water to ensure that the sample results are representative of the water discharged. Flow-paced sampling of the discharged water is conducted at the POC (GS08, GS11, or GS31) immediately downstream of the terminal pond during the batch discharge. As recommended by the Colorado Department of Reclamation, State Engineer's Office, the discharge rate of the ponds during discharge is administratively controlled so that the drawdown limit of one foot per day is not exceeded. This administrative drawdown limit was established to prevent reoccurrence of sloughing of saturated soils that occurred in 1983 to the upstream face of the Pond B-5 dam embankment.

The earthen dam structures are carefully monitored and regularly inspected to ensure dam safety. Annual inspections and testing of the terminal dams are conducted annually in conjunction with inspectors from the Federal Energy Regulatory Commission. Concerns regarding dam safety are conveyed to the Colorado State Engineer's Office. The annual cost to operate the ponds was estimated to be approximately $1.75M in 1996, which includes approximately $720,000 for sampling and analysis (RMRS, 1996). Additional details regarding the current operation for each series of ponds are provided below.

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2.3.7.3 A-Series Ponds

The A-Series ponds lie along North Walnut Creek, in a drainage basin of about 380 acres that includes part of the northern IA. All of the A-Series ponds also receive storm-water runoff from the areas directly tributary to the ponds. The current uses for the A-Series ponds are as follows:

- Ponds A-1 and A-2 are currently off-channel and maintained to contain any spills that may occur. Under normal conditions, groundwater seepage and runoff from the immediate area are the only inflows to these ponds. Ordinary runoff from the upper watershed of North Walnut Creek is diverted around Ponds A-1 and A-2 to Pond A-3 by a pipeline. Pond A-1 was originally built in 1952 and was raised and rebuilt in 1972. Pond A-2 was added to the system in 1972 as well. Between 1952 and 1979, these ponds received water discharged from the northern production facilities as well as process fluids, blow down water, and steam condensate. Pond A-2 has also received laundry wastewater piped from Pond B-2, while Pond A-1 has received waters transferred from the nearby Landfill Pond.
- Pond A-3 is used for detention of storm water originating in the northern IA. The accumulated water in Pond A-3 is transferred to Pond A-4 on an as-needed basis tied to the sampling and batch discharge of the Pond A-4 waters. If required, Pond A-3 water can be pumped into other ponds for storage and subsequent management. This pond was built in 1974 in response to a need to better protect offsite drinking water supplies.
- Pond A-4, built in 1979, is a terminal pond for holding accumulated Site waters until they can be discharged. When the water level in Pond A-4 reaches approximately 40 to 50 percent of the pond's capacity, pre-discharge sampling is initiated. The water is sampled and analyzed for various constituents of concern. The accumulated water is batch-discharged into North Walnut Creek if the analytical results verify that the water is of acceptable quality. Transfers from Pond A-3 to Pond A-4 are suspended during pre-discharge sampling and batch discharge. The batch discharge is terminated if abnormal conditions are encountered (including high water level in Pond A-3) or the set-point for low water level elevation is reached. A gate valve and standpipe were installed in Pond A-4 in 1996 to allow direct gravity discharge.

  During discharge, samples are collected at RFCA POC monitoring station GS11. Water discharged from Pond A-4 is currently diverted around the Great Western Reservoir via the Broomfield Diversion Ditch under the control of the City of Broomfield. Pond A-4 can also receive water under non-routine conditions (retained spills, fire-fighting chemicals, or WWTP upsets) and pump-transferred from Pond B-5 via an aboveground pipeline.

2.3.7.4 B-Series Ponds

The B-Series ponds lie along South Walnut Creek, in a drainage basin of about 310 acres that also includes the central portion of the IA. Like the A-Series ponds, the B-Series ponds receive groundwater seepage and storm-water runoff from areas directly tributary to them. The on-site sewage treatment plant effluent also flows through several of the B-Series ponds. The current uses for the B-Series ponds are as follows:

- Ponds B-1 and B-2 are currently off-channel and maintained to contain any spills that may occur. Ordinarily, runoff is diverted around them to Pond B-4 via a pipeline. Pond B-2 was constructed prior to July 1951 (before the construction of the Site) and was likely used as a stock pond for cattle. Groundwater from adjacent seeps flow into Pond B-2. Pond B-1 was built in 1962. Both ponds were raised and rebuilt in 1972. A gravel drain (consisting from bottom to top: a geotextile, 2-inch diameter rock, and riprap) was installed along the downstream embankment toe of Pond B-2 in 1995 to manage and collect seepage.

  Between 1952 and 1973, these ponds received decontaminated process water and laundry wastewater. Since 1973, the ponds have seen sporadic use to retain sanitary sewage effluent. Waters in Pond B-1 can be transferred to Pond B-2 by pumping. Waters in Pond B-2 can be transferred to Pond A-2 by pumping.

  Characterization results indicate that a portion of Ponds B-1 and B-2 contain sediments with elevated actinide activity. These sediments may be removed as required to meet RFCA requirements after closure activities for the IA have been completed. Water can be sluiced into the ponds from the WWTP effluent pipeline or pumped from other sources (Present Landfill Pond) to prevent these pond sediments from drying out and becoming windborne.

- Pond B-3 was built in 1952, and raised and rebuilt in 1972. This pond was also used to retain decontaminated process water and laundry wastewater between 1952 and 1973. Currently, effluent from the on-site wastewater treatment plant flows to Pond B-3 via a 10-inch diameter cast iron pipe. Pond B-3 is equipped with a standpipe that allows the accumulated effluent to continuously gravity flow into Pond B-4.

  Characterization results indicate that a portion of Pond B-3 contains sediments with elevated actinide activity. These sediments may be removed from Pond B-3 in conjunction with removal of sediments from Ponds B-1 and B-2 (if required).

- Pond B-4 is used for storm water settling, as it is a shallow continuous flow-through pond with no downstream control valve. Pond B-4 was built in 1952, and raised and rebuilt in 1972. A gravel drain (consisting from bottom to top: a geotextile, 2-inch diameter rock, and riprap) was installed along the downstream embankment toe of Pond B-4 in 1995 to manage and collect seepage.

  It receives the flow of South Walnut Creek, which is diverted around Ponds B-1, B-2, and B-3 via a bypass pipeline. It also receives WWTP effluent and

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accumulated water from Pond B-3 that is discharged on a daily basis. The water in Pond B-4 flows continuously into Pond B-5. It was also used to retain decontaminated process water and laundry wastewater between 1952 and 1973.

- Pond B-5, built in 1979, is a terminal pond for holding accumulated Site waters until they can be discharged. The upstream face of the dam required major repairs in 1984 because of a 1983 slope failure induced by excessively rapid drawdown of the reservoir.

  When the water level in Pond B-5 reaches approximately 35 percent of the pond's capacity, pre-discharge sampling is initiated. [Note: Pond B-5 cannot be isolated for sampling due to the continuous discharge of effluent from the onsite WWTP and storm water from South Walnut Creek flowing through Pond B-4.] The water is sampled and analyzed for various constituents of concern on a two-week turnaround priority. The accumulated water is batch discharged into South Walnut Creek if the analytical results verify that the water is of acceptable quality. The water levels in Pond B-5 typically approach about 50 percent of the pond capacity when discharge is initiated. The batch discharge is terminated if abnormal conditions are encountered (including significant inflow into Pond B-5) or the set-point for low water level elevation (10 percent of pond capacity) is reached. A gate valve and standpipe were installed in Pond B-5 in 1996 to allow direct gravity discharge to South Walnut Creek. The batch discharge typically takes about 12 days to complete based on the drawdown limitation of 1 foot per day. During discharge, samples are collected at RFCA POC monitoring station GS08. The discharged water is currently diverted around the Great Western Reservoir via the Broomfield Diversion Ditch under the control of the City of Broomfield. If non-routine conditions are encountered (retained spills, fire-fighting chemicals, or WWTP upsets), Pond B-5 water can be pump-transferred to Pond A-4 via an aboveground pipeline.

2.3.7.5 C-Series Ponds

Both of the C-Series ponds lie along Woman Creek. The drainage basin includes the south edge of the IA. The current uses for the C-Series ponds are as follows:

- Pond C-1 is located on Woman Creek but is not used to manage surface water. Instead, it is configured for continuous flow-through operation. The pond was built in 1952 (raised and rebuilt in 1972) to collect filter backwash water and cooling-tower blow down water from the Site. These functions ended in 1973 and 1974, respectively. The records reviewed do not indicate if Pond C-1 reverted to flow-through operation then, or if it continued to be used for water management until the construction of Pond C-2.
- Pond C-2, built in 1979, is used for detention of storm water runoff and small volumes of treated effluent from Building 891 Consolidated Water Treatment Facility, which is collected and delivered to the pond by the South Interceptor Ditch. Woman Creek bypasses Pond C-2 via an engineered channel located to the north.

When the water level in Pond C-2 reaches approximately 45 percent of the pond's capacity, pre-discharge sampling is initiated. The water is sampled and analyzed for various constituents of concern. The pond is batch-discharged, with a pump and a floating suction line to Woman Creek, which flows into Woman Creek Reservoir. During discharge, samples are collected at RFCA POC monitoring station GS31. The batch discharge is terminated if abnormal conditions are encountered (including significant inflow into Pond C-2) or the set-point for low water level elevation is reached. Batch discharge from Pond C-2 typically occurs once per year and typically involves approximately 10-15 million gallons of water. Design plans to modify the outlet structure to allow manual gravity discharge of Pond C-2 have been developed, but have not been implemented pending the final configuration determination for the pond.

2.3.7.6 Present Landfill Pond

The Present Landfill Pond lies just downstream of the Present Landfill in the No Name Gulch drainage basin. This pond was constructed in 1974 and currently receives direct precipitation and runoff from approximately 18 acres. In addition, a seep located near the eastern base of the landfill flows into the pond. The seepage flow is estimated to be approximately 2 gpm.

The accumulated water is typically transferred into Ponds A-1 or A-2 to keep the sediments in these ponds moist by maintaining a minimal water level in the pond while reserving sufficient capacity in these ponds should spill containment be required. If adequate capacity is not available in Ponds A-1 or A-2, the water from the Present Landfill Pond is typically transferred to Pond A-3. The transfers are accomplished by pumping the water to the headwall of the A-series bypass, where the water is routed to the appropriate pond by proper positioning of the gate valves. Alternatively, the accumulated water can be transferred into one of the B-Series ponds for management and use. Transfers that have occurred between October 1998 and September 2001 are noted below (Ref.: Telephone Conversation with Craig Hoffman, 8/28/01).

Date	Transfer Location	Amount (MM gallons)
May 10-18, 1999	Pumped to Pond A-3	3.6
June 18-19, 2001	Pumped to Pond A-1	0.63
June 19-21, 2001	Pumped to Pond A-2	1.26

As previously discussed, the fate of the Present Landfill Pond is dependent on the feasibility and configuration of the ET Cover to be installed over the Present Landfill.

2.3.8 Site Water Usage and Treatment Plant Effluent

Historically, approximately 400 acre-feet per year (ac-ft/yr) of water from the Denver Water Board was imported onto the Site (Kaiser-Hill, 2001b). Of this amount of imported water, approximately 221 ac-ft/yr has been historically discharged into South

Walnut Creek as effluent from the on-site wastewater treatment plant (ASI, 1991a). Another 150 ac-ft/yr has been historically used for industrial processing including evaporative cooling (ASI, 1991b). Recharge of the groundwater system due to leaks from imported water supply lines is suspected to occur within the IA. The estimated leakage rate is reported to be as high as 10 percent of the total amount of imported water (up to 40 ac-ft/yr).

After closure, it is assumed that imported water will no longer be supplied to the Site (see Data GAP-010). With the cessation of imported water, a net loss to the watersheds of about 260 ac-ft/yr is likely to occur. Discontinuation of the imported water may impact the ability to maintain wetlands and vegetation associated with springs, seeps, and ponds (especially the B-Series ponds) related to the IA. For example, historical gauging for GS10 indicates that flow into South Walnut Creek occurs throughout the year, which is indicative of seep supported stream flow. It is likely that imported water usage at the Site is currently contributing to the flow into the B-Series ponds. The cessation of imported water could change the erosional characteristics of the Site drainages.

The SWWB Project Team is studying the interrelationship between imported water, groundwater, and surface water. The findings and conclusions of the SWWB study will be incorporated into the design basis and initial conceptual design when they are available.

2.3.9 Water Conveyance

Several water supply ditches that affect the hydrology near RFETS are shown on Figure B-02. The current/planned usage associated with these ditches and their potential effects on the drainage at RFETS are discussed below:

- The **South Boulder Diversion Canal** conveys water from Gross Reservoir to the Moffat Filter Plant on an as needed basis. The Denver Water Board owns and operates this canal. This canal is located just west of RFETS and transverses the western portions of the Walnut and Woman Creek basins. In general, the canal within this section of the watershed is constructed as an open ditch with its uphill bank generally at grade. As such, some of the overland flow from the western portions of the Walnut Creek and Woman Creek drainage basins may be intercepted and diverted by the canal. The interception of the runoff is approved by the Denver Water Department (EG&G, 1992). However, the main channel of Woman Creek, and McKay and Upper Church Ditches cross the South Boulder Diversion Canal. As such, drainage from the upper reaches of Walnut and Woman Creeks will be considered.
- The **Kinnear Ditch** diverts water from Coal Creek to Standley Lake via Woman Creek. The discharge into Woman Creek is located upstream of the western RFETS boundary. The City of Westminster owns and operates this ditch. The transfer of water through Kinnear Ditch has not occurred for the last several years; water from Coal Creek is transferred directly to Standley Lake by other means (underground pipeline / Last Chance Ditch).

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- The **McKay Ditch** diverts water from the South Boulder Diversion Canal[1] to the Great Western Reservoir for irrigation. The City of Broomfield owns and operates this ditch. Until 1999, this water reentered the Walnut Creek drainage downstream of No Name Gulch. A diversion structure and pipeline are currently used to convey water to Great Western Reservoir, precluding co-mingling of flows from the IA that are diverted around the Great Western Reservoir by the Broomfield Diversion Ditch. It is assumed that use of the diversion structure and pipeline will continue after completion of active remediation (see Data GAP-080).
- The **Upper Church Ditch** is seldom used, though still an active water conveyance structure which diverts water from Coal Creek to Upper Church Lake and the Great Western Reservoir. The City of Broomfield owns and operates this ditch. Upper Church Ditch runs along the northern portion of the BZ and parallels McKay Ditch on the upslope side. It is assumed that the runoff from the north of Upper Church Ditch will not crossover the elevated ditch banks (see Data GAP-210). Because runoff north of Upper Church Ditch has historically contributed little flow to the Walnut Creek watershed, it will not be considered in the LCDB Project.
- **Smart Ditch I** fills two ponds (D-1 and D-2) located in the southeast corner of the Site for irrigation. Overland runoff is also intercepted and conveyed by Smart Ditch I. **Smart Ditch II** is used to flood irrigate a pasture west of RFETS. Both ditches are fed by Rocky Flats Lake, which are owned and operated by the Church Estate. Overflows from the Smart Ditch I diversion structure and excess flow from the flood irrigation from the operation of Smart Ditch II enter into the Woman Creek watershed. In addition, testing results indicate that the source of water for Antelope Springs is likely to be Rocky Flats Lake. Although these flows are small, they contribute to the support of wetlands and habitats within the Woman Creek watershed.
- The **Mower Ditch** was previously used to divert water from Woman Creek downstream of Pond C-2 to Mower Reservoir. The transfer of water via this ditch was stopped in 1997. Mower Reservoir is now being filled from the Woman Creek Reservoir discharge pipeline. For the purpose of the LCDB Project, it is assumed that Mower Ditch will not be used to transfer water to Mower Reservoir in the future (see Data GAP-080 and GAP-210). However, Mower Ditch does collect and convey runoff from the Site. Just east of Indiana Street, the flow of Mower Ditch is diverted to Woman Creek Reservoir.

Each of the above water supply ditches has a capacity on the order of 10 cfs. Kinnear, Upper Church, and Mower Ditches are not expected to be used or infrequently used to transfer water in the future. The McKay and Smart Ditches are expected to be used for limited periods restricted to spring or summer months. Most of the time, these two ditches carry very little water or are dry. It was concluded that the configuration of these ditches would not significantly contribute to flooding at RFETS or to the Big Dry Creek

[1] The City of Broomfield has junior water rights associated with Coal Creek. During periods of high flow, water from Coal Creek may be diverted into McKay Ditch.

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basin due to a major flood in Coal Creek (EG&G, 1992). However, losses from these unlined ditches to the groundwater have been noticed (WWE, 1995).

Because the DOE does not have water rights for use at RFETS, any storage or depletion of surface water runoff due to final land configuration may need to be replaced. The estimated quantity of replacement or augmentation water for various water management alternatives was presented in Task 14, *Surface Water and Groundwater Rights Study in the Vicinity of the Rocky Flats Plant*, of the Zero-Offsite Water-Discharge Study prepared by ASI (1991c). This report indicates that between 110 and 233 acre-feet of surface water runoff may need to be replaced annually depending on the water management alternative and assuming South Platte River calls for water during a dry year. The implications of various final land configurations versus long-term plans for onsite and offsite water usage after the completion of active remediation have not yet been established with the individual stakeholders.

2.3.10 Channel Hydraulics and Sediment Transport

Various channel hydraulic information and sediment characteristics have been compiled by the AME Project Team to assess sediment transport via the drainage channels using the HEC-6T computer code (Kaiser-Hill, 2000a). This information includes Manning's "n" values, channel cross-sections, channel slope, particle size distribution, settling data, and other channel hydraulic / sediment transport information. This information is based on a combination of field measurements / studies, values from published literature, analytical testing results, and GIS generated data from aerial topographic mapping.

The information compiled and updated by the AME Project Team will be utilized for the LCDB Project as the design basis to evaluate channel hydraulics and sediment transport characteristics of the various bounding scenarios and initial conceptual design.

2.4 Geology and Hydrogeology

Several studies (EG&G, 1991, 1995a, and 1995b) have been undertaken to characterize the geology and hydrogeology at RFETS. These studies include reviews of published reports in the scientific literature, geologic mapping, aerial photo interpretation, description of exposed stratigraphic sections and core samples, stratigraphic correlation efforts, depositional environment characterization, petrographic analysis, mineralogic evaluation, geochemical characterization, geophysics, and seismic investigations. A summary of the results from these investigations is presented in the following sections.

2.4.1 Stratigraphy

RFETS is located on a broad, eastward-sloping pediment surface along the western edge of the Denver Basin. Based on local mapping (Hurr, 1976; EG&G, 1995; and USGS, 1996), the unconsolidated surficial deposits covering the pediment and adjacent watersheds proximal to the IA consist of the Rocky Flats Alluvium (RFA), various terrace alluvia (Slocum and Verdos), valley fill alluvium, and colluvium that unconformably overlie bedrock. Various other younger unconsolidated alluvial deposits

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such as the Piney Creek Alluvium (EG&G, 1995; USGS, 1996) occur topographically below the RFA in the RFETS drainages. These unconsolidated surficial deposits are unconformably underlain by 10,000 feet of Pennsylvanian to Upper Cretaceous sedimentary rocks that have been locally folded and faulted. Figure B-07 presents a generalized stratigraphic section of the Denver Basin bedrock formations (USGS, 1996; EG&G, 1995).

2.4.2 Unconsolidated Surficial Deposits

Four types of soil have been described by the Soil Conservation Service (SCS) (1983b) at the RFETS. These soil types are designated as the following: the Flatiron Series, located on RFA; the Nederland Series, commonly located on the upper slopes flanking the RFA; the Denver-Kutch-Midway Series, located on slopes flanking the Nederland soils; and the Haverson Series, located in drainage bottoms. The specific geotechnical properties of the various soils located within and around the RFETS are described in Table B-07.

The Flatiron Series is a very cobbly sandy loam that exhibits a slow infiltration rate and is located on slopes of 0 to 3 percent. The Haverson Series consists of deep, well-drained soils on flood plains and low terraces with slopes of 0 to 9 percent. The Denver-Kutch-Midway Series is a clay loam, also exhibiting a slow infiltration rate, and is developed on the Arapahoe Formation claystones where slopes range from 9 to 25 percent. The Nederland Series develops adjacent to the Flatiron Series along the periphery of the RFA where slopes are 15 to 50 percent. The Nederland soil exhibits a moderate infiltration rate.

All four soil types at RFETS are partially obscured or replaced by fill materials, gravel, or buildings and other structures. Soil types have not been distinguished in core logs drilled at RFETS. Instead, these soils are described using the Unified Soil Classification System (USCS) designations.

2.4.2.1 Disturbed Ground

Ground disturbed by construction of buildings and other features overlie the RFA and colluvium on the pediment and hill slopes. Disturbed ground consists of unconsolidated clay, silt, sand, gravel, and pebbles derived from the RFA and colluvium.

2.4.2.2 Artificial Fill

Geologic materials native to the Site (RFA) and imported off-site materials have been used as fill at the RFETS for road grade and berm construction, for recontouring around engineered structures, as local valley fill, and as fill in topographic lows for construction of surface water impoundments. Imported crushed rock has been used for landscaping and leveling at the Site. The fill material often consists of poorly sorted gravels and sandy clay with fragments of claystone and concrete rubble. Preliminary soil testing results (ATT Inc., 2001) to determine the typical properties for off-site fill that may be used to construct the ET covers is included in Table B-07. The soil characteristics are

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also considered appropriate for import soils that would be used to fill excavations resulting from the closure of the IA.

2.4.2.3 Autochthonous Constituents of Surficial Materials - Caliche and Calcrete

Some stratigraphic intervals of the sediments described in Section 3.3.1.7 contain significant quantities (25 to 80 percent) of caliche and/or calcrete. Caliche, or calcium carbonate, often forms by evaporation of vadose zone water. Early stages of caliche formation may produce either a powdery granular calcite or development of indurated nodules, termed calcrete (Blatt, 1980).

In the alluvial material, caliche formed *in situ* after deposition (Gile, 1966 and Brown, 1956), whereas younger colluvial and valley fill material may contain reworked sediments containing caliche. Some caliche zones have a significant lateral extent. These intervals indicate significant secondary precipitation and/or replacement of caliche/calcrete by subsurface evaporation of soil moisture in the vadose zone, primarily in the "C" soil horizon. Their presence suggests areas where a capillary fringe is or was present. These intervals may be significant hydrogeologically if they represent areas of low or no recharge to the Upper Hydrostratigraphic Unit (UHSU) (i.e., areas of significant surface evaporation). Caliche-rich intervals are most commonly encountered in the upper 10 feet of the subsurface.

2.4.2.4 Colluvium

Colluvium occurs on the steep hill slopes descending into drainages at RFETS. These deposits are derived from the RFA and the underlying bedrock. Colluvial material consists of unconsolidated clay with silty clay, sandy clay, and gravel layers with sparse cobbles. Occasional dark-yellowish-orange iron staining is present along fractures in reworked bedrock.

2.4.2.5 Landslide and Slump Colluvium

Landslide and slump colluvium deposits have been identified below the pediment surface in nearly all of the drainages at RFETS (EG&G, 1995 and USGS, 1996). These occur primarily in the upper bedrock claystones and involve downward and outward movement along curved slip planes. At RFETS, landslides and slumps are recognized by a curved scarp at the top, a coherent mass of material down-slope that has been rotated back toward the slip plane, and hummocky topography at the base. Landslide and slump deposits are expressed in weakly consolidated, grass-covered slopes as bulges or low wavelike swells (EG&G, 1995 and USGS, 1996). Several distinct landslide and bedrock slump-blocks have been mapped above and along the banks of Walnut and Woman Creeks (EG&G, 1995 and USGS, 1996). Deposits can be up to 35-feet thick. Several slump-blocks north of the Solar Evaporation Ponds (SEPs) and at the Original Landfill area have been core drilled resulting in extensive information on their internal structure and composition. Further details regarding geomorphic processes are presented in Section 2.4.7.

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2.4.2.6 Valley Fill Alluvium

Valley fill alluvium occurs in all the major drainages at the RFETS and consists of unconsolidated, poorly sorted sand, gravel, and pebbles in a silty clay matrix. Shroba and Carrara recognized two stages of valley fill alluvium: a Post-Piney Creek and a Piney Creek Alluvium (USGS, 1996). The Piney Creek Alluvium forms low terraces about 3 to 6 feet above modern stream level, and contains calcium carbonate veinlets and locally one or more buried soil horizons. The Post-Piney Creek Alluvium forms modern stream channels and floodplains, and does not contain secondary calcium carbonate. In addition, remnants of younger terrace deposits, including the Verdos, Slocum, and Louviers Alluvia occur sporadically along the valley side slopes.

2.4.2.7 Rocky Flats Alluvium

The youngest areal extensive stratigraphic unit at RFETS is the early Pleistocene (Nebraskan or Aftonian) RFA. Outcrops of the slightly younger (Kansan or Yarmouth) Verdos and (Illoian or Sangamonian) Slocum Alluvium have been mapped in the eastern portions of the Site (EG&G, 1995; USGS, 1996; Epis, 1980; Weimer, 1973; Scott, 1960). The RFA was deposited by highly unstable ephemeral and/or spasmodically active braided streams and debris flows. Deposition took place on a pediment within a coalescing alluvial fan/apron braid plain system. Coarse gravel was most likely deposited in channels by debris flows. Sand and fine gravel were deposited in channels and along banks, forming natural levees, while silt and clay would commonly be found on floodplains and transverse and longitudinal bars.

The RFA occurs on top of the erosional bedrock surface and is generally poorly to moderately sorted, poorly stratified gravel, sand, cobbles, silt, and clay. The thickness of the RFA ranges from less than 10 feet to slightly more than 100 feet at the RFETS. The coarse (boulders and cobbles) clastic materials were derived primarily from the Precambrian igneous and metamorphic rocks that crop out in Coal Creek Canyon. Other less common source rocks are the steeply east-dipping sedimentary formations exposed at the mouth of Coal Creek Canyon.

Eastward-flowing streams dissected the RFA terrace in several locations. In a few locations, the erosional sub-alluvial pediment surface (unconformity) has been eroded, exposing the Late Cretaceous - Early Tertiary Arapahoe Formation and the Late Cretaceous Laramie Formation.

Alluvial sediments at RFETS were most likely to have been deposited in a medial-fan depositional environment based upon the following observations and assumptions. Mid-fan deposits commonly consist of a braided network of shallow channels with debris flow, water-lain, and some sheet flood deposits. Debris flows comprise interdigitated sheets with non-erosive basal contacts, or occupy channels cut by water flow. Water-lain deposits commonly show erosive, channeled contacts and internal stratification related to bedload transport or bedform migration. Sheet flood deposits accumulate due to spreading of sediment-laden water as it exits a stream channel and are generally thin, widespread sheets of sand and fine gravel. Although sheet flood deposits are found in the

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mid-fan position, they are most commonly located in the distal or "toe" of fan positions. Well-developed channels, sieve deposits, and coarse debris flows are most common on the upper fan (near fanhead trench). Available data suggests that a majority of the alluvial material at RFETS is the shallow braided network type.

2.4.3 Bedrock Deposits

An unconformity representing a depositional hiatus greater than 60 million years in duration separates the Late Cretaceous Arapahoe and Laramie Formations from the overlying RFA. The "top of bedrock" surface (unconformity) upon which the RFA rests is a nonplanar eroded mountain-front pediment. It appears that the irregular, undulating nature of the pediment surface was controlled in part by stream incisement and subsequent deposition of the basal RFA. Incised channels on the bedrock surface represent an important influence on present-day groundwater flow paths.

2.4.3.1 Arapahoe Formation

Arapahoe Formation is mainly composed of claystone and silty claystone, with intercalated lenticular sandstone bodies and is generally less than 50 feet thick at RFETS (EG&G, 1995; EG&G, 1992). The depth of the contact between the Arapahoe Formation and the underlying Laramie Formation is generally less than 100 feet below ground surface in the RFETS area.

Arapahoe Sandstones: Sandstones in the Arapahoe Formation are poorly to moderately sorted, subangular to subrounded, clayey, silty, very fine-grained to medium-grained, with sparse occurrences of coarse to conglomeratic grain sizes. Trough and planar cross-stratification are common sedimentary structures contained in these sandstones (EG&G, 1991 and EG&G, 1995). The sandstones are lenticular in geometry and are interlayered with thin lenses of claystone and siltstone. The subcropping sandstones dip approximately 2 degrees to the east. The depositional environment of the Arapahoe Formation has been interpreted as a subaerial fluvial system with associated channel, bar, and floodplain deposits (EG&G, 1995).

The sandstones are generally weathered to a depth of 30 to 40 feet below the base of the RFA. The weathered sandstone varies from pale orange to yellowish gray and dark yellowish orange in color. Unweathered sandstones are light to olive gray. Fractures have been noted in the weathered zone at depths of 5 to 14 feet. Arapahoe sandstones comprise an important element of the groundwater flow regime at RFETS.

Arapahoe Claystones/Silty Claystones: The Arapahoe claystones and silty claystones are massive, blocky, and contain thin laminae and stringers of sandstone, siltstone, and coal. The weathered claystones extend to approximately 30 feet below the base of the RFA and perhaps farther. Weathered claystones range in color from pale yellowish brown to light olive gray and are moderately stained with iron oxides. Unweathered claystones are typically dark gray to yellowish gray.

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Fractures have been encountered between 6 and 26 feet in depth in Arapahoe claystones and are associated with ironstone concretions and calcareous deposits in the weathered zone. Small vertical, subvertical, horizontal, and 45-degree fractures have been encountered in the unweathered zone at depths of 30 feet to over 100 feet. Many of the shallower fractures are stained with iron oxides or calcareous deposits, implying water movement (Rockwell, 1988). Additional information of fracturing within the Arapahoe Formation is provided in *White Paper: Analysis of Vertical Contaminant Migration Potential* (RMRS, 1996).

2.4.3.2 Laramie Formation

The upper contact of the Laramie Formation occurs at a depth of approximately 100 feet below ground surface at RFETS. The Laramie Formation is divided into two intervals: (1) a lower unit composed of sandstone, siltstone, and claystone with coal layers, and (2) an upper claystone unit (Weimer, 1973). The upper unit, which consists mostly of silty claystones, siltstones, and some fine-grained sandstones, is estimated to be 460 feet thick at some locations at the RFETS. It consists of light- to medium-gray kaolinitic claystones with sparse, dark gray to black carbonaceous claystones. The lower unit is estimated to be about 285 feet thick consisting of coal beds and sandstones (Wiemer, 1973). The sandstones of the lower unit are fine- to coarse-grained, poorly sorted, subangular, and silty. The Laramie Formation is interpreted as having been deposited in coastal or transitional marine deposits (EG&G, 1995).

2.4.4 Structure

Structurally, the RFETS is located on the western flank of the Denver Basin, approximately four miles east of steeply dipping strata on the east flank of the Front Range uplift. The Front Range is the easternmost range of mountains in the Southern Rocky Mountain Province. The Denver Basin is a north-south-trending, asymmetrical basin with a relatively steep western flank and shallow eastern flank. The basin is more than 13,000 feet deep at its deepest point and contains bedrock of Paleozoic, Mesozoic, and Cenozoic age.

Subsidence of large basins and the rise of extensive Front Range uplifts dominate the tectonic framework of the southern Rocky Mountain region. These uplifts were formed predominantly during late Cretaceous to early Tertiary Laramide time because of regional compression related to southwesterly movement of the North American plate over a gently dipping subducted slab of marine sediments. Some Laramide structures, as well as some sedimentation patterns, were strongly influenced by basement anisotropy induced by Precambrian deformation.

2.4.5 Seismic Conditions

In order to define a seismic hazard for the LCDB project, an estimated earthquake hazard must first be established. Variables and critical relationships used to define earthquake hazards and to estimate probable forces are discussed in various documents (Coats, 1984; Blume, 1974; Boore, 1978; Krinitzsky, 1981; Hays, 1980; Algermissen 1969 and 1976;

dePolo, 1990; UCRL-15910, 1990; EG&G, 1994a and b; DOE, 1994b; and DOE Order 6430).

Site-specific seismic hazard analyses have been prepared (EG&G, 1994a and b; Dames and Moore, 1981; and Blume, 1974). Seismic design considerations for the LCDB Project will be drawn from the most recent investigations (EG&G 1994a and b).

The RFETS Seismic Hazard Study (EG&G, 1994a) evaluated the seismogenic (capable of generating M>5 earthquakes) probability of known faults, within 25 km of RFETS. The Walnut Creek Fault, Rock Creek Fault, Valmont Fault, Golden-Boulder Front Range Fault System, Rocky Mountain Arsenal (RMA)/Derby Source, and five regional sources were all evaluated in terms of recurrence probability and probable maximum magnitudes. The RMA/Derby source was determined to be the dominant contributor to the seismic hazard. The Colorado Geologic Survey classified the RMA/Derby source as "potentially active" in 1981. The closest extension of the RMA/Derby source is approximately 8 miles from RFETS. Ground motions for annual probabilities between 1×10^{-3} and 2×10^{-5} (i.e., 1,000 to 50,000 year return period) are estimated to have maximum magnitudes of between 5.75 and 7. The last known seismic event in Colorado in this magnitude range occurred in 1882.

The Site Wide Geologic Characterization Report for the RFETS (EG&G, 1995) identified seven additional inferred shallow bedrock faults in close proximity to the IA (six within 4 km), as shown on Figure B-08. The faults were identified through estimated offset along a unique Laramie aged claystone marker bed. These inferred faults trend north-northeast and are assumed to be high angle reverse faults. Estimated vertical displacement on these faults varies from 10 to 120 feet, horizontal displacement has not been estimated. The lengths of the inferred fault traces vary from 1,000 feet to almost 2 miles. However, there is poor or no evidence for recent or credible movement along these faults within the last 1 million years. Therefore, these faults are not likely to constitute a seismic hazard to the LCDB Project.

2.4.6 Hydrogeology

This section describes the hydrogeology of the RFETS area, including the unconfined and confined groundwater systems present. Unconfined groundwater flow occurs in unconsolidated geologic materials and in subcropping bedrock sandstones. Groundwater flow in the lower sandstone units and possibly in the saturated claystone may occur under either confined or unconfined conditions.

2.4.6.1 Regional Setting

RFETS is situated in a regional groundwater recharge area. The shallow groundwater system is dynamic as evidenced by rapid changes in water table elevation in response to short-term or incident precipitation events and variations in recharge. Generally, water levels are highest in spring and early summer and lowest during the winter months. In the western part of the RFETS, where the thickness of the surficial material is greatest, the depth to the water table is about 50 to 70 feet. Although the water table depth is

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variable, it becomes shallower from west to east as the surficial material thins. Seeps are common in the stream drainages at the base of the RFA, and where the Arapahoe Formation sandstones are exposed.

Two hydrostratigraphic units, designated upper (UHSU) and lower (LHSU), have been identified at the Site. The unconfined groundwater occurs in the UHSU within the unconsolidated geologic material. The UHSU includes alluvium, colluvium and landslide deposits along the valley slopes, the valley fill alluvium present in modern stream drainages, weathered portions of the Arapahoe and Laramie Formations, and all sandstones within the Arapahoe and Laramie Formations that are in hydraulic connection with the overlying, surficial deposits or ground surface. At the RFETS, the vadose zone, saturated unconsolidated sediments, and bedrock units that are in hydraulic connection with the unconsolidated sediments or the surface, are collectively referred to as the UHSU.

Regionally, unconfined groundwater flows within the UHSU materials and along the contact of the unweathered claystones and silty claystones of the Arapahoe and Laramie Formations from west to east, with local flow direction variations along drainages and paleotopographic lows. The claystones have a low hydraulic conductivity, on the order of 1×10^{-7} centimeters per second (3.15 meters per year), effectively constraining much of the flow to the unconsolidated geologic materials above the unweathered bedrock surface. A hydraulic connection exists between the uppermost Arapahoe Formation Sandstone where it is overlain by unconsolidated geologic materials, so that within limited areas where sandstone subcrops beneath the alluvium, colluvium, and alluvial pediment surface, the sandstone is part of the UHSU.

Discharge from the alluvium occurs at seeps at the base of the alluvium and the top of unweathered bedrock claystones on steep slopes along the edges of stream valleys. Most seeps flow intermittently. The RFA in the RFETS area is truncated due to erosion before reaching the RFETS boundary and does not directly supply groundwater to wells located down gradient of RFETS.

Both the UHSU and the LHSU have relatively low hydraulic conductivities and do not produce significant quantities of water. The range of hydraulic conductivities based on packer tests performed in 1986 and 1989 (EG&G, 1992, 1995b) is from 5×10^{-6} to 3×10^{-3} centimeters per second (1.58 to 946.8 meters per year) for the valley fill alluvium. Hydraulic conductivities reported for the RFA of the UHSU range from 7×10^{-5} to 1×10^{-2} centimeters per second (22 to 3,154 meters per year). The reported range of hydraulic conductivities for the highly weathered and unconsolidated subcropping Arapahoe sandstone, which also forms a part of the UHSU, is 2×10^{-6} to 4×10^{-5} centimeters per second (0.63 to 12.6 meters per year) (DOE, 1992b).

The LHSU at RFETS consists of interbedded units of claystone, siltstone, and sandstone of the Arapahoe and Laramie Formations that exist beneath RFETS. The claystone and siltstone units may act to confine groundwater in the sandstones.

Groundwater recharge to confined aquifers occurs as precipitation infiltrates where bedrock crops out in the western portion of the RFETS along the western limb of the monoclinal fold. Groundwater recharge to the unconfined UHSU occurs in the unconsolidated surficial materials and subcropping permeable bedrock throughout the RFETS area. Recharge also occurs because of surface water infiltration from streams, ditches, and ponds. Base flow of some of the perennial streams is sustained by runoff or groundwater discharge.

Hydraulic conductivities reported for the Arapahoe claystones range between 1×10^{-8} and 1×10^{-7} centimeters per second (0.32 to 3.15 meters per year) for both weathered and unweathered claystones (EG&G, 1991). In the deeper subsurface, potentially confined LHSU unweathered sandstones in the Arapahoe Formation have hydraulic conductivities ranging from 4×10^{-8} to 2×10^{-6} centimeters per second (1.26 to 63.1 meters per year).

There are numerous bedrock monitoring wells at the RFETS. In places where the uppermost sandstone is separated from the surficial materials by claystones and silty claystones, the sandstone may exist for a limited area as a confined aquifer. Deeper bedrock wells that are screened in stratigraphically lower sandstones and are bounded by relatively impermeable claystones and silty claystones also exhibit confined conditions. Water levels measured in bedrock wells in other areas of the RFETS indicated a strong downward vertical hydraulic gradient. This suggests that water in the UHSU may be perched on claystone and silty claystone aquatards of the Arapahoe Formation.

It has been concluded that limited hydraulic connection exists between the UHSU and LHSU because vertical hydraulic conductivities for the confining layer materials separating the UHSU from the LHSU range from about 2.8×10^{-10} to 2.5×10^{-7} centimeters per second, or roughly three to seven orders of magnitude lower than for the overlying surficial deposits (RMRS, 1996). Therefore, due to this contrast in hydraulic conductivity, groundwater is expected to move predominantly laterally in the surficial deposits and vertically only in the confining layer. In addition, vertical migration of contaminants have been essentially ruled out because by the time a contaminant would reach the LHSU (on the order of 1,300 to 1.1 million years), it is expected it would be either degraded or sufficiently dispersed that contaminant concentrations would be below regulatory limits.

2.4.6.2 Incised Bedrock Channels and Preferential Flow Paths

At the RFETS, groundwater flow in the UHSU is controlled by the topography of the top of bedrock surface and the lithologies of the saturated UHSU. On the pediment extending from the 903 Pad, through the East Trenches and east towards the edge of the pediment, the topography of the eroded bedrock surface is distinguished by two west-east trending highs or ridges. These two bedrock highs are separated by an incised bedrock channel. The incised bedrock channel conveys groundwater to the east, analogous to a subsurface stream valley system. This incised channel and others, located at the Solar Evaporation Ponds, are significant because they represent preferential flow paths for groundwater and contaminants. The top of bedrock surface is unconformably overlain by an assortment of unconsolidated heterogeneous sediments. The RFA overlies bedrock on the pediment, adjacent to the pediment modern streams have eroded the RFA and bedrock is overlain by valley fill alluvium, on the slopes between the pediment edges and the stream channels bedrock is unconformably overlain by colluvium.

Groundwater will generally flow through the alluvium resting on the top of bedrock surface, with little entering the deeper bedrock system. Groundwater flow is primarily to the east, through the alluvium at the base of the incised bedrock channel. During periods of maximum groundwater flow (spring) the saturated thickness of the alluvium increases. The increase in saturated thickness causes some groundwater to temporarily flow south. When the saturated thickness exceeds the elevation of the southern bedrock ridge, which is slightly lower than the northern bedrock ridge, groundwater will flow over the ridge, off the pediment, and down gradient along the bedrock-colluvium contact into the Woman Creek watershed.

2.4.6.3 Imported Water

Imported water from the Denver Water Board is discharged onsite into the Site hydrogeologic system through underground piping leaks, wastewater treatment plant effluent, and irrigation systems (see Section 2.3.7). This influx of imported water may be artificially raising the water table beneath the Site, increasing groundwater discharge to surface water through seeps and subsurface flow. Elevated water tables and groundwater discharge also tend to increase the rate of slumping and mass wasting.

The elimination of imported water at closure is expected to cause a drop in the water table beneath the Site, which will lead to less groundwater discharge to surface water through seeps and subsurface flow, and a potential general decrease in erosion and stream incision. Slumping and mass wasting may also decline with the drop in the water table. The general decrease in available water may also drive a change in ecology, which will include the elimination of some seep-derived wetlands, changes in habitat, and changes in stable floral and faunal communities. Site hydrogeologic, erosional, and hydrologic characteristics may return to conditions that were present prior to construction of the IA.

The SWWB Project Team is studying the interrelationship between imported water, groundwater, and surface water. The findings and conclusions of the SWWB study will be reviewed to address the potential long-term geomorphic changes to the Site after closure.

2.4.6.4 Seeps

Seepage resulting from discharge of groundwater commonly appears as moist or wet areas even though precipitation has not recently occurred. These areas may or may not be marked by the presence of phreatophytes (plant species with roots that extend to the water table). The seeps are not normally point sources of overland flow and flow rates have not been estimated. Visual observations suggest that most of the seepage currently appears to evaporate or transpire.

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2.4.7 Geomorphology and Long-Term Evolution

This section describes the current landforms at RFETS, and identifies the dominant processes that will interact with driving forces (i.e. climate, gravity, and other forces generated inside the Earth) and the geological framework to shape the long-term evolution of the landscape. An understanding of these processes and the rates at which they are occurring will be used to assess the long-term performance of the initial conceptual design.

The RFETS is located in an area of the eastern Colorado Piedmont where bench and valley uplands are the predominant landforms. A bench is a nearly flat tongue of land that slopes generally eastward at a low angle from the hogbacks or mountain front. These benches can widen away from the mountains, as is the case for RFETS, and many are notched marginally by gullies. Bordering slopes are gentle or steep and smooth or gullied. Heights may be 200 to 400 feet, but are typically less (USGS, 1982).

Nearly all benches are capped with gravel, such as the Rocky Flats Alluvium, that was deposited by streams flowing out of the mountains in the geologic past, when the benches were the valley floors. Valleys between benches have been partly or completely stripped of a once more extensive gravel capping (USGS, 1982).

The current dominant processes at RFETS include slope erosion and the activity of the Walnut and Woman Creeks, which not only erode and convey sediment but also are primarily responsible for developing the valley levels to which the slopes are graded. Erosion of the slopes occurs by mass wasting (i.e. landslides and slumps) and from runoff. Stream erosion occurs primarily by channel incision and headward erosion as channels advance upstream.

Slumps and slides have developed on the hillslopes of Woman and Walnut Creeks where shallow groundwater has saturated the weathered regolith, causing an increase in soil pore pressure and reducing the soil strength until the slope fails. Slumps also occur in locations where the stream flow has undercut the base or toe of the slope, decreasing slope stability until the slope fails.

Gullies are most likely to form in areas along stream banks where slumps and deep fractures are present, seeps are flowing, and the toe of the slope intersects the outside meander loop. Most of the gullies at RFETS, however, have formed as the result of Site activities. For example, gullies have formed on the north and south sides of the IA where runoff is directed through ditches and culverts over the edge of the bench.

North and South Walnut Creeks, in particular, are at a relatively young stage of development. These streams have fairly steep, V-shaped profiles, and little or no floodplains, characteristic of a young developmental stage. Streams at this developmental stage move large quantities of sediment by eroding their channels. This process is called stream down cutting or channel incision. In addition, to down cutting their channels, the streams are actively elongating their stream course or profiles by eroding the upstream end, a process known as headward advance. Woman Creek has an

U-shaped profile and a better-developed floodplain suggesting a relatively mature stage of development. Therefore, less channel erosion probably occurs in this drainage.

2.5 Environmental Characterization and Remedial Actions

Historical operations at RFETS have resulted in environmental contamination. Several remedial actions have been implemented and additional actions will be taken prior to the completion of active remediation to provide protection of human health and the environment. This section summarizes the available characterization information and addresses the completed and planned remedial actions.

The principal contaminants influencing surface water quality at RFETS include Pu, Am, U, VOCs, and nitrate. Studies performed by the AME Project Team and published literature indicates that Pu and Am are insoluble and strongly associated with soil particles. As such, the primary transport mechanism for these actinides to surface water is erosion of surface soil via storm water runoff. This transport mechanism appears to be the primary cause of the historical monitoring data that is elevated above the RFCA surface water action levels. Uranium, VOCs, and nitrate are the principle constituents detected in groundwater plumes at the Site. As such, the pathway for these constituents to surface water would be through groundwater seeps and springs.

2.5.1 Surface Water Characterization Information

This section provides information regarding the designated use classifications, standards, points of compliance, and historical monitoring results for surface water at RFETS.

2.5.1.1 <u>Surface Water Use Classifications</u>

The State of Colorado Water Quality Control Commission (WQCC) is responsible for classifying the present and future beneficial use of State surface waters (see 5 CCR 1002-31.6). The potential beneficial uses identified under the WQCC regulations include public water supplies, domestic, agricultural, industrial and recreational uses, and the protection and propagation of terrestrial and aquatic life (see 5 CCR 1002-31.2). Once the beneficial use of the surface water is determined, the WQCC establishes numerical or narrative standards to maintain and improve the quality of the water. The process for assigning numerical and narrative standards is contained at 5 CCR 1002-31.7.

Both Walnut and Woman Creeks are part of the Big Dry Creek drainage basin. The WQCC divided the Big Dry Creek drainage basin into the following segments for the purpose of establishing water quality standards:

- Segment 1: Mainstem of Big Dry Creek, including all tributaries, lakes and reservoirs, from the source to the confluence with the South Platte River, except for specific listing in Segment 2, 3, 4a, 4b, 5 and 6.
- Segment 2: Standley Lake.
- Segment 3: Great Western Reservoir.

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- **Segment 4a:** Mainstem and all tributaries to Woman and Walnut Creeks from sources to Standley Lake and Great Western Reservoir except for specific listings in Segments 4b and 5.
- **Segment 4b:** North and South Walnut Creek and Walnut Creek, from the outlet of Ponds A-4 and B-5 to Indiana Street.
- **Segment 5:** Mainstems of North and South Walnut Creek, including all tributaries, lakes and reservoirs, from their sources to the outlets of Ponds A-4 and B-5, on Walnut Creek, and Pond C-2 on Woman Creek. All three ponds are located on Rocky Flats property.
- Segment 6: Upper Big Dry Creek and South Upper Big Dry Creek, from their source to Standley Lake.

Segments 4a, 4b, and 5 are within the LCDB Project boundaries. These segments and their associated watersheds (based on anticipated configuration of the Site after completion of active remediation) are shown on Figure B-09. The current beneficial use classifications for these three segments include:

- Water Supply;
- Aquatic Life - Warm Class 2;
- Recreation Classes 1b and 2; and
- Agricultural.

The above classifications were originally established to protect the water supplies associated with Standley Lake and the Great Western Reservoir. Additional details regarding the use classification and current uses for Big Dry Creek, Standley Lake, the Great Western Reservoir, and Walnut and Woman Creeks are discussed below.

Use Classifications for Mainstem of Big Dry Creek (Segment 1)

The primary focus of the segment designations, use classifications, and numerical standards is the protection of the public water supplies associated with Great Western Reservoir and Standley Lake. Unlike the other segments for Big Dry Creek, Segment 1 is located downstream of the Great Western Reservoir and Standley Lake water supplies and is, therefore, not classified as water supply. The use classifications for Segment 1 include:

- Aquatic Life - Warm Class 2;
- Recreation Class 2; and
- Agricultural.

Because Segment 1 is not classified as a water supply, less stringent numeric standards have been established for this segment.

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Use Classifications for Standley Lake (Segment 2)

Standley Lake is currently being used for domestic potable water (after treatment) by the Cities of Westminster, Thornton, Federal Heights, and Northglenn. Standley Lake is also a popular fishery and provides many fishermen with edible species that are likely consumed regularly along with the potable water supplied from the lake. [see 5 CCR 1002-38.32(3)].

DOE funded the construction of the Standley Lake Protection Project (also known as Woman Creek Reservoir or Option "B"). This project, completed in early 1996, consists of a 100-year flood detention reservoir to retain and divert runoff associated with Woman Creek around Standley Lake. As such, Standley Lake is isolated from any potential contaminated runoff from RFETS.

Use Classifications for Great Western Reservoir (Segment 3)

Great Western Reservoir was originally constructed in 1904 and was used as an irrigation reservoir until the 1950's when it was developed as a water supply reservoir by the City of Broomfield. In 1981, the WQCC classified Great Western Reservoir for water supply use only. Although the Great Western Reservoir contains fish, fishing is presently forbidden. However, the WQCC in their December 1989 Rulemaking Hearing stated that, "the potential for allowing that use [fishing] in the future is possible, and water quality adequate to support that use should be preserved." [see 5 CCR 1002-38.32(3)].

Based on a subsequent request by the City of Broomfield, the WQCC added the classifications of Aquatic Life - Warm Class 1 and Recreation Class 1 in 1984 to provide additional protection to the water supply even through these uses do not actually exist. [see 5 CCR 1002-38.50(2)(c)].

DOE funded the construction of the Great Western Reservoir Replacement Project, which is part of a group of projects known as Option "B". This project, completed in 1997, provided an alternate water supply to the City of Broomfield, and the City agreed that Great Western Reservoir would no longer be used as a drinking water source. Instead, the City of Broomfield intends to use the reservoir to store wastewater effluent for reuse as irrigation water.

In the December 1996 rulemaking proceeding [see 5 CCR 1002-38.50(1)], the WQCC reclassified Great Western Reservoir from Aquatic Life - Warm Class 1 to Class 2 and from Recreation Class 1 to Class 2. The WQCC also added an agriculture use classification for the reservoir. The water quality standards were modified to match the revised classifications. The WQCC retained the Water Supply classification for the reservoir to ensure compliance with 40 CFR 131.3(a), which states that uses in place on November 28, 1975 are to be maintained. However, the corresponding water supply standards were deleted since Broomfield has abandoned the reservoir as a domestic water supply and have stated that they have no plans to reinstate the water supply use. Furthermore, Broomfield plans to use the reservoir to hold reclaimed wastewater that is not suitable for water supply.

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Use Classifications for Walnut and Woman Creeks (Segments 4a, 4b, and 5)

In July 1989, the WQCC established new segments, use classifications and standards for Walnut and Woman Creeks. In this action, the WQCC classified Walnut and Woman Creeks as water supplies even though these uses did not in fact exist in these segments. The basis for this action was "to establish an extra layer of protection for the major water supplies in Great Western Reservoir and Standley Lake, particularly considering the proximity upstream of a major industrial, complex utilizing nuclear materials." [see 5 CCR 1002-38.32(2)]. During the July 1989 and November 1992 Rulemaking Hearings, the WQCC stated,

> "If in the future permanent diversion structures are constructed, with an appropriate capacity to assure that Walnut and Woman Creek water will not enter the two reservoirs, the Commission can reconsider the appropriateness of the water supply classification at that time." [see 5 CCR 1002-38.32(2) and 5 CCR 1002-38.38(E)(3).]

Although the Great Western Reservoir will no longer be used for water supply and all runoff from RFETS associated with the Walnut and Woman Creek drainage basins are currently diverted around the Great Western Reservoir and Standley Lake, the WQCC has not modified the use classifications for Walnut and Woman Creeks. The Water Supply use classification for Segments 4a and 4b have not been revised because the vision statement for RFETS contained in RFCA indicates water leaving the Site will be of acceptable quality for any use and downstream waters flow near populated areas where human contact with the water is possible. [see 5 CCR 1002-38.50(2)(c)].

For the purpose of the LCDB Project, the current use classifications and associated standards for Walnut and Woman Creek (Segments 4a/4b and 5) specified in RFCA, Attachment 5 (21 March 2000) will be used to develop the initial conceptual design. However, the Site may submit a petition to the WQCC to revise the on-site use classifications and water quality standards to be consistent with downstream use classifications and the latest EPA guidance / technical data.

2.5.1.2 Surface Water Quality Standards

The surface water requirements that apply to RFETS after active remediation are specified in RFCA Attachment 5 (*Action Levels and Standards Framework for Surface Water, Groundwater, and Soils*) Paragraph 2.3 (DOE, 2000d), which states that surface water must be of sufficient quality to support any surface water use classification in both Segments 4a/4b and 5.

The numeric values for the surface water quality standards and associated requirements that have been adopted as the design basis for the LCDB Project are listed in RFCA Attachment 5. It is recognized that these standards and associated requirements are subject to change. For the purpose of developing the design basis and initial conceptual design for the final land configuration under this work plan, the standards and associated requirements identified in 21 March 2000 version of Attachment 5 were adopted and the

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following criteria and assumptions for implementing the RFCA requirements have been adopted:

- **Temporary Modifications:** Per RFCA Attachment 5, Paragraph 2.3, all temporary modifications will expire upon completion of active remediation. The potential impact associated with the elimination of these temporary modifications will be considered in developing the bounding scenarios and the initial conceptual design. A list of the temporary modifications is provided below.

Compound	Temporary Modification (mg/L)	Surface Water Quality Standard (mg/L)
Carbon tetrachloride	5.00E-03	2.50E-04
1,1-Dichloroethene	7.00E-03	5.70E-05
1,2-Dichloroethane	5.00E-03	4.00E-04
Benzene	5.00E-03	1.00E-03
Nitrate	1.00E+02	1.00E+01
Nitrite	4.50E+00	5.00E-01
Tetrachloroethene	5.00E-03	8.00E-04
Trichloroethene	5.00E-03	2.70E-03

- **PPRGs:** RFCA Attachment 5, Table 1: *Surface Water Action Levels and Standards,* states that values based on PPRGs are applied only as action levels and are not enforceable standards. RFCA Attachment 5, *Summary Table: Action Levels and Standards Framework,* states that after active remediation, all actions levels will either be discontinued or converted to enforceable standards. The decision to discontinue action levels or convert them to enforceable standards has not been made. For the purpose of the LCDB Project, PPRGs will be considered to develop the initial conceptual design.
- **Practical Qualification Limits (PQLs):** RFCA Attachment 5, Table 1: *Surface Water Action Levels and Standards,* states that whenever the PQL for a pollutant is higher (less stringent) than its corresponding standard, the PQL was used as the compliance threshold [e.g., standard].

It is noted that the Comprehensive Risk Assessment (CRA), which includes both human health and ecological considerations, will be completed following active remediation of the Site. For the purpose of the LCDB Project, it is assumed that the surface water quality standards specified in RFCA will be sufficiently protective of the human health and ecological risk-based remediation levels derived from the Comprehensive Risk Assessment and include in the CAD/ROD (see Data GAP-180). This assumption is reasonable because the surface water quality standards are already based on human health consumption of the water as a drinking water source. It is noted that the developed of the CRA and alternate risk-based remediation levels is outside the scope of the LCDB Project.

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2.5.1.3 Points of Compliance

As specified in RFCA Attachment 5, Paragraph 2.2.B.3, the POCs for surface water will be at the outfalls of the terminal ponds and near where Indiana Street crosses both Walnut and Woman Creeks. These POCs are shown on Figure B-09 and include:

- Terminal Pond A-4 as monitored by GS11,
- Terminal Pond B-5 as monitored by GS08,
- Terminal Pond C-2 as monitored by GS31,
- Walnut Creek flow at Indiana Street as monitored by GS03, and
- Woman Creek flow at Indiana Street as monitored by GS01.

This paragraph of RFCA also states that if the terminal ponds are removed, new monitoring and compliance points will be designated and will consider groundwater in stream alluvium. For the purpose of developing and evaluating LCDB Project scenarios that involve removal of the terminal ponds, it is assumed that only the Walnut Creek (GS03) and Woman Creek (GS01) monitoring points at Indiana Street will be POCs (see Data GAP-040). The appropriateness of the monitoring locations will be evaluated during the initial conceptual design to determine if any POC should be relocated.

Compliance at the POCs will be determined in accordance with the monitoring methods identified in RFCA Attachment 5 and the IMP for the analytes of interest. For the purpose of the LCDB Project, it is assumed that compliance with the RFCA standards will be based on the 30-day moving average.

2.5.1.4 Summary of Surface Water Monitoring Results

RFCA states that compliance with the surface water quality standards is to be determined at the POCs using a 30-day moving average unless otherwise specified in the IMP. The 30-day moving average for a particular day is calculated as a volume-weighted average based on the previous 30-days when flow was recorded. For the purpose of calculating the 30-day average, the following guidelines are applied:

- For days where no flow is recorded or sample results are not available, no 30-day average is reported.
- Flow-measurements error is not considered. [For example, flow measurement error for SW093 is estimated to be in the 5% - 15% range (DOE, 1999b).]
- Data rejected through the validation process are not used.
- Laboratory duplicate and replicate QC results are not used.
- When a negative result is returned from the lab due to blank correction, a value of zero is used.
- Counting errors are not considered. [However, it is noted that the counting error can be significant, especially for environmental samples, which typically have low activities consistent with background levels.]

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- When field duplicate or laboratory re-run results are available, the average of all the sample results is used.

RFCA monitoring of surface water was initiated on 1 October 1996 at 5 points of compliance (POCs) and 3 points of evaluation (POEs). Table B-08 identifies the location of the POCs and POEs and summarizes the calculated 30-day moving averages for these 8 monitoring locations from 1 October 1996 through 31 March 2001. The 0.15 pCi/L surface water action level for Pu and Am has been historically exceeded at POCs GS03 and GS08, and all three POEs (GS10, SW027, and SW093). The most frequent exceedences and highest calculated 30-day moving averages typically occur at GS10, which is located just upstream of the B-1/B-2 bypass on South Walnut Creek.

RFCA requires that a source evaluation be conducted to identify the potential cause of 30-day moving average values that exceed the surface water action level and provide recommendations to preclude future reoccurrences. Several Source Evaluation Reports have been prepared over the years (DOE, 1998a; DOE, 1998b; DOE, 1999a; DOE, 1999b; DOE, 2001a; DOE, 2001b; and DOE, 2001c). The most significant findings are summarized below:

- The analytical results for Am (0.256 ± 0.116 pCi/L) and Pu (0.465 ± 0.129 pCi/L) from the composite sample collected for the period 15 May through 25 June 1997 resulted in the only reportable exceedence that occurred at GS03. This composite sample was collected during low-flow conditions, which resulted in a sample volume (approximately 1 liter) less than the minimum recommended sample volume of 4 liters specified radiochemical analysis. No specific source of the exceedence was identified and water from the terminal ponds (Pond A-4 and B-5) were not discharged during the sample collection interval. Since this sample was collected during low-flow conditions, sediment transport and suspension within the surface water should have been minimal. It was concluded that the most probable cause of the exceedence at GS03 was due to transport of legacy actinide-bearing sediments that were already present within the drainage channel between the terminal ponds and GS03. (DOE, 1998a).
- The analytical results for Pu (0.864 ± 0.124 pCi/L) from the composite sample collected for the period 11 through 17 August 2000 resulted in the only reportable exceedence that occurred at GS08. During the discharge of Pond B-5, results of the pre-discharge sample and the composite sample collected at GS03 were well below the standard. Although the sample analysis did pass verification and validation, the laboratory reported unusual difficulties in completing the analysis. It was also noted that sample result did not fit with the historical dataset; the Pu to Am ratio was significantly higher than all other results and the Pu activity was significantly higher than expected based on the corresponding TSS concentration. Although the validity the sample result is suspect, this result may actually be a manifestation of a greater amount of spatial or temporal inherent variability than expected for Pu in surface water. Mechanisms such as 'hot' particles, particle aggregation, transport of selective particle sizes (enrichment), or other physiochemical/biochemical processes may be responsible for high actinide concentrations detected in the surface waters at RFETS. Site personnel concluded

that the likely source of the reportable 30-day moving averages for Pu at GS08 is diffuse radionuclide contamination from past Site operations released to the environment through events and conditions over past years. (DOE, 2001b).

- Exceedences at GS10 occur more frequently and at higher activity levels than the other POC/POE monitoring locations the Site. The average Pu/Am ratio at GS10 is lower than observed in other drainages across the Site and varies significantly in the various monitored sub-drainages that flow to GS10. This trend suggests that an Am source exists within the GS10 drainage. The Site concludes that the likely sources of the reportable 30-day moving average values at GS10 are:

  1. Diffuse actinide contamination associated with soils and sediments from past Site operations released to the environment through events and conditions over past years. This actinide contamination is transported with suspended solids in surface-water runoff during precipitation events.

  2. Actinide contamination enriched in Am that has been incorporated into the stream sediments in South Walnut Creek from past Site operations through events and conditions over past years. This actinide contamination is transported through sediment resuspension by surface-water runoff during precipitation events.

  (DOE, 1998a, 1999a, and 2001c).

- Exceedences at SW027 typically coincide with larger storm events that may result in more overland flow and erosion into the SID or resuspension of sediment already present in the SID. A significant volume of water is lost through infiltration and evaporation due to the storage capacity of the SID. It appears that a portion of the Pu load is lost to the streambed as the sediments settle within the SID. Higher actinide levels are also associated with runoff from the 903 Pad. Site personnel conclude that the likely source of the reportable 30-day moving averages for Pu at SW027 is diffuse radionuclide contamination from past Site operations released to the environment through events and conditions over past years, particularly from the 903 Pad. (DOE, 1998b and 2001a).

- Exceedences at SW093 have occurred only twice for Pu. On both occasions, the duration of the exceedence was short and occurred in the August time frame when more intense thunderstorms are likely to occurred. No single source has been identified as the cause of the exceedence; however, the Building 779 sub-drainage (monitored by GS32) may be a significant contributor of actinide loads to SW093. The average activity at GS32 is typically 50 to 100 times greater than observed at SW093. (DOE, 1999b).

Based on the Source Evaluations, Site personnel conclude that no specific remedial action(s), other than scheduled remedial actions and closure activities for the Site, are required.

The SEP plume is a potential source of nitrate in North Walnut Creek. Although nitrate concentrations have been historically below the temporary modification of 100 mg/L, samples collected from Pond A-3 and GS13 have been above the water quality standard

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of 10 mg/L. Because all temporary modifications will be eliminated after completion of active remediation, the potential for exceedence of the nitrate standard will be considered. Approaches to comply with the surface water quality standard for nitrate will be developed in conjunction with previous remedial actions and decision documents.

Exceedence of the pH standard (9.0) has occurred in the past. RFCA indicates that pH exceedence is due to detention and batch release mode of operation for the terminal ponds. Although the pH values for flow into the ponds (including wastewater treatment plant effluent and storm water) ranges from 6.5 to 9.0, the nutrients contained with the flow promotes algae growth in the ponds. The algae can shift carbonate equilibrium and thus raise the pH above 9.00. With the elimination of the wastewater discharge, exceedence of the pH standard after completion of active remediation is unlikely.

Although the exceedences identified above are based on conditions prior to completion of active remediation, the potential for future exceedences are likely to be restricted to these compounds. That is to say, other compounds (including VOCs) are not expected to cause an exceedence after the completion of active remediation. The results of future investigations will be incorporated into the design basis and will be used to confirm that the current and/or planned groundwater remedial actions will be effective, in conjunction with the final land configuration, to maintain compliance with the surface water quality standards at the POCs.

2.5.2 Surface and Subsurface Soil Characterization Information

Under RFCA, surface soil is defined as the top 6 inches of soil and subsurface soil is defined as soils deeper than 6 inches below the ground surface (DOE, 1996a). Soil characterization data for samples collected within the BZ is presented in the *RFETS Buffer Zone Data Summary Report* (Kaiser-Hill, 2001a). Soil characterization data for samples collected within the IA is presented in the *RFETS Industrial Area Data Summary Report* (Kaiser-Hill, 2000e). These reports identify the sample locations and available characterization results. The soil characterization data is used to determine if a remedial action is required based on exceedence of Tier I or Tier II action levels.

Current characterization efforts for the IA have focused on the identification of contaminated areas that will be removed as part of closure activities. Areas where under building contamination may be located in the IA are identified on Map ID: 99-0183-PAC, *Potential Areas of Concern and Under Building Contamination Sites* (available on EDDIE). The primary under building contaminants are uranium, plutonium, americium, and nitrate, although others may be present. Additional characterization information will be developed throughout the closure process and upon completion of closure activities to support a final No Further Action decision for the Site.

Potential areas of soil contamination in the BZ include the landfills, the east firing range and target area, and the 903 Pad area. Trench T-3 (located in the southeastern part of the BZ) contains soils that are between Tier I and II action levels. For the purpose of the LCDB Project, it is assumed that soils between the Tier I and II action levels will remain in place (see Data GAP-150).

The potential impact to surface water quality due to soil erosion and migration of actinides [e.g., americium-241 (Am-241) and plutonium-239/240 (PU-239)] is being studied by the AME Project Team. It is generally understood that surface soils over portions of RFETS were impacted by accidental releases of these actinides. Erosion of soils with Am or Pu contamination is considered the key transport mechanism in achieving compliance with surface water quality standards. Particle size and the associated distribution of contaminants is one factor in determining the amount contaminants that can be eroded to surface water and the ability of the particle to remain suspended. In surface water systems, particles less than 2 microns in diameter are generally considered unsettlable (WWE, 1998). Larger-size particles will settle unless disturbed. The unsettled fractions typically cause surface water quality exceedences. In theory, activity should increase with decreasing particle size due to the higher surface area to volume ratio of smaller particles. However, analytical results performed on soil samples collected from RFETS indicate that activity is relatively constant with decreasing particle size (RMRS, 1998c).

The AME Project Team performed geostatistical analyses (including kriging using a weighted moving average technique to interpolate values from a sample data set onto a grid of points for contouring) for Am and Pu soil sample results. This procedure allowed Site-wide surface concentrations to be approximated using a limited number of discrete surface soil samples. Maps showing the distribution of Am-241 and Pu-239 concentrations in surface soils are contained within the *Report on Soil Erosion and Surface Water Sediment Transport Modeling for the Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site* as Map 2k-0048 (am_grid.aml) and Map 2k-0048 (pu_grid.aml), respectively (Kaiser-Hill, 2000a).

The Pu and Am activities in soil and sediment range from zero to more than 4,000 pCi/g (DOE, 1999b). Most soil at RFETS is in the 0.1 to 10 pCi/g range. Soils with the highest activities are located under the 903 Pad and, therefore, would not erode. Remedial actions are being taken to remove soil that is above the Tier I action levels of 1,429 pCi/g for Pu and 215 pCi/g for Am. Actinide concentrations are generally below the Tier II action levels of 252 pCi/g for Pu and 38 pCi/g for Am at most locations. There are no management restrictions for soils that are below Tier II action levels. Soil samples with results above Tier II, but below Tier I, are generally restricted to the east of the 903 Pad and in the sediments associated with the B-Series ponds (see Map ID: 98-0208, Surface Soil and Sediment Sampling Locations).

The AME group collected stormwater runoff from GS10 to assess the particle-size distribution of plutonium in suspended solids and to evaluate the characteristics of plutonium-containing particles in surface-water. Approximately 300 liters of water were collected in April for ultrafiltration with various nominal pore-size ultrafilters by Texas A&M researchers. The filtered particles will be analyzed for actinide activity, selected metals, organic carbon, and surface charge. These data should provide clues as to the sources of the plutonium-contaminated particles and how their transport might be controlled. This investigation also considered the affects on plutonium mobility due to changes in oxidation/reduction (redox) conditions. This portion of the investigation was conducted to evaluate what happens to the plutonium-contaminated sediments when they

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are deposited in deep-water or wetland environments that are present in Site detention ponds. A final report was provided to the Site in September 1999 (Santschi).

The properties of Site soil aggregates and the affect of disaggregation on actinide migration was investigated to determine the dominant forms of materials that bind smaller, primary soil particles into larger soil particles. Knowledge of the aggregating properties of the Site soils provide insight to the mechanisms by which plutonium-contaminated soils are moved by natural processes such as freeze-thaw cycling, raindrop impact, erosion and sediment transport.

The AME Project Team has also calibrated mathematical models (WEPP and HEC-6T) to estimate actinide movement to surface water via soil erosion. The calibration results for existing conditions are presented in *Report on Soil Erosion and Surface Water Sediment Transport Modeling for the Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site* (Kaiser-Hill, 2000a).

Significant conclusions from the above AME investigations include:

- Partition coefficients for soil/sediment-water system (ranging from 10^4 to 10^5 L/kg) suggest that Pu and Am are strongly bound to particulates, and are likely mobilized by physical transport mechanisms, not by dissolution under normal conditions (Santschi, 1999).
- Site soil aggregates are predominantly held together with organic materials, not iron and manganese oxide cements (Santschi, 1999).
- Experimental results (Santschi, 2001) indicate that Pu and Am solubility in soils does not increase in strong reducing environments (i.e. low oxygen content). This means that waterlogged soils or wetland environments should not necessarily be regarded as areas with high actinide mobility terms. Rather, these environments could be actinide "sinks," as AME data suggests that actinide solubility actually decreases with decreasing Eh (redox potential).
- Pu in the Site environment is predominantly in the +4 oxidation state. Therefore, the plutonium is in the form of PuO_2, which is extremely insoluble and will be transported as a particulate, not a dissolved species.
- Pu at femptocurie levels (fall out levels) is present almost entirely in colloidal form in Walnut Creek water discharged from the Site.
- Research (Santschi, 1999) also supports the hypothesis that the Pu and Am in soils is not evenly distributed amongst particle sizes. A majority of the total activity is associated with particular size fractions of the total soil mass. Selective transport of small grain particle via storm water runoff may be causing "enrichment" of the actinide activities detected in surface water. The enrichment ratio for clay- and silt-sized particles (less than 10 microns) is about 1.65 for the GS42 drainage basin (Ranville, 1998). In other words, the activity per gram of the suspended solids is approximately twice the parent surface soil located in the drainage basin.

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- HEC-6T modeling for Walnut Creek indicates that channel erosion accounts for a majority of the suspended sediment concentration for a one-year return period (35 mm rain in 11.5 hours, one-year event), but erosion due to overland runoff contribute more sediment than channel erosion process for larger events (97.1 mm, 100-year, 6-hour event). In general, at least 30 mm rainfall in less than an hour is required to produce overland flow on the hillsides at RFETS (Kaiser-Hill, 2000a).
- Povetko and Higley (2000) identified 990 discrete Pu-containing particles that included several large (greater than 2 microns) conglomerate particles containing Pu and Am. One such conglomerate with a particle size of about 500 microns contained 1.87 Bq (50.5pCi) or 94% of the total recorded alpha activity of 1.98 Bq in all 990 particles. In other words, the conglomerate contained 94% of the sample Pu, while the other 989 particles contained the remaining 6%.

Since the radionuclide action levels for subsurface soils are the same as surface soils, the subsurface soil actions are considered protective in the event that subsurface soils become exposed due to erosional processes.

2.5.3 Landfills and ET Covers

For the purpose of the LCDB Project, it is assumed that evapotranspiration (ET) covers will be installed over the Original Landfill, the Present Landfill, and the Solar Evaporation Ponds and fully vegetated (see Data GAP-130 and GAP-140). The feasibility to cover these areas and the initial conceptual design for the ET covers is being developed under a separate project. The anticipated footprints for the proposed ET covers are shown on Figure B-03. This section provides background information for the Original Landfill, the Present Landfill, and the Solar Evaporation Ponds, and presents preliminary design information for the ET covers.

2.5.3.1 <u>Original Landfill</u>

The Original Landfill is located just outside the southwest corner of the IA. The Original Landfill and the overlying Water Treatment Plant Backwash Pond occupies approximately 20 acres. Hazardous materials were buried at the landfill in addition to a suspected amount of depleted uranium from previously buried ash and scrap. Surface radiological contamination has been detected in several areas. The current remedial action plan calls for hot spot identification and source removal prior to installation of the ET cover. The Backwash Pond, which was previously located on the top of the landfill, was used as an evaporation/settling pond for the back flushing sand filters from the Building 124 water treatment facility.

The landfill slope towards Woman Creek is steep. Erosion and sloughing of the landfill slope has been observed. A retaining wall may be required to facilitate installation of the ET cover. The landfill boundary is adjacent to wetland areas and encroaches into the habitat of the Preble's Meadow Jumping Mouse (Preble's mouse). Additional details regarding the Original Landfill are presented in the *Final Phase I RFI/RI Report, Woman Creek Priority Drainage, Operable Unit 5* (DOE, 1996c)

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2.5.3.2 Present Landfill

The Present Landfill is located in the north BZ at the headwater to No Name Gulch. The Present Landfill was operated as a municipal landfill from 1968 through 1998; however, it is identified as an Interim Status unit under RCRA because it received hazardous waste. The area consists of approximately 21 acres of landfill with an additional 9 acres of buttress and pond. The pond is used to retain and store discharge from a seep located at the toe of the landfill. A passive system is in place to treat the seep water prior to flowing into the pond (see Section 2.5.5.5). An investigation is currently underway to determine whether groundwater is moving into the landfill, bypassing the slurry wall barrier designed to minimize this movement. The investigation will also determine if corrective actions are warranted. *Operable Unit 7 Revised Draft Interim Measure/interim Remedial Action Decision Document and Closure Plan* (DOE, 1996d) provides additional detailed design criteria and information on the Present Landfill.

A steeply sloped buttress is located adjacent to the seep area. Sloughing of the slope has been observed over time and is likely caused by saturated conditions under the landfill and possible groundwater intrusion from the northwest through a potentially failed slurry wall at the northern boundary of the landfill. The final grades of the ET cover are to correct the sloughing problem at the buttress. Current closure plans call for the installation of a gravel drainage layer from the current seep area to the east edge of the ET cover. The gravel drainage will be sloped to allow seepage to discharge through the ET cover into No Name Gulch. The current passive flagstone step treatment system (see Section 2.5.5.5) will be relocated to treat the seep water.

2.5.3.3 Solar Evaporation Ponds

The Solar Evaporation Ponds (SEPs) are located in the northeastern quadrant of the IA and encompass approximately 12 acres. The five ponds were used to temporarily store and evaporate radioactive and neutralized acidic wastes. SEPs are identified as an RCRA interim-status unit under RFCA. *OU4 Solar Evaporation Ponds Interim Measure/Interim Remedial Action Environmental Assessment Decision Document* (DOE, 1995b) provides additional detailed design and information on the SEPs.

Several of the evaporation ponds have asphalt planks built into the liners that typically contain asbestos. The final design will address whether the liners need to be removed or can remain in place. The SEPs will be closed in-place by bringing the pond area to grade, perhaps utilizing the Pond Berm material, prior to installation of the ET cover.

2.5.3.4 ET Cover Design Description

A separate project is developing the initial conceptual design for the ET covers. The work includes modeling the performance of the ET cover, justifying the design, developing the foundation for subsequent detailed design efforts, and determining the feasibility of the ET cover application. A reasonable design life for the ET covers, including consideration of the 1,000-year design criteria specified in UMTRA, is to be established as part of the ET cover project. The results of the ET cover design will be

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used to support the LCDB Project. The components of a typical ET cover are shown on Figure B-10 and consist of (starting form the bottom of the cover):

1. **Subgrade -** Common fill is typically used to provide the required contours/slope for storm-water runoff. The subgrade also serves as the base material for supporting the overburden layers of the cover.

2. **Biota Barrier -** EPA and CDPHE recommend that inclusion of a biota barrier to prevent the formation of preferred pathways for seep water created by burrowing animals (e.g., prairie dogs, etc). The biota barrier is typically 12 to 18 inches thick. The source of the biota barrier material may be offsite borrow sources or clean (meeting the unrestricted release criteria) concrete rubble from onsite building foundations. The top of the biota barrier is typically covered with a geotextile fabric to keep soil particles from filling void spaces within the biota barrier.

3. **Select Soil Backfill -** The backfill, which is approximately 42 inches thick, serves the following functions:

   - Promote vegetative growth for efficient ET process;
   - Provide sufficient water storage capacity during months when vegetative growth is dormant;
   - Provide a weather-resistive, abrasive surface to resist wind and water erosion at RFETS; and
   - Control the rate of runoff from precipitation.

   It is envisioned that the top 12 inches of backfill material could be RFETS alluvium, which has shown remarkable resistance to wind and rain over many years. The remaining material will be selected to achieve the functions listed above.

4. **Vegetative Cover** - The vegetation will be composed of perennial species indigenous to RFETS that are capable of surviving harsh summers and winters with little precipitation. The vegetation will be required to germinate and flourish with minimum maintenance. The vegetative species selected will be recommended by the RFETS Ecology Group with input from other government agencies (e.g., U.S. Fish and Wildlife Service, and Natural Resources Conservation Service).

2.5.4 Groundwater Characterization Information

Per RFCA, contaminated groundwater is being remediated only to protect surface water and ecological resources. Groundwater action levels are based on a two-Tier approach as specified in RFCA Attachment 5. Tier I action levels consist of near source action levels for accelerated cleanup projects. Tier II levels are action levels which are designed to be protective of surface water. Groundwater characterization information presented in the following sections is based on comparison to Tier II action levels.

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Based the 1999 groundwater monitoring data, constituents above the RFCA Tier II action levels include carbon tetrachloride, 1,1-dichloroethylene (DCE), *cis*-1,2-DCE, *cis*-1,3-dichloropropene, methylene chloride, tetrachloroethylene (PCE), trichloroethylene (TCE), vinyl chloride, antimony, chromium, fluoride, manganese, molybdenum, nickel, nitrate/nitrite, selenium, U-233/234, U-235, U-238, and Strontium 89/90. Some of the constituent concentrations that are above the Tier II action levels are attributed to natural background. It is likely that these constituents will remain in groundwater at closure and could impact surface water quality.

The 1999 Tier II exceedences detected were detected primarily in the eight areas presented in the following subsections. The projected locations of the VOC and nitrate plumes above Tier I and II action levels are identified on Figure B-03. Further details (including maximum concentrations and plume locations) are provided in the *1999 Annual Rocky Flats Cleanup Agreement Groundwater Monitoring Report* (RMRS, 2000).

The uranium plume associated with the Solar Evaporation Ponds was not included in developing Figure B-03 because the nitrate plume encompasses the uranium plume. The highest concentrations of uranium are found adjacent to the Solar Ponds, while the higher concentrations of nitrates are found at a greater distance from the ponds. The historical data also suggest that the uranium in groundwater near North Walnut Creek is naturally occurring and not part of the uranium plume. (Primrose, 1999).

2.5.4.1 903 Pad/Ryans Pit Plume

This plume originates from the 903 Pad/Ryans Pit area and extends south and east toward Woman Creek. The plume is mainly composed of carbon tetrachloride from the 903 Pad area and TCE from the Ryans Pit area. In 1999, groundwater constituents that exceeded Tier II action levels in the 903 Pad/Ryans Pit plume consisted of carbon tetrachloride, methylene chloride, PCE, TCE, U-233/234, U-238, selenium, antimony, chromium, molybdenum, nickel, and nitrate/nitrite.

2.5.4.2 PU&D Yard Plume

The PU&D Yard Plume is an elongate plume south of the Present Landfill that extends from the PU&D Yard to approximately 2600 feet down gradient. In 1999, groundwater constituents that exceeded Tier II action levels in the PU&D Yard Plume consisted of 1,1-DCE, nitrate/nitrite, fluoride, U-233/234, and U-238.

2.5.4.3 East Trenches Plume

The East Trenches Plume is located north of East Perimeter Road (RMRS, 2000). This groundwater plume consists of VOC contamination believed to originate from the East Trenches and the 903 Pad and extends to the north and northeast to where the plume discharges as seeps and subsurface discharges into the South Walnut Creek (RMRS, 2000). In 1999, groundwater constituents that exceeded Tier II action levels in the East Trenches Plume consisted of carbon tetrachloride, PCE, TCE, *cis*-1,2-DCE,

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U-233/234, and U-238. A groundwater plume system was installed in 1999 to collect and treat the groundwater associated with this plume (see Section 2.5.5.3).

2.5.4.4 881 Hillside Plume

The 881 Hillside Plume is located in the southern part of the IA on the hillside south of Building 881 and just north of Woman Creek (RMRS, 2000). The 881 Hillside Plume historically contained VOCs (RMRS, 2000). A french drain was installed in 1992 to collect groundwater from this plume. The french drain was taken out of service in September 2000 since groundwater constituents have been consistently below the Tier II action levels (see Section 2.5.6.1).

2.5.4.5 Carbon Tetrachloride Plume

The Carbon Tetrachloride Plume is located just southeast of Building 701 and consists primarily of dissolved phase carbon tetrachloride issuing from a secondary dense non-aqueous phase liquid (DNAPL) source (RMRS, 2000). The secondary DNAPL source is a result of spills a carbon tetrachloride storage tank, which has subsequently been removed (RMRS, 2000). In 1999, groundwater constituents that exceeded Tier II action levels in the Carbon Tetrachloride Plume consisted of carbon tetrachloride, 1,1-DCE, cis-1,3-dichloropropene, TCE, selenium, U-233/234, U-235, U-238, and nitrate/nitrite.

2.5.4.6 Industrial Area VOC Plume

The IA VOC Plume spans the middle of the IA in a north-northeast orientation and is migrating toward both Woman and North Walnut Creeks (RMRS, 2000). In 1999, groundwater constituents that exceeded Tier II action levels in the IA VOC Plume consisted of TCE, methylene chloride, manganese, nickel, selenium, thallium, nitrate/nitrite, U-233/234, and U-238.

2.5.4.7 Solar Ponds Plume

The Solar Ponds Plume consists primarily of nitrate and uranium isotopes and extends from the Solar Evaporation Ponds to North Walnut Creek (RMRS, 2000). In 1999, groundwater constituents that exceeded Tier II action levels in the Solar Ponds Plume consisted of selenium, nickel, nitrate/nitrite, U-233/234, U-235, and U-238.

Geochemical modeling has shown that the groundwater under the Solar Evaporation Ponds are under saturated with respect to uranium minerals that would suggest that the uranium should be free to move with the groundwater unless attenuated. In the conditions found at the Site, uranium will exist primarily in the +6 oxidation state. In natural waters, U (VI) will form complexes with carbonates, which will keep it relatively soluble. Uranium is less likely to exhibit strong sorptive behavior like americium or plutonium. A groundwater plume system was installed in 1999 to collect and treat the groundwater associated with this plume (see Section 2.5.5.4).

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2.5.4.8 Mound Plume

The Mound Site consists of a former waste burial area where 1,405 drums containing uranium and beryllium contaminated lathe coolant were buried in 1954 (RMRS, 2000). In 1970, all of the drums were exhumed along with some radiologically contaminated soil (RMRS, 2000). The Mound Plume, comprised primarily of VOC contamination, extends from the Mound Site to the South Walnut Creek where it discharged through seeps and subsurface flows (RMRS, 2000). In 1999, groundwater constituents that exceeded Tier II action levels in the Mound Plume consisted of vinyl chloride, manganese, U-233/234, and U-238. A groundwater plume system was installed in 1998 to collect and treat the groundwater associated with this plume (see Section 2.5.5.2).

2.5.5 Groundwater Treatment Systems Remaining After Closure

Four passive groundwater treatment systems may be operated after the completion of active remediation. The system locations are shown on Figure B-03 and include:

- Mound Site Plume Treatment System,
- East Trenches Plume Treatment System,
- Solar Ponds Plume Treatment System, and
- Present Landfill Seep Treatment System.

The standard details for the Mound, East Trenches, and Solar Pond Plume Systems are described in Section 2.5.5.1. Specific details for these three systems are provided in Sections 2.5.5.2 through 2.5.5.4. The fourth system installed to treat seepage from the Present Landfill is discussed in Section 2.5.5.5. The results of future investigations will be incorporated into the design basis and will be used to confirm that the current and/or planned groundwater remedial actions will be effective, in conjunction with the final land configuration, to maintain compliance with the surface water quality standards at the POCs.

2.5.5.1 Standard Details for the Mound, East Trenches, and Solar Pond Plume Systems

The Mound, East Trenches, and Solar Pond Plume Treatment Systems have a similar design (see Figure B-11) to passively collect and treat contaminated groundwater to the Tier II Groundwater Action Levels specified in RFCA. The design consists of a sloped collection trench to allow gravity flow of the intercepted groundwater to a treatment cell. (DOE, 2000a and DOE, 2000b).

The collection trench is an excavated box trench that is approximately 24 inches wide with a maximum depth of 35 feet. The down gradient side of the trench is lined with 80 mil high-density polyethylene (HDPE) geomembrane panels. Each panel is approximately 15 feet wide and overlaps each other to provide a hydraulic barrier. The panels extend to the base of the trench where a 2-foot thick bentonite seal is installed. Granular drainage material is placed above the bentonite seal to a height that extends above the water level elevation. A perforated pipe is installed within the granular

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drainage material at least 1-foot above the bentonite seal. The remainder of the excavation is backfilled with native soil with the upper 1-foot being topsoil.

The intercepted groundwater flows from the collection trench to the treatment cells by a solid pipe. Each system has two treatment cells containing a granular treatment media and can be operated individually, in series, or in parallel. The treatment cells are typically operated in series. Water flows down through the treatment media by gravity. The water level is maintained above the top of the treatment media based on the elevation of the outlet piping. As such, the treatment media is maintained under saturated conditions. The effluent from the treatment cells passes through a metering sump and is subsequently discharged.

Each plume system is passively operated and requires limited maintenance. The ongoing maintenance includes raking and changing the treatment media, retrieving flow rates and water level data, and collecting water samples. Additional details regarding each plume system are provided in the following subsections.

2.5.5.2 Mound Site Plume Treatment System

The Mound Site Plume Treatment System is located east of the IA to collect and treat contaminated groundwater from the Mound Site. The contaminated source area was removed as an accelerated action in 1997. The plume system consists of a 220-foot interceptor trench followed by two treatment cells in series. Each treatment cell contains 4 feet of reactive iron filings. Replacement of the treatment media is expected to be required every 5 to 10 years. The treated effluent is discharged to a french drain for infiltration into the soils. The french drain has an overflow pipe that discharges to surface water.

The system has been in operation since September 1998. The total volume of groundwater flow through the system as of 5 March 2001 was approximately 673,300 gallons. From January 2000 to March 2001, the recorded flow rate ranged from 0.06 to 2.1 gpm with an overall average flow rate of approximately 0.45 gpm (Kaiser-Hill, 2001d). The treated effluent is below Tier II action levels. Water level measurements indicate that the collection system is working as designed (Kaiser-Hill, 2001d).

2.5.5.3 East Trenches Plume Treatment System

The East Trenches Plume Treatment System is located east of the IA to collect and treat contaminated groundwater from the Trench 3/Trench 4 area. The sources for the contaminated groundwater plume were removed as an accelerated action in 1996. The plume system was installed in 1999 and consists of a 1,200-foot long collection trench that extends 7 to 23 feet below grade. A perforated collection pipe runs the entire length of the trench.

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The intercepted groundwater flows by gravity to two reactive treatment cells containing reactive iron filings. Replacement of the treatment media is expected to be required every 5 to 10 years. The treated effluent is discharged to a french drain for infiltration into the soils. The french drain has an overflow pipe that discharges to the surface water.

The system has been in operation operated since September 1999. The total volume of groundwater flow through the system as of 5 March 2001 was approximately 3.0 million gallons. From January 2000 to March 2001, the recorded flow rate ranged from 1.6 to 7.0 gpm with an overall average flow rate of approximately 2.9 gpm. The treated effluent is below Tier II action levels. Water level measurements indicate that the collection system is working as designed (Kaiser-Hill, 2001d).

2.5.5.4 Solar Ponds Plume Treatment System

The Solar Ponds Plume Treatment System is located along the northern perimeter road to collect and treat contaminated groundwater from the SEPs containing low-levels of nitrate and uranium. The SEPs were used to store and evaporate process wastewater effluent from the IA. The SEPs were drained and sludge removal was completed in 1995. An ET cover is to be placed over the Solar Evaporation Ponds (see Section 2.5.3.3).

Six interceptor trenches were installed in 1971 to dewater the hillside. The original six trenches were abandoned in place and the Interceptor Trench System (ITS) was installed in 1981. An open french drain/ditch was also installed at the top of the hillside to convey groundwater and surface water from the Solar Ponds into the ITS.

The current Solar Ponds Plume System was installed in 1999 and consists of a 1,100-foot long collection trench that extends 15 to 35 feet below grade. A perforated HDPE pipe runs the entire length of the collection trench. The french drain/ditch was also capped to preclude direct flow of surface water into the collection system. Because the collection trench severed the ITS pipes, the groundwater intercepted by the french drain and portions of the ITS upstream of the collection trench is directed to the treatment chamber. The portion of the ITS that is downstream of the collection trench is plugged at the pump house and, therefore, can no longer convey groundwater.

The water from the collection trench flows into a rectangular treatment chamber that has internal dimensions of 43 feet long, 17 feet wide and 23 feet high. The treatment media is approximately 9 feet deep and consists of iron filings and wood chips. Replacement of the treatment media is expected to be required every 10 to 20 years. The treated effluent is discharged via a perforated distribution pipe into a gravel discharge gallery located adjacent to North Walnut Creek. The effluent then flows along a pre-existing, abandoned dirt road that is reclaimed by volunteer vegetation.

The system has been operational since September 1999. As of 14 June 2001, approximately 421,700 gallons of water were treated. From January 2000 to June 2001, the recorded flow rate ranged from 0 to 11.3 gpm with an overall average flow rate of approximately 0.57 gpm.

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The total volume of groundwater flow through the treatment chamber is less than anticipated. Per the original design, the treatment chamber was to be located near North Walnut Creek to allow gravity flow from the based of the collection trench. However, due the presence of the Preble's mouse (a federally listed threatened species), the treatment chamber was relocated to be higher up the hillside. As a result, the water level within the collection trench must rise above 10 feet to develop sufficient hydraulic head to allow flow through the treatment chamber.

Water levels in the collection trench tend to fluctuate rather than holding a constant level that corresponds to the treatment cell outlet elevation. As such, limited flow is entering into the treatment cell. The nitrate concentration in samples collected from the discharge gallery has been as high as 260 mg/L in August 2000 (Kaiser-Hill, 2000b). The water level data and high nitrate concentrations regularly detected in the discharge gallery indicate that untreated groundwater may be bypassing the plume system and entering North Walnut Creek. However, the standing water at the discharge gallery supports wetlands (including rushes and cattails), which typically have relatively high nitrate uptake rates. It is anticipated that the discharge gallery and associated wetlands will aid in removal of nitrates. (Kaiser-Hill, 2000b).

Surface water results for Pond A-3 and GS13 are below the temporary modification of 100 mg/L for nitrate and the surface water quality standard of 10 pCi/L for uranium (Kaiser-Hill, 2000d). However, the seasonal dieback of the vegetation in the fall and winter months combined with decreased flow in North Walnut Creek, apparently causes nitrate levels to increase slightly at GS13 (Kaiser-Hill, 2001e). The system is being closely monitored to verify that compliance with the surface water quality standards can be maintained when the temporary modification for nitrate expires on 31 December 2009.

2.5.5.5 Present Landfill Seep Collection System

Groundwater contaminated with VOCs and SVOCs is known to seep in the area of the Present Landfill. The seep water is collected and retained within a pond that is located to the east of the Present Landfill. The water from the Landfill Pond is transferred to Pond A-3 when required (typically on an annual basis). For the period from April 2000 to March 2001, the recorded average monthly flow rate ranged from 1.1 to 3.6 gpm with an overall average flow rate of approximately 2.1 gpm.

Between May 1996 and October 1998, the seep water was collected and passively treated through a granular activated carbon (GAC) system before being discharged into the Landfill Pond. The GAC treatment system was replaced in October 1998 with a passive air stripping system to improve removal of vinyl chloride and benzene, which are not effectively removed by GAC. The new system consists of collecting the seep water in a settling basin, allowing the water to cascade over a series of seven flagstone steps followed by flow over a 6-foot long gravel bed before discharging into the Landfill Pond. The new system minimizes waste generation and is more effective in removing vinyl chloride with little change noted in the removal performance for benzene (Kaiser-Hill, 2000b). All effluent concentrations are at or below performance objectives except benzene, which sometimes has an effluent concentration of 2 ug/L. The effluent samples are collected from the discharge area (SW00196), which is located between the gravel bed and landfill pond.

It is assumed that the passive treatment will be relocated during landfill closure (see Section 2.5.3.2). As such, the operation and maintenance of the Present Landfill seep system is included as a constraint for the LCDB Project. This assumption (see Data GAP-130) will be revised as required when final closure plans for the Present Landfill have been completed.

2.5.6 Groundwater Treatment Systems Abandoned Prior to Closure

The following groundwater collection / treatment systems are assumed to be abandoned prior to the closure of RFETS.

- 881 Hillside French Drain, and
- 881 Hillside Collection Well.

As such, the operation and maintenance of these systems are not considered physical constraints for the LCDB Project. Additional details regarding the design, historical operation, and abandonment of these systems is provided below.

2.5.6.1 881 Hillside French Drain

The 881 Hillside french drain was installed in 1992 to intercept contaminated groundwater from the IA. The system consists of a 1,435-foot long french drain keyed into bedrock. The french drain is upgradient of (e.g., north) and parallels the SID. Prior to September 2000, the collected groundwater from the french drain was pumped from a central sump to the Combined Water Treatment Facility (CWTF) through existing buried pipes.

Because groundwater collected by the french drain was consistently below RFCA Tier II Action Levels, the french drain was taken out of service per the provisions of the OU1 Corrective Action Decision (CAD)/Record of Decision (ROD). In September 2000, the french drain was taken out of service by removing the collection gallery sump pump system. The gravel-filled collection gallery sump was then breached by excavating an outfall trench from the SID to the sump location. The trench was lined with geotextile and backfilled with drain rock, allowing groundwater collecting in the sump to flow by gravity from the sump into the outfall trench and into the SID. Additional details of the decommissioning of the french drain system are presented in the OU1 - 881 Hillside Area French Drain Decommissioning Closeout Report. The operation and maintenance of the french drain is not included as a constraint for the LCDB Project.

2.5.6.2 881 Hillside Collection Well

A separate collection well is also located at the 881 Hillside. Groundwater from the Collection Well was pumped into a portable trailer and then transported to the CWTF. Based on the declining concentrations of VOCs in the plume, it is expected that

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extraction and treatment of groundwater from the Collection Well will continue until 2002. At that time, it is expected that water removal and treatment will be discontinued.

Samples will continue to be collected from the Collection Well to demonstrate that contamination is no longer present above Tier I action levels (Kaiser-Hill, 2000b). It is assumed that the monitoring efforts will be completed to allow abandonment of the Collection Well prior to closure of RFETS in 2006. As such, the operation and maintenance of the Collection Well is not included as a constraint for the LCDB Project.

2.6 Ecological Considerations

The relatively undeveloped Buffer Zone at RFETS provides numerous plant communities that are used by wildlife to satisfy habitat needs. These communities include upland grasslands that are representative of plains ecosystems prior to wide-scale fragmentation and urbanization, riparian woodlands along streams and ponds, and several types of wetlands. This section describes the wildlife, threatened and endangered species, and wetlands that are present at RFETS. Future land configuration alternatives could affect these high-interest resources.

2.6.1 Wildlife

RFETS, with the relatively undeveloped expanse of the BZ, provides habitat for many species of wildlife. The exclusion of the public and restricted access on the BZ has allowed wildlife populations to persist with relatively low levels of disturbance, especially when compared to similar habitats in the surrounding Denver metropolitan area. Information in this section is primarily from the *1999 Annual Wildlife Report for the RFETS* (Kaiser-Hill, 2000f).

Mule deer (*Odocoileus hemionus*) are abundant and white-tailed deer (*O. virginianus*) regularly use the areas at RFETS. Mammalian carnivores are well represented at the Site by the coyote (*Canis latrans*) and raccoon (*Procyon lotor*). Numerous rodents and lagomorphs (rabbits) are present. Avian species include 34 species of waterfowl that use habitats at RFETS, four species of raptors that nest on the Site, and numerous migratory bird species. In 1999, 85 migratory bird species were recorded on-site and 194 species have been recorded since 1990. Amphibians and reptiles can be found in appropriate habitats on the Site. More detailed information on the species that use the habitats at RFETS is provided in the *1999 Annual Wildlife Report for the RFETS* (Kaiser-Hill, 2000f).

Some habitats at RFETS can be considered of special importance for wildlife and should not be unduly disturbed by the LCDB Project. These include, but are not limited to, the areas favored by mule deer as fawning areas, the black-tailed prairie dog (BTPD) colonies, and the riparian habitats where raptors and migratory birds may nest.

Wildlife populations are dynamic. For example, BTPDs were numerous on the Site less than 10 years ago, but an outbreak of sylvatic plague decimated the population. The

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prairie dogs are just beginning to recover at several locations within the LCDB area and their population status could significantly change by 2006.

2.6.2 Threatened and Endangered Species

For purposes of the LCDB Project, the term "threatened and endangered species" (previously referred to as "protected species" in past RFETS documents) includes federally listed species (threatened and endangered), federal proposed and candidate species, state-listed species (threatened and endangered), and state species of special locations and requirements concern.

The threatened and endangered (T/E) species known to currently occur at RFETS include the Preble's mouse (*Zapus hudsonius preblei*) (federally- and state-listed as threatened), the bald eagle (*Haliaeetus leucocephalus*) (federally- and state-listed as threatened), and the black-tailed prairie dog (*Cynomys ludovicianus*) (a federal candidate species and state species of special concern). Other T/E species may be found at RFETS irregularly or have the potential to use the habitats at the Site. For a complete list of these species, refer to the *1999 Annual Wildlife Report for the RFETS* (Kaiser-Hill, 2000f). Because the list of T/E species is dynamic, there is uncertainty regarding what species will be listed in 2006 at closure. It is assumed that the species currently listed will retain their status and no species at RFETS will be newly listed (see Data GAP-190).

The T/E species of primary concern at RFETS is the Preble's mouse. The preferred habitat for the Preble's mouse is found in the riparian corridors bordering streams, ponds, and wetlands at the Site. Detailed monitoring for Preble's mouse has resulted in a large body of information regarding the mouse's habitat and the population at RFETS. The Preble's mouse protection areas within the LCDB Project boundary are shown on Figure B-12. Closure activities are subject to evaluation under Procedure 1-D06-EPR-END.03, *Identification and Protection of Threatened, Endangered, and Special-Concern Species* to assess potential project impacts to threaten and endangered species. Any necessary work that may cause significant disturbance, destruction, or other impacts to Protection Areas[2] or Contiguous Wetlands[3] identified on Figure B-12 must be

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2 Protection Areas include all characteristic habitats where the Preble's mouse has been documented, based on studies conducted at the Site since 1991. This habitat is comprised of woody vegetation types: riparian woodland, riparian shrubland, tall upland shrubland, and short upland shrublands (snowberry and skunkbush sumac adjacent to streams). Also included in the protection area category is a 100-foot band of grassland/herbaceous wetland from the perimeter these woody vegetation types. These Protection Areas are along stream channels, pond margins, and around seep wetlands in all stream drainages of the Site.

3 Contiguous Wetlands include wetlands adjacent to, contiguous with, or upstream from Protection Areas. Although these areas already receive protection under the Clean Water Act, they shall receive additional protection at the Site as potential Preble's mouse habitat and because they are essential to maintaining the quality of adjacent Preble's mouse habitat. Wetlands play an important role in capturing upstream waters, and regulating their release downstream. Wetlands are also a natural filtration system that helps settle silt and purify water. Thus, wetlands have a direct effect on Preble's mouse habitat by ensuring that a clean, consistent source of moisture is available to sustain the downstream areas. This naturally controlled release of water throughout the year may be an essential factor in long-term maintenance of the riparian vegetation communities and requisite for the survival of the Preble's mouse. Additionally, wetlands within the riparian zone are now known to act as travel corridors between occupied areas of Preble's mouse habitat and dispersal routes.

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approved in advance of any work per the requirements of the *Preble's Meadow Jumping Mouse Protection Plan* (DOE, 2000f). [Note: The "Contiguous Wetlands" mapped on Figure B-12 and the Site wetlands identified on Figure B-13 may not encompass the same area. Determination of activities that require advance approval for Preble's mouse protection is to be based on Figure B-12 and consultation requirements for the protection of jurisdictional wetlands is to be based on Figure B-13.] The requirements of the Preble's mouse protection plan are subject to periodic revision/update. The latest protection plan should be obtained from the Kaiser-Hill Ecology Group.

Although Preble's mouse population estimates are not definitive, much is known about their preferred habitat. The correlation between the presence of the Preble's mouse and riparian habitats with specific vegetation structural characteristics is high. The changes in hydrology associated with closure of the IA could reduce riparian habitat acreage in the drainages at RFETS, which may cause a decline in the Preble's mouse population at the Site. after closure if supplemental water sources are not provided to support the current extent of riparian habitat.

2.6.3 Water Depletions to the Platte River

The central Platte River is designated "critical habitat" reach for federally threatened and endangered species (see Federal Register, Volume 47, No. 94, 15 May 1978). As such, any depletion of water to the Platte River basin could represent a potential adverse effect to the designated critical habitat and would require consultation with the U.S. Fish and Wildlife Service, including identification of potential mitigation measures. Making annual payments to the Platte River Basin Endangered Species Recovery Implementation Program is the common mitigation measure. The funds are used to purchase water to maintain minimum instream flows and to restore and maintain habitat in the critical habitat reach of the central Platte River. The annual payment of each individual contributor is based on a formula that takes into account the amount of the water depletion on a proportional basis.

2.6.4 Wetlands

Jurisdictional wetlands at RFETS, identified in 1994 by the United States Army Corps of Engineers (USACE), can be broadly grouped into stream wetlands and seep- and spring-fed wetlands based on geomorphic, hydrologic, and ecological differences (USACE, 1994). The wetland information presented here is based on the USACE 1994 wetland report. The delineation of jurisdictional wetlands at the Site is subject to periodic revision/update. The latest wetland delineation map should be obtained from the Kaiser-Hill Ecology Group.

There are approximately 1,100 wetlands and deep water habitats that are considered "jurisdictional" at the Site as shown on Figure B-13. These jurisdictional areas encompass approximately 191 acres at RFETS of which roughly 105 acres are located within the LCDB Project boundary. Riparian habitat, pond, seep, and hillside wetlands are included in the inventory. The USACE wetland inventory is summarized below.

	Stream Wetlands		Slope Wetlands		Total	
Watershed	**Number**	**Acreage**	**Number**	**Acreage**	**Number**	**Acreage**
Walnut Creek	300	40.0	43	8.1	343	48.1
Woman Creek	135	30.0	85	25.7	220	55.7
Rock Creek	163	25.4	152	32.2	315	57.6
Smart Ditch	204	28.2	17	1.4	221	29.6
Total	**802**	**123.6**	**297**	**67.4**	**1,099**	**191.0**

Generally, the Walnut Creek drainage supports more stream wetlands than seep- and spring-fed wetlands, particularly in the areas near the A- and B-series ponds, while the Woman Creek drainage area has a higher proportion of seep- and spring-fed wetlands, as typified by wet meadow and marsh wetlands. The stream wetland habitats vary because of irregular and ephemeral stream flows in some areas, while other wetlands are more stable because of their association with regular inflows to the ponds. There are at least 16 active seep areas in the upper Woman Creek drainage and at least 3 in the Walnut Creek basin. The number and size of seeps varies depending on fluctuations in precipitation rates and water recharge/discharge rates.

The current extent of wetlands is likely to change due to closure of the IA. Preliminary review of historical aerial photographs from 1951 show that stream wetlands were relatively limited compared to current conditions. Additional evaluation of the aerial photographs will be completed as discussed in Appendix E of the Work Plan. Grazing influences on the photographed features will be considered and the interpretations will be limited accordingly.

The removal of impervious surfaces and water sources in the IA is likely to change the hydrological conditions that would result in a loss of stream wetlands and a trend toward the natural conditions represented in the historical (pre-plant) aerial photographs. The extent of wetlands after completion of active remediation cannot be accurately predicted at this time, but it is assumed that the extent of stream wetland acreage will diminish due to the cessation of imported water usage (see Data GAP-260). As hydrologic models are developed as part of the SWWB project, the extent of wetlands at closure could be more reliably predicted.

Site closure activities (including cessation of imported water) could adversely impact existing wetlands. The closure activities are subject to evaluation under Procedure 1-S73-ECOL-001, *Wetland Identification and Protection*, to assess potential project impacts to the wetlands identified on Figure B-13 and to ensure compliance with the Clean Water Act. DOE's policy under 10 CFR 1022 is, first, to avoid and minimize adverse impacts if possible and, second, to mitigate unavoidable impacts. If wetland mitigation is required, the goal established for the Site is to achieve no overall net loss of wetland function and values (wildlife habitat, critical habitat for endangered species, flood control, water quality improvement, and groundwater recharge) due to Site closure. Off-site locations may be used to mitigate some or all of the losses to onsite wetlands.

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2.7 *Vegetation Restoration Considerations*

The following sections establish the physical and biological environmental factors considered essential for achieving the FDOs established for restoring and maintaining vegetation cover on the project area after closure is completed. The following sections identify existing vegetation conditions, establish objectives important for vegetation restoration or development, and identify information still to be acquired to develop specific design criteria. Vegetation conditions have been extensively described as a series of systematic vegetation survey investigation and monitoring reports that are identified below. These systematic investigations began in 1993, although Site-wide vegetation mapping and classification results were reported by Clark et al. (1980) for conditions that existed in 1974.

2.7.1 Existing Vegetation Conditions

Recent mapping (RMRS, 1998b) adequately depicts the existing vegetation conditions coverage across the entire LCDB Project area. The dominant vegetative character of the project area is one of plateaus and hillsides mostly vegetated with one of several types of grassland communities. Generally, major drainage bottoms and lower side slopes are vegetated with wetlands and with woody riparian trees and shrubs, with a dense ground cover of grasses and forbs. The width of this zone varies much, but generally tends to extend less than 75 feet from the bottom of the drainage.

As of 1999, approximately 585 plant species have been documented at RFETS through plant inventory and characterization investigations (Kaiser-Hill, 2000c). Of this total, different combinations of about 20 dominant plant species characterize the vegetation types. These species establish overall appearance and functional values, and dominate the type based on the species' abundance, biomass, and physical size. The physical and biological properties of these dominant species may be used to achieve the FDOs for soil, soil water, and land management practices that would be needed to create or restore these vegetation types in the future. These 20 species have been identified for possible incorporation into the initial conceptual design and vegetation restoration specifications.

Existing plant communities of the LCDB Project area serve as useful indicators of self-sustaining vegetation communities that have successfully adapted to long-term climatic, soil, water, and biological conditions of the area. There is substantial Site-specific quantitative and qualitative information available describing the vegetation types (or communities), species composition, locations, and acreage presently and historically occupying the project area. This information is contained in a series of annual Site vegetation investigation reports that were first published starting in 1996.

The classification of vegetation types differs among different report authors and contractors that have worked on the Site. In spite of technical differences, the classification approaches have generally remained consistent in organizing vegetation into five broad categories. These categories are differentiated based on dominant species composition and plant growth life forms (e.g., grass, tree, shrub) and are analogous to

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cover-type classifications that are used in other vegetation classification approaches. The categories and estimated abundance within the LCDB Project boundary are listed below.

Mixed mesic grassland	48.4 percent (1,861 acres)
Xeric tallgrass prairie	24.2 percent (931 acres)
Riparian woodlands	1.4 percent (54 acres)
Wetlands	5.7 percent (219 acres)
Tall upland shrublands	0.1 percent (2 acres)

With the exception of the mixed mesic grassland, all the types have been identified as increasingly rare and unique by the Kaiser-Hill Ecology Group and the Colorado Natural Heritage Program. These designations suggest each type warrants special management consideration in future land use decision-making.

Dominant species for each vegetation type (including both native and non-native species) are listed in Table B-09. Grassland types are composed of both cool-season and warm-season species. This combination of two types is an important design consideration because maintaining a combination of both types of species provides a better chance of achieving a stable and self-sustaining ground cover that can survive long-term weather or climatic conditions should the present regime shift towards either colder or hotter conditions.

Grasslands of the LCDB area are composed of two basic types of plant life forms, bunch grasses (such as big bluestem and little bluestem) and mid-height sod grasses, which include the mixed mesic grassland species (such as western wheat grass and Kentucky bluegrass) and short grasses (such as blue grama and buffalo grass). These differences have potentially important implications to future land configuration design because there are substantially different water infiltration rates associated with sod-forming and bunch-forming grasses. Several studies of these characteristics have determined that areas vegetated predominantly with bunch grasses consistently have higher water infiltration rates than areas that are vegetated with sod-forming grasses (Kidwell et al., 1997; Hanson et al., 1978; and Thurow et al., 1986). This characteristic may prove useful in developing scenarios that require revegetation to maximize water infiltration.

Vegetation management concerns of importance under both present and reasonably foreseeable future conditions include managing to eliminate noxious weed species and minimizing soil disturbance activities that encourage spreading noxious weeds and starting localized erosion. Current noxious weed species include diffuse knapweed, Russian knapweed, common mullein, Dalmatian toadflax, and musk thistle. Controlling noxious weeds is an important design consideration because once watershed alteration activities are implemented; revegetation efforts will have to address the aggressive and persistent invasion of weed species.

2.7.1.1 Industrial Area

Vegetation conditions within the IA have been substantially altered from pre-development conditions. The basic character of vegetation within this area is one of short grasses and a higher proportion of introduced horticultural species. Plant species are

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predominantly characterized by horticultural varieties of turf grasses, ornamental shrubs, and imported tree species. These species are maintained by periodic irrigation and lawn watering.

Much of the pre-development range vegetation within the IA has been replaced by buildings, roads, parking lots, drainage features, and other industrial-processing structures. Remnant parcels of the pre-development range grasses and shrub species still occupy small parcels of ground that are located among the developed areas. These species and overall vegetative character appears very similar to upland vegetation conditions that occur in the surrounding BZ. These remnant parcels are predominantly mesic mixed grasslands and xeric tallgrass prairie types.

Approximately 91 percent of this area is presently unvegetated because the ground surface is occupied by either impermeable surfaces or activities that exclude plant growth (e.g., dirt roads and parking areas).

2.7.1.2 Buffer Zone

The portion of the LCDB Project area within the BZ supports examples of all five vegetation types. In order of approximate decreasing abundance and aerial distribution the vegetation types include mesic mixed grassland (which for this summary includes reclaimed mixed grassland and short grassland mapping units from the 1998 vegetation map); xeric tallgrass prairie (xeric tallgrass prairie and xeric needle-and-thread grass prairie mapping unit); wetlands (wet meadow/marsh ecotone, tall marsh, and short marsh mapping units); riparian woodlands (riparian woodland and willow riparian shrubland mapping units); and the tall upland shrublands (tall upland shrubland and short upland shrubland mapping units).

Approximately 8.2 percent of this area is presently unvegetated because the ground surface is occupied by either impermeable surfaces, activities that exclude plant growth (e.g., dirt roads and parking areas), landfills, or water storage reservoirs.

2.7.2 Vegetation Characteristics

Important vegetation characteristics that should be considered when developing, evaluating, and designing the final land configuration include:

1. Plant species composition,
2. Water and soil moisture needs of dominant plant species for each vegetation type,
3. Soil rooting depths of dominant plant species,
4. Ground cover characteristics of dominant plant species, and
5. Drainage characteristics of the soil (including topography and slope) to support specific plant communities.

2.7.2.1 Plant Species Composition

The plant species that dominate and establish the overall appearance and ecological characteristics of each vegetation type are listed in Table B-09.

2.7.2.2 Soil Moisture Needs

Site-specific water and soil moisture needs for dominant plant species have been addressed to a very limited extent by previous RFETS vegetation investigations. Table B-10 defines soil moisture ranges required for each of the dominant species that characterize each vegetation type. It is expected that water needs will range from about 2.3 mm per day (daily average for an entire year) for drought-tolerant species like blue grama (Weltz and Blackburn, 1995) to about 6.0 mm per day (daily average) for water-tolerant sedge species (Kadlec et al., 1988).

2.7.2.3 Plant Rooting-Depths

Site-specific rooting depths for dominant plant species have been addressed to a very limited extent by previous RFETS vegetation investigations. Table B-11 defines the plant-rooting depths for each of the dominant species that characterize each vegetation type. When specific information for the target plant species located at RFETS was not available, the vegetation characterization information is based on similar plant species. The surrogate information was deemed suitable for developing a conceptual design. The rooting depths for the plant species are expected to range from about 30 cm (12 inches) for 80 to 90 percent of the root biomass for shallow-rooted wetland species like sedges and rushes (Reed et al., 1995) to about 90 cm (36 inches) for about 95 percent of the root biomass for upland grass species. [Note: Red gamma was used as a surrogate species to characterize the upland grasses.] No grass or forb root depths are expected to extend more than 140 cm (55 inches) (Weaver, 1920). Investigations by Doormaar et al. (1981) of rooting depths of blue grama (a dominant upland grass species of the mixed mesic and xeric tallgrass prairies) indicate that most (84 percent by weight) of the root biomass occurs in the top 15 cm (about 6 inches) of the soil profile and 93 percent occurs in the top 30 cm (12 inches).

Investigations of rooting depths for upland shrub species adapted to arid conditions similar to or perhaps more severe than those of the LCDB Project area, suggest that roots of woody upland shrubs extend to 200 cm (about 79 inches), although the majority (83 percent) of their roots were in the top 120 cm (about 48 inches) of the soil profile (Weltz and Blackburn, 1995).

2.7.2.4 Ground Cover Characteristics

Ground cover is an expression used to describe the living and dead herbaceous plant materials that cover the ground surface. The quantity of living plant material is usually expressed as basal cover. The quantity of dead plant material is usually referred to as either litter or duff. For planning purposes, both components of cover were combined into a single expression of percent ground cover. Generally, the greater the percent cover

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occupying the ground surface, the lower the potential for water and wind erosion of the surface soil material and the greater the potential for surface water infiltration from rain and snow events.

In general, ground cover is highest in the wetland and riparian woodland vegetation types and lowest in the mixed mesic grassland and xeric tallgrass prairie vegetation types. The various studies have measured these vegetation parameters for a variety of purposes at established monitoring stations and elsewhere. Percent ground cover results vary among areas as indicated in Table B-12.

2.7.3 Constraints for Vegetation Development

From a planning perspective, it is important to recognize the distribution and plant species composition of each type are determined by interactions of several environmental variables. The most important are soil moisture, soil depth, soil texture, and land use/management. Historically, fire frequency was an important environmental factor, but under current land use practices it is has become a relatively unimportant consideration. Fire is being given increasingly more consideration as an effective and economical vegetation management tool, especially to address the invasion of noxious weeds. For those areas where vegetation cover is a critical component to maintain compliance with surface water quality standards or the effectiveness of remediation systems, a vegetation management plan may be developed to specifically identify the inspection, maintenance, and control activities that are required after Site closure.

Of the environmental variables noted above, the timing and quantity of plant-available soil moisture is the most important variable that regulates plant species composition, abundance, and locations of vegetation types. Soil moisture availability is in turn primarily regulated or substantially affected by the interactions of soil texture, soil depth, and soil organic matter. By controlling these physical properties, the type and productivity of vegetation conditions can be managed within the limits imposed by the available water supply.

From a natural water supply perspective, the existing RFETS vegetation types can be organized along a water-abundance gradient from the most drought-tolerant category (xeric tallgrass prairie) to the least drought-tolerant category (cattail wetlands). Creating a successful and long-term self-sustaining vegetation condition requires creating environmental conditions within the tolerance range of the target plant species that will ensure the plant species survives the natural environmental fluctuations of weather and temperature cycles. The most critical design elements for a long-term vegetation plan are ensuring that plant ET needs are accommodated within the natural range of precipitation and that soils are deep enough and have the correct textures so the target plant species can obtain sufficient soil moisture during dry periods.

Descriptions and quantification of the floristic characteristics of the plant species present in each vegetation type are well documented. However, based on information reviewed to date, there seems to be only limited information available regarding either Site-specific or species-specific ET characteristics and root depths. These characteristics are key considerations in future restoration planning for determining whether an adequate water supply would be available for the target vegetation conditions during both average and dry-year or drought conditions.

Therefore, these aspects of the overall vegetation restoration activities are considered key design constraints. The magnitude of these constraints will be further defined through additional technical literature reviews and factored into the initial conceptual design. In general, it is anticipated the future design goals would simulate existing vegetation conditions occurring in the BZ. Current vegetation characteristics indicate which species have already adapted to prevailing weather and temperature regimes, thus indicating which species would be good candidates for future ground cover. These species have successfully demonstrated their ability to adapt to existing variations in temperature, precipitation, land use, soils and other factors important for developing and sustaining an effective plant cover.

2.7.4 Topsoils and Borrow Sources

The surficial soil information provided in this summary is intended to support planning decisions associated with developing vegetation on disturbed areas in the LCDB Project area. Soil conditions of up to the top 60 inches of soil material were mapped for the entire RFETS from 1980 field information by Price and Amen (1984). This soil unit mapping and characterization information are the primary references for most of the previous soil characterization reports prepared for the RFETS and is considered adequate for developing the initial conceptual design. The entire RFETS contains a total of 19 soil mapping units, with the most extensively distributed mapping units consisting of the Denver-Kutch clay loam (soil mapping unit 29), Denver-Kutch-Midway clay loam (31), Flatirons very cobbly sandy loam (45), Haverson loam (60), and Nederland very cobbly sandy loam (100).

2.7.4.1 Soil Conditions within the Industrial Area

The IA, encompassing 396 acres, is located in the center of the Site. The parent soil materials of this area have been extensively altered by many construction and maintenance activities. It has also been noted that substantial quantities of fill material were imported into the area for building foundations and other uses (EG&G, 1995). Additional soil alterations are anticipated as structures and contaminated soils are removed and back-filled with off-site borrow soils.

This area was initially mapped as consisting predominantly of three mapping units that also dominate other upland areas of the RFETS. The mapping units, (listed in general order of decreasing areal distribution, include Flatirons very cobbly sandy loam (45), Denver-Kutch-Midway clay loam (31), and Nederland very cobbly sandy loam (100).

2.7.4.2 Soil Conditions within the Buffer Zone

Soil alterations in the 5,870-acre BZ have been largely confined to less than 8.7 percent of the entire BZ and about 15.0 percent of the LCDB Project area. Largely retained as

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undisturbed open space, BZ alterations include support facilities such as surface water retention ponds, monitoring stations, sanitary landfills and dirt roads used for access and fire breaks. Approximately 2,804 acres (47.8 percent) of the BZ are included within the LCDB Project boundary. The entire BZ contains 19 soil-mapping units. The LCDB component of the BZ contains 13 soil-mapping units. Of this total, the following five soil-mapping units are the most common:

- Flatirons very cobbly sandy loam (45) on ridge tops and plateaus;
- Denver-Kutch-Midway clay loam (31) on upland side slopes;
- Nederland very cobbly sandy loam (100) in drainage bottoms;
- Haverson loam in drainage bottoms (60); and
- Denver-Kutch clay loams (29) on hill slopes and shoulders.

2.7.4.3 Soil Constraints for Vegetation Restoration

The major constraints regarding the use of soils for vegetation restoration are susceptibility to wind and water erosion, inability to be readily revegetated once disturbed, poor water-retention capability, inadequate soil depth, and inadequate soil fertility. Generally, soil infertility for range grass development is not a concern. Soil fertility characteristics are usually adequate to support plant growth (as evident from existing range grass conditions) and will therefore be assumed adequate for all target plant species to be considered for developing the initial conceptual design (see Data GAP-240). Soil constraints associated with each LCDB soil mapping units are summarized in Table B-13. The individual characteristics of each soil comprising a mapping unit are presented for each constraint category, which explains why some table cells have multiple entries.

In general, the results indicate moderate to difficult revegetation conditions due to different combinations of low water-holding capacities, moderate to severe water erosion hazards, and relatively shallow soil depths in many areas. Excessive livestock grazing is an identified constraint to maintaining a protective ground cover. However, the anticipated final land use does not include livestock grazing of the LCDB area.

2.7.4.4 Borrow Sources

A study was performed to gather technical and logistic information to compare onsite and offsite borrow sources (EG&G, 1994a). The study identified significant obstacles (including DOE does not own the mineral rights for using on-site soils) to using on-site borrow soils and recommended that future efforts focus on using borrow materials from offsite sources. Mount (1999) identified 17 potential borrow sources located within a 10-mile radius from RFETS. The LaFarge site is being evaluated as the potential source of borrow materials for the ET Covers Project. Additional soil testing information is being obtained and will be incorporated into the initial conceptual design when available. The adequacy of the borrow soil will be evaluated to determine its suitability for restoration of vegetation.

Depending on the amount of borrow material required, pre-shipment and on-site stockpiling may be necessary to meet project schedules. Jefferson County limits the number of trucks per day for each borrow source to control fugitive dust and traffic volume on designated highways such as Highway 93. As such, intra-project coordination with other projects (e.g., ET cover) is required. The initial conceptual design will consider other issues such as location of interim stockpiles and erosion protection.

2.8 Land Usage

This section discusses the historical and future lands uses surrounding RFETS. For the purpose of the LCDB Project, the developing of the bounding scenarios and initial conceptual design was based on open space as the designated future land use.

2.8.1 Current Surrounding Land Uses

RFETS is located near the cities of Arvada, Westminster, Broomfield, Golden, Superior, and Boulder, as well as unincorporated portions of Jefferson and Boulder Counties. Land around the Site primarily consists of ranchland, preserved open space, mining areas, and low-density residential areas. However, this rural pattern is beginning to change due to spread of development from the surrounding communities.

The towns of Superior and Broomfield have already experienced extensive development north and northeast of the Site. A similar development, known as Vauxmont, is proposed to be located south and west of the Site within the Jefferson Center. State-owned lands southwest of the Site are used for grazing, mining, and potential environmental purposes. Along Highway 93, an area of land approximately 1,200 feet wide adjacent to the Site's western boundary is available for eventual development, open space or highway right of way. The 280-acre DOE National Renewable Energy Laboratory Wind Site is located in the northwest corner of the BZ on lands transferred from DOE/RFFO. Preserved open space is the primary existing and proposed use of the lands north and east of the Site. Areas within the BZ and adjacent privately-owned lands to the west of the Site have been permitted by the State and County for mineral extraction (mining).

There are two reservoirs just downstream from the Site that supply the cities of Broomfield, Westminster, Thornton, and Northglenn, and are used for irrigation, domestic water supply, recreation and wildlife enhancement and preservation. A diversion ditch (know as the Broomfield Diversion Ditch) routes Walnut Creek waters around Great Western Reservoir, which is no longer used as a drinking water supply (see Section 2.3.1). A protection reservoir (known as Woman Creek Reservoir) was constructed between RFETS and Standley Lake to intercept flows from RFETS and divert them around Standley Lake (see Section 2.3.5). Rocky Flats Lake located upgradient of the Site is owned and operated by Church Ranch Estates for irrigation.

2.8.2 Existing RFETS Land Use Constraints

The RFETS possesses a number of existing features and conditions that represent potential planning constraints that should be considered in developing the initial conceptual design. The constraints included natural heritage resources, cultural resources, and real property rights. Each of these groups is summarized in the following sections.

2.8.2.1 Natural Heritage Resources

There are several natural heritage and cultural resource constraints associated with the Site and with the LCDB project area that could influence decisions regarding future land uses.

The Colorado Natural Heritage Program (CNHP), a research entity of the Nature Conservancy housed at Colorado State University's College of Natural Resources, assessed the BZ for its ecological value (DOE, 2000e). The CNHP concluded the Site contains highly significant natural elements important for the protection of Colorado's natural diversity and encouraged DOE to take actions to protect and appropriately manage the Site. Some of those highly significant natural elements are located in the LCDB Project area.

The CNHP classifies the xeric tallgrass prairie plant community as very rare. Most of the remaining xeric tallgrass prairie in Colorado is found in Boulder and Jefferson counties in small, dispersed parcels. The CNHP identified the Rocky Flats macrosite as the largest known remnant of xeric tallgrass prairie in Colorado, and probably the largest remaining parcel in all of North America. Less than 20 occurrences of the xeric tallgrass prairie are known worldwide (DOE, 2000e). Approximately 1,800 acres of this xeric tallgrass prairie unit occurs within Site boundaries and about 788 acres occurs within the LCDB Project boundary.

The Great Plains riparian community, identified by CNHP as Great Plains riparian woodlands and riparian shrublands, is classified as rare and declining. Examples of this community are found in the Rock Creek, Walnut Creek, Woman Creek, and Smart Ditch drainages (DOE, 2000e). Approximately 54 acres of this type (includes riparian woodland, willow riparian shrubland, and lead plant riparian shrubland) occurs within the LCDB Project boundary.

The tall upland shrubland community is found on north-facing slopes primarily in the Rock Creek drainage and was identified by the CNHP as a potentially unique shrubland community, possibly not occurring anywhere else. This community commonly occurs just above wetlands and seeps (DOE, 2000e). This type is not found in the LCDB Project boundary.

Wetlands and riparian areas associated with Walnut Creek, Woman Creek, and the South Interceptor Ditch, currently support populations of the federally-designated endangered Preble's mouse. This species is protected by the Endangered Species Act (ESA). Some of the wetlands and riparian areas located in the drainage bottoms and associated seep- and spring-fed wetlands would be considered subject to federal regulatory jurisdiction under provisions of Section 404 of the Clean Water Act (CWA). These land use constraints occur within the LCDB Project boundary. Approximately 453 acres of

Preble's mouse protection area and approximately 219 acres of jurisdictional wetlands occur with the LCDB Project boundary. These features are all located in the BZ.

2.8.2.2 Cultural Resources

Two archeological surveys were conducted at RFETS in 1989 and in 1991. While the surveys identified points of local interest in the BZ, such as Lindsay Ranch and an apple orchard, no sites or artifacts eligible for listing on the National Register of Historic Places were found in the LCDB Project Area (DOE, 2000e).

A survey of the IA was prepared in 1995 (Aero, 1995). The survey report concluded several facilities in the IA are of historic importance because of the role they played in the Site's contribution to the Cold War. The State Historic Preservation Office (SHPO) agreed with these conclusions. Subsequent discussions with the SHPO determined how the historic information at the Site will be recorded.

A Cultural Resource Management Plan (CRMP) was prepared that incorporated information from both the archeological and IA surveys and established guidelines regarding how to manage Site cultural resources.

2.8.2.3 Real Property Rights

When the government bought the Site, the purchase did not include subsurface mineral rights. About 94 percent of mineral rights for the Site are held by a number of private parties. Mining has occurred on or adjacent to the Site for at least the last 60 years. Mineral extraction has included oil, coal, iron ore, sand, clay and gravel. Mining for sand, gravel and clay is currently ongoing and expansions are planned in the northwest corner of the Rocky Flats BZ and in a section of State of Colorado land located immediately west of the southwest corner of the Site.

Under Colorado law, a subsurface mineral owner may exercise their rights to extract subsurface minerals, but must ensure that the land surface owner will retain reasonable use of the land surface. There are no current or active mineral extraction activities occurring or planned for the LCDB Project area. It is assumed that either the subsurface mineral owners will not exercise their mineral rights within the LCDB Project area or the required permits for mining/reclamation activities will not be issued by the State (see Data GAP-170).

2.8.2.4 Easements

A list of private entitlers that possess easements at RFETS is provided as Table B-14. A list of federal license/easement agreements for land at RFETS is provided as Table B-15. The easement locations are identified on Figure B-14. It is assumed that these easements will need to be preserved as part of the final land configuration.

2.8.3 Future RFETS Land Use

Specific future land use(s) for RFETS has not been finalized as of June 2001. The following land use and resource management plans have been developed to establish a vision for future uses.

- Rocky Flats Cleanup Agreement (RFCA) established in 1996
- The Natural Resources Management Policy (NRMP) established in 1998
- Cultural Resource Management Plan (CRMP)

Within the context of these plans, many important issues have yet to be resolved that will affect the type, distribution, timing, and duration of one or more future land uses both on the Site and in the LCDB Project area.

2.8.3.1 Open Space Usage

The activities permitted in open space areas vary depending on the surrounding land uses, size, and physical attributes of the property. Activities permitted at other open space areas located within Jefferson County include multi-use trails, equestrian trails, picnicking (with tables or shelters), scenic views, parking, wildlife blinds, fishing, restrooms, fitness trails and stations, and camping.

The most-likely anticipated land uses within the LCDB based on their compatibility with anticipated access restrictions to certain portions of the project area would be day-use of hiking trails, scenic views, picnic tables/shelters, restrooms, wildlife observations, photography, and parking.

Authorized land uses are usually determined during the development of a master plan for a property. The master plan seeks to determine the most compatible balance of public use(s) with natural resource tolerances to use.

2.8.3.2 National Wildlife Refuge Designation

This Design Basis, scenario development and evaluation (see Tab 3, Attachment A), and the initial conceptual design description (see Tab 3, Attachment C) were developed based on an assumed final land use of open space. Now that legislation to designate RFETS a National Wildlife Refuge has been enacted, this Design Basis and these documents will be re-evaluated and appropriately revised during the detailed design of the final land configuration. The potential impacts associated with changing the final land use from open space to National Wildlife Refuge are discussed in this section.

The potential impacts identified below are based on consideration that the management of the RFETS National Wildlife Refuge will be similar to the Rocky Mountain Arsenal National Wildlife Refuge. Based on this consideration, the following land use changes from the open space designation may be required to accommodate a National Wildlife Refuge at RFETS.

- The U.S. Department of the Interior, U.S. Fish and Wildlife Service (FWS) would administer the national wildlife refuge.
- Land ownership for all or certain portions of RFETS would be transferred from the Department of Energy to the Department of Interior.
- The transferred lands would be managed as a unit of the National Wildlife Refuge system, but management would still be subject to remediation actions and restrictions for designated areas.
- Some portions of the RFETS could be designated as exempt from transfer if they are to be used for water treatment; the treatment, storage, or disposal of hazardous substances, pollutants, or contaminants; or other purposes related to response action at the RFETS and any action required under any other statute to remediate contaminants.
- It is likely that the Department of Energy would retain responsibilities to carry out long-term stewardship for remedial actions (such as ET covers, groundwater plume systems, surface water controls, and other final land configuration features required to protect human health and the environment).
- The action levels specified in RFCA Attachment 5, Action Level Framework might need to be modified to include an exposure scenario for an onsite wildlife refuge worker (see Data GAP-180).
- It is also likely that all management actions would continue to remain subject to provisions of the Endangered Species Act, the Migratory Bird Treaty Act, the Bald Eagle Protection Act, and the Fish and Wildlife Coordination Act.
- The refuge fish and wildlife resources would be managed in a manner consistent with the goals and objectives to be established in a Comprehensive Conservation Plan prepared by the United States Fish and Wildlife Service. Input received from consultation with State and local agencies and public participation is typically considered in developing these plans.
- The FWS would manage the refuge to achieve the mission set forth in legislation establishing the refuge in accordance with the National Wildlife Refuge System Administration Act. The purposes of the RFETS refuge, as listed in the proposed legislation, are: (1) restoring and preserving native ecosystems, (2) providing habitat for and population management of native plants and migratory and resident wildlife, (3) conserving threatened and endangered species, (4) providing opportunities for compatible, wildlife dependant environmental scientific research, and (5) providing public with opportunities for compatible outdoor recreational and educational activities.
- Once designated as a National Wildlife Refuge, the transferred property would not be subject to annexation by any unit of general local government.
- Existing right-of-ways and easements may be maintained or new ones permitted at the discretion of the USF&W, if the right-of-way or easement serves greater interest of the community and is consistent with the purpose of the National Wildlife Refuge (see 50 CFR 29).

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- Restrictions would probably be established on future land uses for (1) residential, commercial, or industrial purposes; (2) surface water or groundwater as sources(s) for potable water supply; (3) hunting or fishing; and (4) agricultural use, including any farming or raising livestock, or producing crops or vegetables.

2.8.3.3 Long-Term Operation, Maintenance, and Monitoring

The design for the final land configuration will need to accommodate long-term operation, maintenance, and monitoring of remediation systems. These activities may include maintaining the ET covers, groundwater plume systems, and ponds / dams (if any), as well as, conducting environmental monitoring for ground and surface water.

The maintenance activities associated with the ET covers may include periodic inspections, regrading and revegetation of erosion and upkeep of the passive treatment system for the Present Landfill seep. These activities would be conducted on an as-needed basis. Access roads to the ET covers would be maintained.

Maintenance activities associated with the groundwater plume collection and treatment systems include periodicreplacement of treatment media, flow monitoring and sampling of effluent, and raking of treatment media. Access roads to the groundwater plume systems for heavy truck traffic would be maintained.

Maintenance activities for ponds and dams could include sediment removal, batch water discharge, sampling and monitoring, and safety inspections and repairs. The level of required maintenance will be further defined during the development of the initial conceptual design. Access roads to ponds / dams would be maintained. These access roads would also be used in support to collect surface water samples.

There are currently numerous groundwater monitoring wells located on site. Some of the wells will be abandoned, and some will remain. Well abandonment has yet to be defined (e.g., whether casings will be removed, partially removed, or left in place). In addition, wells that will remain active for future monitoring have not yet been identified. The well abandonment evaluation program is scheduled to begin in 2002. A description of the current monitoring program and the well locations are provided in the Integrated Monitoring Plan (IMP) Background Document. For the purpose of the LCDB Project, it is assumed that monitoring will be restricted to the remediation systems that will be present after the completion of active remediation. If required, existing monitoring wells would be relocated or replaced to facilitate implementation of the final land configuration. It is assumed that lightweight all-terrain vehicles designed for minimal ecological impact will be used to access monitoring locations to minimize disturbance on vegetated areas. As such, access roads would not need to be provided.

3.0 FUNCTIONAL DESIGN OBJECTIVES

Functional Design Objectives (FDOs) are the conditions, limitations, aspects, and other provisions that the design must adhere to in order to fulfill the objectives and performance functions established for the project. FDOs are specified on a systems level rather than its specific components. The identified FDOs were divided into primary objectives and balancing performance functions / criteria as follows:

- The terms **'shall'** or **'must'** refer to primary objectives ("must have") that must be incorporated into the design for the final land configuration. Whenever a primary objective is not adopted, the exception with reasons thereof will be identified.
- The terms **'should'**, **'may'**, or **'can'** indicate a balancing performance function or criterion ("want to have") that is to be incorporated into the design to the extent practicable considering such factors as cost, schedule, reliability, and long-term performance. These balancing performance functions / criteria will be weighted accordingly and used to comparatively evaluate the bounding scenarios to develop the initial conceptual design.

The FDOs for the LCDB Project are listed in Table B-16. The FDOs have been developed and established based on the Data Quality Objectives (DQOs) established for the LCDB Project as identified in Appendix A of the Work Plan. The FDOs are divided into the following functional areas for developing and evaluating the bounding scenarios.

- GEN – **General** objectives related to the overall functions and criteria of the LCDB Project.
- GW – Objectives related to the function of **groundwater** remediation systems and the control of **groundwater** contamination.
- SEIS – **Seismic** objectives for designing LCDB required structures.
- SOIL – Objectives related to the control of **surface soil** contaminant migration through erosion and slope stability.
- SUB – Objectives related to the control of **subsurface soil** contaminant migration via colloidal and dissolution transport.
- SW – Objectives related to s**urface water and surface water control features** including drainage and retention structures.
- T/E – Objectives related to **threatened, endangered and special concern species.**
- USE – Objectives related to the designated **future land use** (e.g., open space) and maintaining access controls for long-term operation, maintenance, and monitoring of the Site and associated remediation systems.
- VEG – Objectives related to restoring **vegetation** in disturbed areas.
- WILD – Objectives related to **wildlife** and associated habitats.
- WET - Objectives related to **wetlands** and associated habitats.

4.0 ENGINEERING DESIGN CRITERIA

The intent of this section is to provide the applicable design criteria, which is primarily civil, structural, instrumentation for surface water applications, and safety criteria. This comprehensive collection of supporting documents is provided as a guide in the design of the final land configuration. The engineering codes, standards, and guidelines that will be considered are identified in the following subsections.

4.1 Civil and Structural Design Criteria

Civil and structural engineering design criteria that apply to storm water drainage and control structures include:

- *Rule and Regulations for Dam Safety and Dam Construction (2 CCR 402-1),* Division of Water Resources, Office of the State Engineer, Department of Natural Resources.
- *Dam Safety Project Review Guide,* Dam Safety Branch, Division of Water Resources, Office of the State Engineer, Department of Natural Resources. 23 September 1994.
- *Design of Small Dams (3rd Edition),* Bureau of Reclamation, United States Department of Interior. Washington, D.C. 1987.
- *Urban Storm Drainage Criteria Manual; Volumes 1 and 2.* Urban Drainage and Flood Control District. Denver, CO. June 2001.
- *Urban Storm Drainage Criteria Manual; Volume 3 - Best Management Practices.* Urban Drainage and Flood Control District. Denver, CO. September 1999.

4.2 Mechanical Design Criteria

The final land configuration is not envisioned to include any mechanical equipment. Mechanical engineering design criteria will be established if mechanical equipment is identified during the development of the initial conceptual design.

4.3 Electrical Design Criteria

The final land configuration is not envisioned to include any electrical equipment. Electrical engineering design criteria will be established if electrical equipment is identified during the development of the initial conceptual design.

4.4 Instrumentation and Controls Design Criteria

Instrumentation and controls include sampling and monitoring devices that would be required to monitoring drainage flows, water levels in ponds, and surface water quality at the POCs. Design criteria for these devices will be established during the initial conceptual design.

4.5 Life Safety Design Criteria

The final land configuration will include provisions to minimize the potential for accidents for other unplanned incidents that could threaten human health or the environment including releases of hazardous materials to air, soil, or surface water. Any facilities, structures, and devices will be designed to comply with the safety criteria identified in applicable portions of the National Fire Code, US Occupational Safety and Health Administration regulations (29 CFR), and State of Colorado Dam Safety Regulations (2 CCR 402-1).

To the extent practicable, inclusion of pits, vaults, and other confined spaces in the design of the final land configuration will be avoided. When confined spaces are required, appropriate safety features will be included in the design.

The design will consider the need for other safety devices and emergency equipment required to conforming to recognized codes and standards.

4.6 Design Life

Any actinide-bearing soils remaining at RFETS has the potential to influence surface water quality at the POCs after Site closure. The geomorphic processes are dynamic will continue to shape the landscape at RFETS including the potential transport of actinide-bearing surface soils to the drainage through erosion and mass wasting. The actinide-bearing surface soils could contribute to surface water activity for significant periods after Site closure. For example, the half-life of Pu-239 is on the order of 24,000 years. As such, any Pu-239 in the soil could contribute to surface water activity for a very long period after Site closure.

However, the continued evolution of the RFETS landscape and the long-term presence of actinides in soils at the Site do not necessarily pose a continued risk of surface water quality exceedences at the POCs. Current surface water activities are expected to be further reduced as Site closure activities and remedial actions are implemented. The surface water activities would be expected to continue to decrease after Site closure over time as the finite sources of actinides are dissipated.

Instead of designing for an unreasonable or arbitrary design life, an adaptable design philosophy has been adopted to the LCDB Project to accommodate the ever-changing environmental conditions. As such, a specific design life for the final land configuration has not been established as part of the design basis. The design life is envisioned to be indefinite to the extent required to ensure compliance with the surface water quality standards at the POCs. The design components would continue to be maintained or modified as required in response to monitoring data and changed conditions.

Individual components will be designed using standard industry practices and criteria with 5-year reviews to assess performance, continued O&M requirements, and configuration changes. The final land configuration will be designed to withstand a 100-year, 6-hour storm event and will be evaluated over a 1,000-year period to assess the long-term geomorphic processes on the design components.

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Table B-01
Summary of Monthly Temperature Data for RFETS [a/]

Month	Normal Temperature (°F)			Mean Temperature (°F)		Extreme Temperature (°F)	
	Monthly Maximum	Monthly Minimum	Monthly Average	Highest Monthly Average	Lowest Monthly Average	Maximum	Minimum
January	41.0	23.5	32.3	40.2 (1986) [b/]	19.4 (1984)	69.0 (01/16/74)	-12.0 (01/04/72)
February	42.9	25.3	34.0	40.4 (1991)	22.9 (1964)	71.0 (02/28/72)	-8.7 (02/01/85)
March	47.4	29.3	38.3	46.5 (1972)	28.0 (1965)	82.0 (03/26/71)	-5.0 (03/25/65)
April	55.3	36.7	46.1	52.0 (1992)	38.4 (1973)	80.7 (04/30/92)	5.0 (04/09/73)
May	64.5	45.8	55.1	61.3 (1974)	48.0 (1969)	89.0 (05/28/74)	26.0 (05/01/70)
June	74.5	54.5	64.4	71.8 (1971)	58.9 (1969)	99.0 (06/23/71)	34.8 (06/10/75)
July	80.7	60.2	70.5	75.9 (1966)	66.1 (1992)	102.0 (07/12/71)	37.6 (07/17/75)
August	78.8	59.0	68.9	72.6 (1970)	65.2 (1992)	97.0 (08/08/69)	45.6 (08/30/93)
September	69.7	50.8	60.3	65.5 (1969)	53.2 (1965)	91.0 (09/10/74)	24.0 (09/19/71)
October	60.1	41.2	50.8	57.1 (1965)	38.8 (1969)	82.1 (10/16/91)	4.0 (10/14/69)
November	48.2	31.4	39.9	51.0 (1965)	33.4 (1972)	72.0 (11/25/70)	-3.3 (11/24/93)
December	42.1	24.5	33.4	39.7 (1976)	25.8 (1990)	72.0 (12/04/65)	-23.6 (12/21/90)
Annual Average	**58.8**	**40.2**	**49.5**	**52.5 (1988)**	**31.3 (1985)**	**102 (07/12/71)**	**-23.6 (12/21/90)**

a/ Source: Aero, 1995. Data covers the period from 1964 through 1977 and from 1984 through 1993.

b/ Year or date of the most recent recorded temperature value is provided in parentheses.

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Table B-02
Summary of Monthly Precipitation Quantity Data for RFETS [a/]

Month	Precipitation Quantity - Water Equivalent (inches)			
	Monthly Mean	Monthly Median	Monthly Maximum	Daily Maximum
January	0.42	0.30	1.73 (1959) [b/]	0.50 (01/12/72)
February	0.54	0.50	1.81 (1959)	0.70 (02/20/71)
March	1.19	0.85	4.20 (1970)	1.06 (03/30/70)
April	1.51	1.20	4.73 (1973)	2.30 (04/13/67)
May	2.65	1.96	9.70 (1969)	3.40 (05/06/69)
June	1.56	1.17	4.79 (1969)	2.94 (06/27/87)
July	1.46	1.26	5.10 (1965)	1.46 (07/20/86)
August	1.29	1.00	3.69 (1967)	2.10 (08/30/67)
September	1.43	1.12	4.53 (1976)	1.81 (09/26/76)
October	1.02	0.53	4.83 (1969)	1.83 (10/04/84)
November	0.79	0.68	2.00 (1972)	0.75 (11/01/72)
December	0.44	0.31	1.50 (1958)	0.50 (12/23/73)
Annual Average	**14.30**	**10.88**	**25.72 (1959)**	**3.40 (05/06/69)**

a/ Source: Aero, 1995. Data covers the period from 1964 through 1977 and from 1984 through 1993.

b/ Year or date of the most recent recorded precipitation value is provided in parentheses.

Table B-03
Summary of Precipitation Intensity Data for RFETS [a/]

Storm Event Return Period (year)	Maximum Precipitation (inches) for Specified Duration						
	15-minute [b/]	1-hour [b/]	3-hou [b/]	12-hour [b/]	Daily [c/]	Monthly [c/]	Annual [d/]
2	0.06	0.11	0.19	0.26	0.35	0.84	13.34
5	0.20	0.30	0.40	0.59	0.71	1.84	18.06
10	0.28	0.41	0.61	0.89	1.00	2.65	20.79
20	0.37	0.56	0.78	1.13	1.37	3.54	22.59
50	0.50	0.76	1.03	1.37	1.83	4.68	23.66
100	0.53	0.80	1.15	1.46	2.18	4.85	24.69

Notes:

a/ Source: Aero, 1995. Data covers the period from 1964 through 1977 and from 1984 through 1993.

b/ Based on data collected from 1984 to 1993.

c/ Based on data collected from 1964 to 1977 and from 1984 to 1993.

d/ Based on data collected from 1953 to 1977 and from 1984 to 1993.

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Table B-04
Summary of Monthly Precipitation Frequency Data for RFETS [a/]

Month	Number of Days for Specified Precipitation Amounts													
	>0.01 in. <0.05 in.		>0.05 in. <0.1 in.		>0.1 in. <0.25 in.		>0.25 in. <0.5 in.		>0.5 in. <0.75 in.		>0.75 in. <1.0 in.		>1.0 in.	
	Monthly Mean	Monthly Maximum	Monthly Mean	Monthly Maximum	Monthly Mean	Monthly Maximum	Monthly Mean	Monthly Maximum	Monthly Mean	Monthly Maximum	Monthly Mean	Monthly Maximum	Monthly Mean	Monthly Maximum
January	4	7 (1987) [b/]	2	5 (1974)	2	3 (1974)	2	3 (1973)	1	1 (1974)	-	-	-	-
February	4	9 (1971)	3	5 (1974)	2	4 (1968)	1	2 (1974)	1	1 (1975)	-	-	-	-
March	7	12 (1970)	5	12 (1970)	4	11 (1970)	2	7 (1970)	2	4 (1970)	2	2 (1992)	2	2 (1992)
April	7	13 (1990)	6	12 (1973)	4	12 (1973)	3	10 (1973)	2	5 (1973)	1	2 (1971)	1	1 (1964)
May	8	14 (1992)	6	10 (1967)	5	9 (1969)	4	7 (1969)	2	5 (1969)	2	4 (1969)	2	4 (1969)
June	8	16 (1965)	6	12 (1967)	4	10 (1969)	3	8 (1969)	2	4 (1969)	1	2 (1987)	1	1 (1993)
July	9	17 (1990)	6	12 (1965)	4	10 (1965)	2	8 (1965)	2	5 (1965)	1	3 (1965)	1	1 (1986)
August	8	14 (1991)	5	7 (1989)	4	7 (1987)	2	6 (1987)	1	2 (1991)	1	2 (1967)	1	1 (1992)
September	7	13 (1990)	5	11 (1973)	4	7 (1989)	3	5 (1976)	2	4 (1970)	1	2 (1976)	1	1 (1976)
October	5	11 (1993)	4	11 (1969)	3	10 (1969)	2	7 (1969)	2	5 (1969)	2	3 (1969)	2	2 (1984)
November	5	12 (1970)	4	11 (1970)	3	5 (1991)	2	3 (1991)	1	3 (1972)	1	1 (1972)	-	-
December	4	7 (1967)	3	7 (1967)	2	6 (1967)	2	3 (1973)	1	1 (1973)	-	-	-	-
Annual Value	**76**	**92 (1990)**	**55**	**73 (1973)**	**41**	**55 (1973)**	**27**	**36 (1973)**	**19**	**14 (1973)**	**13**	**9 (1969)**	**10**	**5 (1969)**

a/ Source: Aero, 1995. Data covers the period from 1964 through 1977 and from 1984 through 1993.

b/ Year or date of the most recent recorded precipitation value is provided in parentheses.

Table B-05
Summary of Wind Speed Data for RFETS [a/]

Month	Average Wind Speed (mph) [b/]	Average Peak Wind Speed (mph) [c/]
January	12.3	45.7
February	11.5	59.6
March	10.7	64.7
April	10.5	59.4
May	9.6	52.7
June	8.7	53.7
July	8.4	45.2
August	8.1	42.0
September	8.2	49.0
October	8.4	50.5
November	10.3	67.0
December	10.9	69.9
Annual Average	**9.8**	**55.0**

a/ Source: Aero, 1995. Data covers the period from 1964 through 1977 and from 1984 through 1993.

b/ Based on data collected from 1964 through 1977 and from 1984 through 1993.

c/ Based on data collected from 1953 through 1977 and from 1984 through 1993.

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Table B-07
Summary of Geotechnical Properties of Soil and Overburden

Soil Name	Sample Depth (inches)	Unified Soil Classification	Percentage Passing Sieve Number				Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Liquid Limit	Plasticity Index	Permeability (inches/hr)	Available Water Capacity (inches/inch)
			4	10	40	200						
Flatirons	0 - 13	GM, SM	40 - 80	35 - 70	20 - 45	10 - 30	---	---	15 - 25	0 - 5	2.0 – 6.0	0.07 – 0.10
	13 - 47	GC	40 - 60	35 - 55	30 - 50	25 - 40	---	---	35 - 60	20 - 50	0.06 - 0.2	0.08 - 0.10
	47 - 60	GC	40 - 60	35 - 55	30 - 50	15 - 30	---	---	25 - 35	10 - 20	0.6 - 2.0	0.08 - 0.10
Nederland	0 - 10	SM-SC	70 - 90	70 - 85	40 - 55	25 - 35	---	---	20 - 30	5 - 10	2.0 - 6.0	0.10 - 0.12
	10 - 62	SC	70 - 90	70 - 90	40 - 65	25 - 50	---	---	30 - 40	10 - 20	0.6 - 2.0	0.08 - 0.12
	62 - 70	SM-SC, SC	65 - 80	60 - 80	30 - 50	20 - 30	---	---	20 - 35	5 - 15	---	---
Denver	0 - 6	CL	95 - 100	90 - 100	75 - 100	70 - 90	---	---	30 - 50	10 - 25	0.2 - 0.6	0.16 - 0.20
	6 - 29	CH-CL	95 - 100	95 - 100	90 - 100	85 - 100	---	---	40 - 75	20 - 45	0.06 - 0.2	0.14 - 0.18
	29 - 60	CL, CH	95 - 100	90 - 100	80 - 100	75 - 95	---	---	35 - 60	15 - 30	0.06 - 0.6	0.014 - 0.18
Kutch	0 - 3	CL	95 - 100	90 - 100	90 - 100	70 - 80	---	---	30 - 50	15 - 30	0.2 - 0.6	0.15 - 0.20
	3 - 26	CH, CL	95 - 100	90 - 100	90 - 100	75 - 95	---	---	45 - 60	20 - 35	0.06 - 0.2	0.18 - 0.20
Midway	0 - 3	CL	75 - 100	75 - 100	70 - 100	70 - 95	---	---	30 - 40	10 - 20	0.2 - 0.6	0.14 - 0.18
	3 - 14	CL, CH	95 - 100	95 - 100	90 - 100	70 - 95	---	---	35 - 60	20 - 35	0.06 - 0.2	0.14 - 0.18
Haverson	0 - 6	ML	95 - 100	90 - 100	85 - 100	55 - 70	---	---	25 - 35	0 - 10	0.6 - 2.0	0.14 - 0.18
	6 - 46	CL, CL-ML	95 - 100	85 - 100	70 - 95	50 – 70	---	---	25 - 40	5 - 15	0.2 - 0.6	0.14 - 0.18
	46 - 60	GM, SM	35 - 55	30 - 50	20 - 40	5 – 15	---	---	---	0	0.2 - 0.6	0.04 - 0.06
Imported Fill for ET Covers	---	SM - SC	75 - 90	65 - 80	40 - 50	20 – 25	120 - 130	10.5 – 11.8	---	---	3.1 - 27	---

Table B-08
Summary of RFCA Surface Water Monitoring Exceedences

Monitoring Location	30-Day Moving Average Results for Am-241			30-Day Moving Average Results for Pu-239/240		
	Dates Above 0.15 pCi/L Action Level	**Maximum Result (pCi/L)**	**Percent Days Above Action Level**	**Dates Above 0.15 pCi/L Action Level**	**Maximum Result (pCi/L)**	**Percent Days Above Action Level**
GS01 (POC) Woman at Indiana Street	No exceedences identified	0.036	0.0%	No exceedences identified	0.037	0.0%
GS03 (POC) Walnut at Indiana Street	13 June to 24 June 1997	0.256	1.2%	12 June to 2 July 1997	0.465	2.1%
GS08 (POC) Pond B-5 Discharges	No exceedences identified	0.080	0.0%	14 Sept. 2000 ***21 Nov. to 24 Nov. 2000***	0.151 ***0.154***	1.9%
GS11 (POC) Pond A-4 Discharges	No exceedences identified	0.016	0.0%	No exceedences identified	0.021	0.0%
GS31 (POC) Pond C-2 Discharges	No exceedences identified	0.015	0.0%	No exceedences identified	0.021	0.0%
GS10 (POE) IA to South Walnut Creek	25 May to 14 June 1997 4 Aug. to 21 Oct. 1997 5 April to 15 April 1998 22 May to 14 June 1998 23 July to 23 August 1998 30 March to 10 July 1999 24 July to 3 August 1999 ***15 April to 22 June 2000*** 10 July to 14 August 2000	0.215 1.063 0.161 0.173 0.346 1.521 0.210 ***4.723*** 0.278	23.7%	13 April to 24 April 1997 25 May to 20 June 1997 2 Aug. to 3 Sept. 1997 22 Sept. to 17 Oct. 1997 19 March to 2 May 1998 18 May to 20 June 1998 7 April to 22 April 1999 26 April to 28 April 1999 22 May to 20 June 1999 24 July to 29 August 1999 ***28 April to 22 June 2000*** 16 July to 14 August 2000 27 August to 19 Sept. 2000	0.221 0.262 0.921 0.220 0.294 0.386 0.246 0.154 0.363 0.750 ***1.299*** 0.240 0.175	22.8%
SW027 (POE) SID to Pond C-2	No exceedences identified	0.113	0.0%	***5 May to 30 May 1998*** 5 June to 18 June 1998 30 July to 6 August 1998 26 June to 29 June 2000 18 July to 21 July 2000 18 Aug to 20 Aug 2000	***0.543*** 0.508 0.223 0.244 0.182 0.173	12.8%
SW093 (POE) IA to North Walnut Creek	No exceedences identified	0.146	0.0%	2 August to 3 August 1997 ***25 July to 3 August 1999***	0.181 ***0.247***	0.8%

Table B-09
List of Dominant Plant Species by Vegetation Type

Vegetation Type	Dominant Plant Species
Mixed mesic grassland	• Blue grama, western wheat grass, sideoats grama, little bluestem, Japanese brome, mountain muhly, Kentucky bluegrass, and Canada bluegrass
Xeric tallgrass prairie	• Little bluestem, big bluestem, mountain muhly, and Canada bluegrass
Riparian woodland	• Plains cottonwood, coyote willow, peachleaf willow, and snowberry
Wetlands	• Cattail and coyote willow
Tall upland shrubland	• Hawthorn, wild plum, chokecherry, and skunkbush sumac

Source: Kaiser-Hill, 2000c.

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Table B-10
Summary of Evapotranspiration Rates

Plant Species	Life Form	Annual ET (mm/day)(1)	Growing Season ET (mm/day)(2)	Reference
Blue grama (Bouteloua gracilis)	Warm-season grass	2.3	3.1	Anyone, 1990
Baltic rush (Juncus balticus)	Warm-season rush	—	4.6	Meyboom, 1967
Hardstem bulrush (Scirpus acutus)	Warm-season emergent bulrush	—	3.2 – 3.5	Burba et al., 1999
Western Cottonwood (Populus sp.)	Deciduous tree	—	8.8	Meyboom, 1967
Willow-sedges (Carex spp.)	Warm-season sedge	—	6.0	Kadlec et al., 1988
Sedges (Carex spp.)	Warm-season sedge	—	4.5	Kadlec et al., 1988
Willow (Salix spp.)	Warm-season shrub	—	3.0	Robinson and Waananen, 1970
Willow (Salix spp.)	Warm-season shrub	—	2.4	Meyboom, 1967
Wet meadow (3)	Warm-season sedges, rushes, and grasses	1.64	—	Shjeflo, 1968
Wet meadow (3)	Warm-season sedges, rushes, and grasses	2.2	3.5	Novitzki, 1978
Colorado shortgrass grasslands	Warm-season grasses	—	1.4 – 4.2 (4)	Lauenroth and Sims, 1976

1. The daily ET rate for the species for the entire year, which includes both the growing and non-growing season.
2. The daily ET rate for the species only during the growing season, which occurs between May 15 and September 30 for the RFETS.
3. Wet meadow complex of hydric grass, sedge, and rush species would be analogous to side-slope seep wetlands at RFETS.
4. Need to confirm estimates are for growing season period.

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Table B-11
Summary of Rooting Depth Requirements for Dominant Vegetation Species

Plant Species	Most of Root Biomass (1)		Max Rooting Depth (2)		Reference
	Depth (cm)	Percent	Depth (cm)	Percent	
Blue grama (Bouteloua gracilis)	15	84	30	93	Doorman et al. 1981
Blue grama (Bouteloua gracilis)	25	>87	—	—	Coffin and Lauenroth, 1991
Blue grama (Bouteloua gracilis)	51-110	—	70-130	—	Weaver, 1920 as reported by K-H (3)
Sideoats grama (Bouteloua curtipendula)	135	—	170	—	Weaver, 1920 as reported by K-H (3)
Big bluestem (Andropogon gerardii)	150	—	280	—	Weaver, 1920 as reported by K-H (3)
Little bluestem (Schizachyrium scoparium)	90-205	—	110-240	—	Weaver, 1920 as reported by K-H (3)
Kentucky bluegrass (Poa pratensis)	100	—	212	—	Weaver, 1920 as reported by K-H (3)
Needle-and-thread grass (Stipa comata)	75-105	—	90-150	—	Weaver, 1920 as reported by K-H (3)
Needle-and-thread grass (Stipa comata)	30	71	60	99	Melgoza and Nowak, 1991
Rabbitbrush (Chrysothamnus viscidiflorus)	30	73	60	100	Melgoza and Nowak, 1991
Broadleaf cattail (Typha latifolia)	30	90			Knight, 1984
Cattail (Typha spp.)	30	—	60	—	Kadlec and Knight, 1996
Cattail (Typha spp.)	—	—	30	—	Reed et al., 1995
Bulrush (Scirpus spp.)			>76	—	Knight, 1984
Hardstem bulrush (Scirpus acutus)	—	—	60	—	Reed et al., 1995

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Table B-11 (Continued)
Summary of Rooting Depth Requirements for Dominant Vegetation Species

Plant Species	Most of Root Biomass (1)		Max Rooting Depth (2)		Reference
	Depth (cm)	Percent	Depth (cm)	Percent	
Bulrush (Scirpus spp.)	30	—	60	—	Kadlec and Knight, 1996
Softstem bulrush (Scirpus validus)	30		76	—	Hunter et al, 2000
Softstem bulrush (Scirpus validus)	—	—	60	—	Reed et al., 1995
Nebraska sedge (Carex nebraskensis)	15	80	40	100	Svejcar and Trent, 1995
Nebraska sedge (Carex nebraskensis)	20	85	40	—	Manning et al., 1989
Douglas sedge (Carex	20	85	40	—	Manning et al., 1989
Cottonwood (Populus spp)	—	—	800	—	Stromberg et al. 1991

1. Depth beneath soil surface in which most of the root biomass is located. The approximate amount of total root biomass (by weight) at that depth as reported by the author is specified as percent.
2. The greatest depth of root penetration or the depth beyond which roots were not detected. Percent indicates the amount of total root biomass reported by the author for the specified depth below the surface.
3. These values may over-estimate root penetration depths for the soil conditions prevailing within the LCDB Project boundary.

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Table B-12
Summary of Vegetation Ground Cover by Vegetation Type

Vegetation Type	Percent Ground Cover	Reference
Mixed mesic grassland	68 - 97	Kaiser-Hill (2000d)
Xeric tallgrass prairie	75 - 85	Kaiser-Hill (2000d); Exponent (1999)
Riparian woodland	57 – 89	PTI Environmental Services (1997)
Tall upland shrubland	—	
Wetlands	88-95	Exponent (1999)

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Table B-13
Summary of Soil Constraints for Vegetation Restoration

Soil Mapping Unit	Wind Erosion Potential	Water Erosion Potential	Revegetation Potential	Water Holding Capacity	Plant Rooting Depth (in.)
Widely Distributed Units					
Flatirons very cobbly sandy loam (45) [1/]	Slight	Slight	Difficult	Low	More than 60
Denver-Kutch-Midway clay loam (31)	Moderate, slight, moderate[2]	Severe, severe, severe	Difficult	High, low, low	More than 60; 20 to 40; 6 to 20
Nederland very cobbly sandy loam (100)	Slight	Severe	Difficult	Moderate	More than 60
Haverson loam in drainage bottoms (60)	Moderate	Slight	Good	High	More than 60
Denver-Kutch clay loams (29)	Moderate; slight	Moderate; moderate	Difficult	High, low	More than 60; 20 to 40
Limited Distribution Units					
Denver clay loam (27)	Moderate	Moderate	*Moderate?*	High	More than 60
Engelwood clay loam (41)	Moderate	Slight	*Moderate?*	High	More than 60
Leyden-Primen-Standley cobbly clay loams (80)	Slight, slight, slight	Severe, severe, severe	Difficult	Low, low, high	20 to 40; 10-20, more than 60
Midway clay loam (98)	Moderate	Severe	Difficult	Low	6 to 20 (shallow)
Gravel pits (111)	Moderate to severe	Slight	Difficult	Low	6 to 20 (shallow)
Standley-Nunn Gravelly Clay Loam (149)	Slight, slight	Moderate, moderate	*Moderate?*	High, high	More than 60; more than 60
Valmont clay loam (168)	Moderate	Slight	*Moderate?*	Moderate	More than 60
Willowman-Leyden cobbly loams (174)	Moderate, slight	Severe, severe	*Moderate?*	Low; low	More than 60; 20 to 40

1/ Unique number is associated with map unit.

2/ Multiple entries indicate members within a map unit.

Table B-14
List of Private Easement Holders

Easement Holder	Utility	Activities
Church Ranch, Inc. (Charles McKay)	Smart and Church Ditches for conveyance of water rights.	Water rights are conveyed through ditches and ponds across RFETS in accordance with longstanding easement.
City of Broomfield	McKay and Upper Church Ditches and McKay Bypass Pipeline for conveyance of water rights.	Biweekly or more frequent inspection visits during exercise of water rights and maintenance.
Denver Water Board	Raw water pipeline	No routine activity.
Industrial Gas Company Coors Energy Pipeline	High-pressure gas line	Periodic inspections with vehicle and maintenance
Mountain States Telephone and Telegraph	Telephone lines	Periodic inspections with vehicle and maintenance
Public Service Company of Colorado	Electric lines	Periodic line inspections, either by helicopter or by pickup truck.
Rocky Mountain Energy	Low-pressure gas line	Periodic inspections with vehicle and maintenance
Southern Pacific Railroad	Railroad spur line	Periodic train traffic to Western Aggregates gravel operations (Lafarge)
Sprint/US West	Fiber optic lines	Periodic inspections with vehicle and maintenance
State of Colorado Emergency Preparedness	Telecommunications and meteorological equipment	Periodic maintenance
TXI/Western Aggregates	Electric lines	Not identified.
Union Rural Electric Association, Inc.	Electric lines	Not identified.
United Power	Electric lines	Periodic inspections with vehicle and maintenance
US West Telecommunications	Telephone lines	Periodic inspections with vehicle and maintenance
West Gas	Gas line	Not identified.
Western Slope Gas	Gas line	Not identified.

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Table B-15
List of Federal License/Easement Agreements with Offsite Outside Parties

Owner	Purpose
Arvada Electric Company.	Railroad crossing under power line. Railroad spur crossing under power line.
City & County of Denver	Railroad crossing for Boulder Canal. Construction and maintenance raw water line
Denver and Rio Grande Western Railroad Company	Water line right-of-way to cross railroad.
Farmers Res. and Irrigation Company	Railroad and water line crossing for Woman Creek.
Private Individuals	Access road. Railroad spur and water line. Railroad crossing and water line for residential inlet.
Public Service Company of Colorado	Railroad spur crossing under telephone line. Railroad spur crossing under transmission line.
State of Colorado	Railroad crossing for Highway 93. Railroad crossing for Highway 72. Railroad spur and water line.
Union Pacific Railroad	Railroad spur and water line.
Union Rural Electric Association, Inc.	Railroad crossing under power line.

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Table B-16
Functional Design Objectives for the Final Land Configuration

ID	Functional Design Objective	Basis of Design Objective
GEN-01	The final land configuration shall prevent residual contaminant from migrating to surface water so that human and ecological surface water receptors (both on-site and off-site) are protected based on a final land use of open space.	RFCA, Attachment 5, Section 2.0.
GEN-02	The final land configuration shall not interfere with previous remedial actions taken under RFCA.	Project-specific performance objectives identified in previous RFCA remedial action decision documents.
GEN-03	The final land configuration should be designed to allow unattended, passive operation and to minimize required maintenance and active management to achieve the selected final land use. The final land configuration shall minimize life-cycle cost for construction, long-term stewardship, operation, and maintenance.	LCDB Project Strategy Document DOE Order 430.1A
GEN-04	The final land configuration shall be capable of withstanding severe storm events. The magnitude of the design storm event will be developed during the initial conceptual design.	LCDB Project Strategy Document
GEN-05	The final land configuration should avoid the inclusion of aesthetic distractions such as water catch basins, culverts and barriers. When such features are required to fulfill the FDOs, they should be designed to minimize its aesthetic distraction by blending the structure with the existing landscape to the extent practical.	LCDB Project Strategy Document
GEN-06	The final land configuration design input and outputs (including format, identified geographical areas of concern, baseline concentrations, climatic data, erosion parameters, topography, vegetation, etc.) should be compatible with other RFETS designs, assessments and modeling efforts.	LCDB Project Strategy Document
GW-01	The final land configuration shall, in combination with previous remedial actions, assist in preventing surface water from exceeding surface water standards and action levels via groundwater transport.	RFCA, Attachment 5, Section 3.2.
SEIS-01	The final land configuration shall be capable of withstanding probable seismic events.	LCDB Project Team
SUB-01	The final land configuration shall not interfere with the successful performance of previous remedial actions in preventing residual contamination from subsurface soil from causing a surface water exceedence via groundwater transport.	RFCA, Attachment 5, Section 4.1.

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Table B-16 (Continued)
Functional Design Objectives for the Final Land Configuration

ID	Functional Design Objective	Basis of Design Objective
SUB-02	The final land configuration should prevent or eliminate subsurface pathways/conduits (e.g., footing drains, outfalls, UG utilities, or process line corridors) that could convey residual contamination to surface water.	LCDB Project Strategy Document
SW-01	Surface water leaving RFETS shall be of sufficient quality to support any surface water use classification.	RFCA, Attachment 5, Section 2.3
SW-02	The final land configuration shall not prevent surface water monitoring.	RFCA, Attachment 5, Section 2.5.
SW-03	Jurisdictional dam structures included in the final land configuration design shall be constructed and operated to meet State of Colorado Engineer requirements.	2 CCR 402-1
T/E-01	The final land configuration shall minimize disturbance to the designated Preble's mouse protection areas, to the extent practicable.	Endangered Species Act, Section 7 Colorado Revised Statute 33-2-105
T/E-02	The final land configuration should establish and maintain self-sustainable habitat conditions associated with the designated Preble's mouse protection areas.	Endangered Species Act, Section 7 Colorado Revised Statute 33-2-105
T/E-03	The final land configuration should conserve and maintain habitats associated with species that are or may be listed as threatened in the future.	Endangered Species Act, Section 7
T/E-04	In designing the final land configuration, the U.S. Fish and Wildlife Service shall be consulted to balance the interests of the Preble's mouse and water depletions that may affect Platte River species with reconfiguration needs.	RFCA, Attachment 5, Section 1.3.
USE-01	The final land configuration shall incorporate open-space land use values to the extent practical.	LCDB Project Strategy Document RFCA, Attachment 5, Section 1.1.
VEG-01	The final land configuration should establish long-term, self-sustaining vegetative cover that is capable of supporting the selected final land use (e.g., open space).	Natural Resource Management Policy for RFETS
VEG-02	The final vegetative cover should be dominated by, and blended with, native plant species to the extent practicable. The establishment of monocultures should be avoided.	LCDB Project Strategy Document
VEG-03	The final vegetative cover should minimize the amount of unvegetated soil surface area subjected to water and wind erosion (especially in areas with elevated levels of contamination).	Natural Resource Management Policy for RFETS

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Table B-16 (Continued)
Functional Design Objectives for the Final Land Configuration

ID	Functional Design Objective	Basis of Design Objective
VEG-04	The final land configuration should minimize disturbance to protected and special-interest plant communities present in the project area. These communities include wetlands, riparian woodlands, xeric tall grass prairie, and tall upland shrublands.	Natural Resource Management Policy for RFETS
VEG-05	The final vegetative cover should minimize need for artificial or human intervention to ensure long-term survival.	Natural Resource Management Policy for RFETS
VEG-06	Soil or other vegetation growth media should have adequate texture and fertility to support the plant species to be established; should have adequate depth to support the root systems of the plant species to be established; and if imported, should be free of chemical bioavailable contaminants and seeds of noxious weed species.	LCDB Project Team
WET-01	The final land configuration should minimize disturbance to jurisdictional wetlands identified on Figure B-13 to the extent practicable.	Clean Water Act, Sections 401 & 404
WET-02	The final land configuration should maintain hydrology suitable for maintaining existing and new wetlands that will remain after closure. These wetlands should not require artificial or human intervention to ensure long-term survival.	Clean Water Act, Sections 401 & 404
WET-03	In designing the final land configuration, the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency shall be consulted to balance the interests of preserving Site wetlands the and associated Preble's mouse habitat with reconfiguration needs.	RFCA, Attachment 5, Section 1.3.
WILD-01	The final land configuration should minimize disturbance to wildlife habitats, especially identified sensitive habitats (i.e., breeding sites and preferred foraging areas).	Migratory Bird Treaty Act Fish and Wildlife Coordination Act Bald Eagle Protection Act
WILD-02	In designing the final land configuration, the U.S. Fish and Wildlife Service shall be consulted to balance the needs of sensitive wildlife habitats with reconfiguration needs.	RFCA, Attachment 5, Section 1.3.

FIGURES

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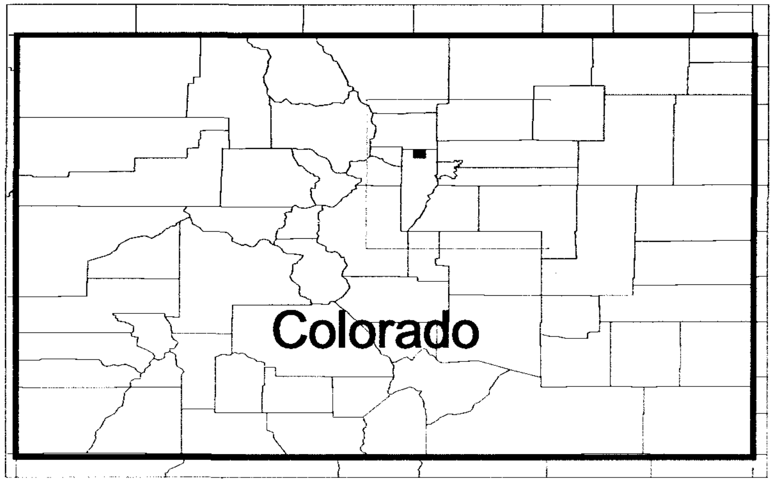

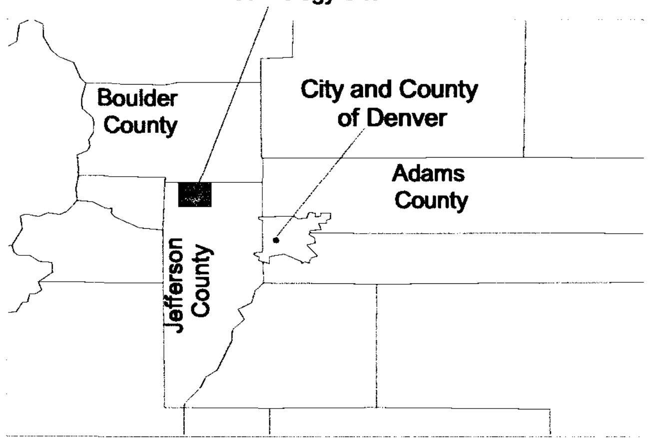

Figure B-01

Site Location Map

Rocky Flats Environmental Technology Site

Jefferson County, Colorado, USA

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

Prepared by:

PARSONS

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Feb 5, 2002

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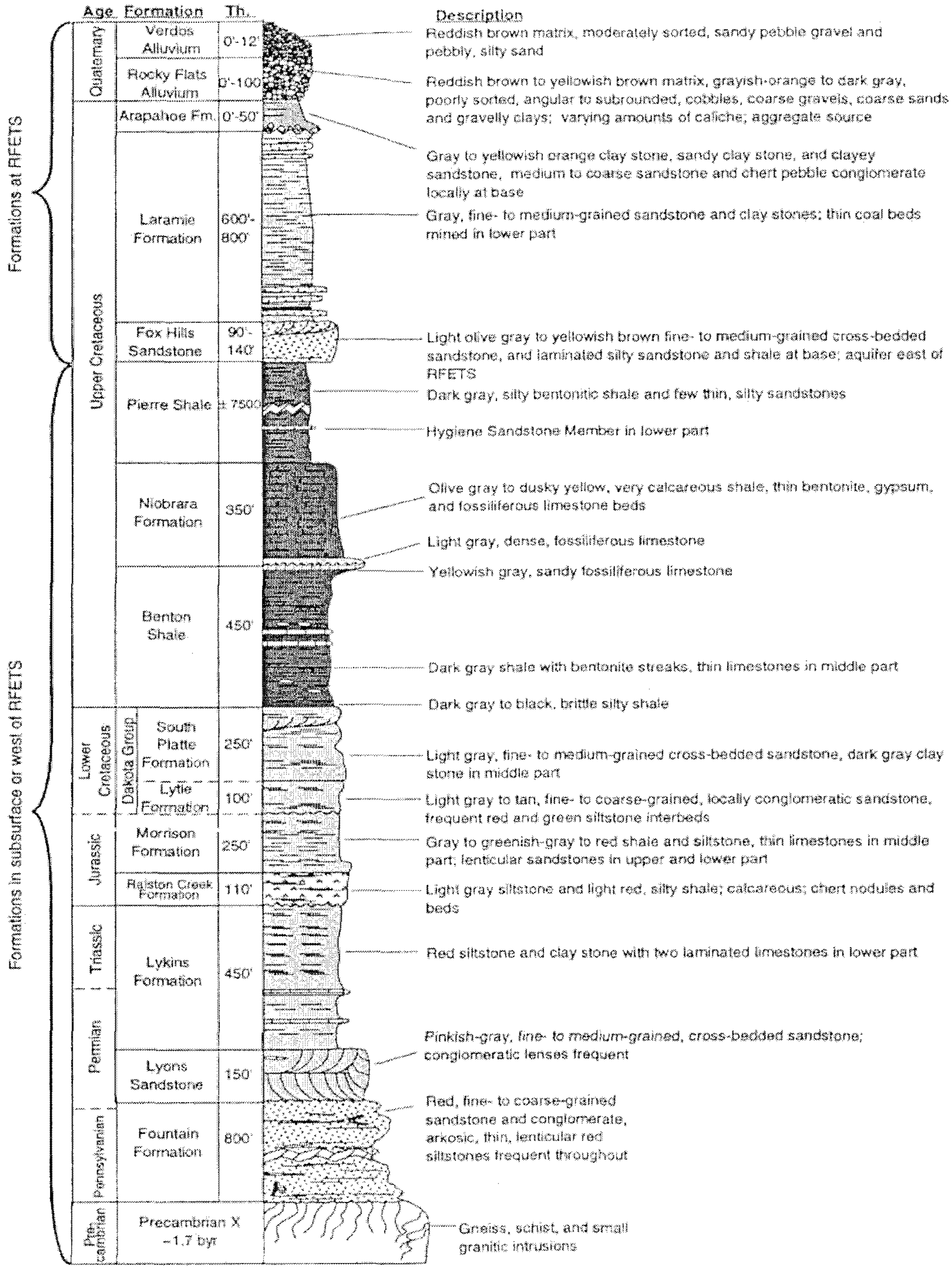

Modified from LeRoy and Weimer (1971)

FIGURE B-07

Generalized Stratigraphic Column for the Rocky Flats Area

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

Prepared By: **Parsons Infrastructure and Technology Group, Inc.**

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December 13, 2001

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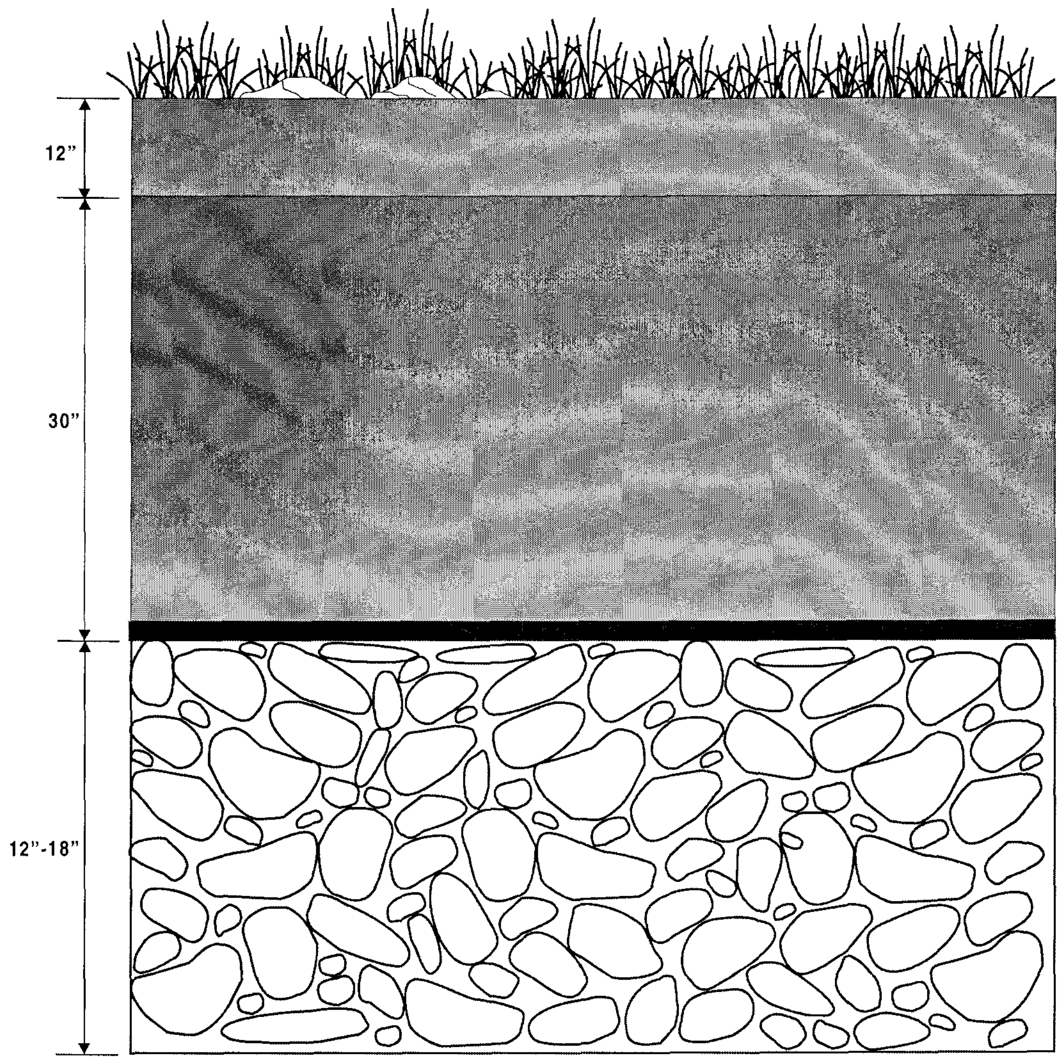

FIGURE B-10
Components of a Typical ET Cover

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

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APPENDIX C

DATA GAPS, MISSING INFORMATION, UNCERTAINTIES, AND ASSUMPTIONS FOR LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This appendix has been revised since its last issuance dated July 2001 to incorporate responses to DOE/FWS Comments 60, 61, and 94.

This appendix has also been updated and renumbered to reflect the current data gaps that are considered significant to developing the LCDB Project.

A section was also added to discuss future activities that can be implemented to resolve identified data gaps or support the development of the final land configuration design.

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1.0 IDENTIFICATION OF DATA GAPS

Data gaps include missing information, uncertainties, tentative plans, unsubstantiated constraints and assumptions that could not be verified during the development of this work plan. For example, when site-specific or regional information is not available or inappropriate to define the design basis for the final land configuration, a data gap exists. A description of the currently identified data gaps for the LCDB Project is identified in Table C-01. A unique number has been assigned to each data gap for tracking purposes.

2.0 DATA GAP RESOLUTION AND DATA ACQUISTION

Many of the data gaps previously identified have been filled by information from electronic and GIS databases, available Site information, and discussions with Site personnel. Some additional data gaps will be filled as the results from other ongoing RFETS projects become available, or as additional decisions regarding the final land configuration are made. Resolution of some data gaps may require completion of additional study or evaluation activities.

3.0 PRIORITY FOR RESOLUTION

The significance of each data gap was qualitatively assessed to prioritize its resolution. A "high", "moderate", or "low" priority was assigned to each data gap based on consideration of the following factors:

1. Importance of data gap or missing information to allow development of the design basis and initial conceptual design to proceed.
2. Availability of substitute information.
3. The reasonableness of assumptions to allow the design basis and initial conceptual design to proceed in the event that the data gap cannot be resolved prior to issuance of the CDR.
4. Likelihood that the design basis or initial conceptual design will need to be significantly revised based on resolution of the data gap or determining that the assumption is not correct.

In general, the priorities were assigned as follows:

- **High** – This information must be obtained in order to complete the design basis and initial conceptual design.
- **Moderate** – The analysis is incomplete without this data, but a reasonable assumption can be made to allow the design basis and initial conceptual design to be completed.
- **Low** – Substitute information is available or assumption does not significantly affect completion of the design basis and initial conceptual design.

The priority to resolve the data gap and a proposed resolution date are identified on Table C-01. If "Use Assumption" is listed in the proposed resolution date column, the corresponding assumption has been used for the purposes of developing the design basis and initial conceptual design.

4.0 ASSUMPTIONS

In the event that the data gap cannot be resolved within the time frame for completing the CDR, the assumptions listed in Table C-01 has been used to allow bounding scenario development and initial conceptual design activities to proceed. Some of the assumptions encompass the proposed plans for environmental restoration and closure of RFETS. The data gaps associated with these decisions may not be fully resolved until the completion of active remediation in 2006.

5.0 DATA GAP UPDATES

The list of identified data gaps and assumptions will be updated as additional site information is obtained during the execution of the work plan. Data gaps that cannot be resolved prior to the completion of the initial conceptual design will be carried forward and presented in the CDR. The presentation of data gaps in the CDR will include a recommendation for the subsequent method of acquisition of information necessary to fill each data gap.

6.0 DATA GAP RESOLUTION AND FUTURE DESIGN ACTIVITIES

Various studies and investigations being conducted by the AME, SWWB, and ET Covers Project Teams are in progress. The results of these studies and investigations are expected to fully or partially resolve many of the data gaps listed in Table C-1, including (but not limited to) Data GAP-010, GAP-020, GAP-030, GAP-070, GAP-120, GAP-130, GAP-140, GAP-145, GAP-260, and GAP-280. This section identifies additional sub-studies and future design activities can be initiated to resolve some of the other data gaps and to proceed with detailed design of the final land configuration.

- Develop phasing plans and details for IA Grading and Drainage (G&D) Concept (Data GAP-070, GAP-140, GAP-145, GAP-160, and GAP-240).
- Develop soil balance and inventory controls for cut and fill activities (Data GAP-240 and GAP-250).
- Obtain additional information to apply the Pond Reconfiguration Strategy to the ICD description (Data GAP-040, GAP-080, GAP-090, GAP-100, and GAP-110).
- Identify facilities and infrastructure required to support long-term stewardship and final land use management (Data GAP-050, GAP-060, and GAP-120).

Additional details regarding each identified activity are provided in the following sections.

6.1 IA Grading and Drainage Plan Implementation

The IA currently consists of an extensive network of drainage controls and ditches. As the IA is transitioned to its final configuration, the sequence of removing buildings and other impervious surfaces will directly impact local drainage patterns and water volumes. The existing drainage controls and ditches may need to be progressively altered to accommodate changes in the runoff characteristics and to prevent localized ponding, flooding, or erosion.

A G&D Concept was developed to establish a potential final topography and drainage configuration for closing the IA. Appropriate portions of the G&D Concept should be considered when developing planning documents for individual D&D and ER projects to achieve the overall final configuration for the IA and Site. However, the G&D Concept does not include phasing plans that identify interim storm water controls that may be required to facilitate the planned sequencing for closing the IA. Interim control features may include constructing temporary ditches or berms, replacing or removing culverts, and phased installation of permanent channel stabilization.

To ensure that drainage problems are avoided, the level of detail contained in the G&D Concept should be expanded. This expanded detail will assist ER and D&D project managers with the planning for individual buildings/complexes. The following tasks could be completed to coordinate the interim drainage controls and transition to the final grading and drainage configuration.

1. Refine the proposed final topography contained in the G&D Concept (currently based on 10-foot contour intervals) to detailed construction drawings with 2-foot contours at a scale of 1-inch to 50-feet. In addition, incorporate any changes in the closure planning for the Solar Evaporation Ponds, Original Landfill, and 903 Pad hillside.

2. Develop a phased G&D implementation plan based on the planned sequencing of D&D activities. This plan should consider the incremental status of the IA for each fiscal year through 2006 (Site closure) to identify interim drainage requirements. Describe how the transition between various interim phases will be managed, controlled, and implemented. Describe how the interim controls will be integrated into the final configuration for the IA and stabilization of associated drainage channels (North Walnut Creek Tributary and South Walnut Creek).

3. Prepare detailed design drawings for the interim and final drainage control features. Prepare supporting calculations to verify adequacy of the interim and final controls. Show the sequence and time frame for implementing each construction phase.

4. Develop standard design details and specifications to implement each construction phase. Standard design details and specifications may include revegetation, imported soil, ET provisions, erosion controls, drainage stabilization, and hillside armoring. Review and incorporate existing Site specifications as appropriate.

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The appropriate interim construction drawings, and standard design details and specifications could be incorporated into the planning documents or subcontractor procurement packages for each D&D project to ensure consistency and integration between projects that will implement portions of the final land configuration.

6.2 Cut and Fill Soil Balance

An initial cut and fill balance was developed for the G&D Concept, but the soil balance does not account for soils that may be required to close individual buildings, construct ET covers, or provide a topsoil layer to revegetate the IA. The initial balance indicates a soil surplus of approximately 290,000 cubic yards, which could be used to make-up shortages associated with other projects. However, no mechanism is currently in place to manage, coordinate, schedule, and control the need for and availability of soil materials between the various projects. The following provisions could be implemented to balance cut and fill requirements, thereby minimizing the need to import soil as well as reducing the amount soils taken offsite for disposal.

1. Develop soil management plan and procedures to identify the requirements for handling and reusing excess soil. The plan should identify the location of a stockpile area, sampling/analysis provisions to meet RFCA requirements, and the organizational entity responsible to implement the management plan.

2. Develop a database to identify and manage individual project requirements for soil materials. The database would be regularly updated and could contain the following suggested fields.

    - Activity/project name.
    - Point of contact information.
    - Quantity of required/generated soil.
    - Soil properties and characteristics.
    - Schedule for required/generated soil including flexibility of schedule dates.

    An important aspect of the database would be the identification of the any specific soil properties and characteristics that are required to meet project requirements during Site closure. This data field would identify physical properties (unified soil classification, grain size distribution, mineral/organic content, etc.) for required soil or special restrictions (Tier II RFCA management) regarding the use of generated soil. The compiled information could be used to verify that excavated soils from regrading of hillsides and constructing the engineered drainages are suitable for their intended reuse. The database could also be used to identify alternate uses or the feasibility of adding amendments to allow large quantities of surplus soils to be economically used to meet project requirements. For example, excavated soils may be appropriately conditioned or mixed with other additives for use as a growth media for revegetation.

3. Prioritize and coordinate individual project needs/schedules to match supply and demand requirements and minimize the size/number of stockpiles. Optimize project schedules to ensure availability of required soil. If feasible, soil-producing activities (hillside regrading, dam breaching, or culvert removals) should be accelerated to ensure soil availability for projects that require fill material (backfill of building excavations). The stockpile area would be used to temporarily store excess soils for inventory control and to accommodate projects that will generate/use large amounts of soil.

4. Implement erosion controls for the soil stockpile as required. The stockpile should be located to avoid impacts to surface water, minimize material handling, and allow integration with the final land configuration. If excess soil remains after completing Site closure, the stockpile should be designed to allow the flexibility to vegetate the soils in place.

6.3 Pond Reconfiguration Strategy Information

The Pond Reconfiguration Strategy identifies a number of items that should be considered to determine the preferred final configuration for the existing ponds and associated ancillary structures. Several of these considerations are contingent on developing additional information. Some of this information, such as water availability at completion of active remediation, is currently being investigated by other project teams. The following additional information can be generated now or in the future to facilitate applying the Pond Reconfiguration Strategy to the ICD description.

- Identify post-closure water conveyance and diversion configuration requirements.
- Develop additional flow-through performance predictions using preliminary calculations or computer codes specifically developed for sedimentation basins.
- Develop detailed design and phasing plans to reconfigure ponds.

One item that can significantly influence the reconfiguration of the existing ponds is the future plans for operating the third-party water conveyance and diversion structures. The water conveyance structures include the McKay Ditch, Bypass Canal, and Pipeline; Upper Church Ditch; Kinnear Ditch; Smart Ditches; and Mower Ditch. The assumed future operations discussed in Section 2.3.9 of the Design Basis (see Tab 2, Appendix B) should be confirmed with the appropriate ditch owner and the necessary agreements for their operation and maintenance after closure of RFETS should be secured. In addition, discussions with the ditch owners should also focus on the fate of onsite and downstream diversion structures including the SID/Woman Creek Diversion Dam, West Diversion Dam, and the Broomfield Diversion Ditch. Alteration of any of these structures could significantly change the hydraulic characteristics of individual drainage systems and the associated requirements for the existing ponds. If possible, these diversion structures should be removed to return these drainages to a more natural state thus reducing the potential for long-term maintenance problems. The elimination of the West Diversion Dam would also benefit wetland components and ecological resources located in North Walnut Creek by returning the currently diverted runoff to this watershed. However, the elimination of the West Diversion Dam would required modification of McKay

Ditch/Bypass Canal to allow continue transfer of water to the Great Western Reservoir. If the diversion structures are not eliminated, further evaluation of the current configuration should be conducted during detailed design to identify any features that are needed to stabilize the diversion structures.

If passive flow-through ponds are used as a component in the ICD, the removal effectiveness of the existing ponds estimated through the HEC-6T modeling efforts performed by the AME Project Team should be verified. The HEC-6T modeling is based on a simplifying assumption that the ponds are full at the start of the storm event and overflow. This simplification does not take full credit for the actual design of the flow-through pond, especially any outlet control structure and associate storm detention capacity. The sediment removal effectiveness of flow-through ponds is dependent on a number of factors, including its physical dimensions (length, width, and depth), particle size distribution and densities, settling velocities, and flow. The effectiveness of the existing ponds can be estimated using Stoke's Law and other appropriate estimating techniques. Preliminary removal effectiveness calculations for the A- and B-series ponds operated as passive flow-through ponds are contained in the *Pond Operations Plan* (RMRS, 1996b). Computer codes are also available to estimate removal effectiveness for a variety of hydrologic and sediment conditions. These calculations and computer codes can be used to further assess the adequacy of the existing ponds to be reconfigured as passive flow-through ponds. The appropriate design modifications (if any) that are required to increase settling performance to maintain compliance with the surface water quality standards can be quickly assessed using a computer code.

A preferred final configuration for the existing ponds will be developed based on applying the Pond Reconfiguration Strategy to a complete ICD. Detailed design drawings and a transition plan could be developed to describe how the existing ponds will be reconfigured. The transition plan should describe operational constraints and interim controls that would be employed during the transition period.

6.4 Post-Closure Facilities and Infrastructure

The Design Basis identifies that the East and West Access Roads, and the North Perimeter Road will be retained or minimally modified (see Section 2.2.3.1 in Tab 2, Appendix B). The vision for closing RFETS also includes removing all aboveground buildings and structures, and parking lots. However, certain existing facilities and infrastructure may be beneficial to support long-term stewardship activities and management of the Site as a National Wildlife Refuge. Such facilities may include parking areas, storage/maintenance facilities for equipment (including environmental sampling devices), administrative offices for Refuge workers, and a visitor center. These facilities would also require functional utilities, such as electric power, water, and sewer.

The facility and infrastructure requirements to support long-term stewardship and management of RFETS as a National Wildlife Refuge should be identified and discussed with the Fish and Wildlife Service. The reuse of existing buildings and structures to meet these requirements should be considered and appropriately incorporated into Site closure planning documents. The need to retain or upgrade unimproved roads in the buffer zone should also be considered and discussed with the Fish and Wildlife Service. Plans to close and revegetate unnecessary buffer zone roads should be included in the detailed design for the final land configuration. The final plans should consider the needs for the entire Site, including the Rock Creek and Smart Ditch drainage basins.

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Table C-1
Identified Data Gaps, Proposed Resolutions, and Assumptions

ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-010	Availability, quantity, and suitability of water to sustain wetlands after Site closure (cessation of imported water, increase in infiltration rate in IA). This information includes groundwater elevations and the location, quantity, and seasonal distribution of groundwater discharges.	Use SWWB information to determine changes due to Site closure to the sustainability of wetlands. Utilize 1937 and 1951 aerial photographs to identify pre-Site wetland conditions. Develop a defensible method to determine potential impacts (by acreage) to wetlands, riparian, and Preble's mouse habitat using SWWB results. Assess potential water depletion to South Platte River.	High	October 2002	With elimination of manmade influences, imported water and ponds, Site wetlands will return to conditions that generally resembles pre-Site conditions depicted in the 1937/1951 photographs. With cessation of imported water, groundwater elevations in the IA will be lower and the flux of groundwater to seeps would be reduced, thus decreasing the natural sustainability of existing wetlands associated with the IA. In areas with high groundwater levels, seeps that contribute to soil saturation would support wetland vegetation. Note: It is intended that the initial conceptual design be evaluated by the SWWB Project Team to assess potential impacts to wetlands.
GAP-020	Understanding of contaminant transport mechanisms between surface waters, soils and subsurface contamination, especially resuspension of sediments from drainage channels. Relationship between surface water actinide concentrations and sediment actinide concentrations.	AME Project Team will continue to evaluate these processes. Model smaller storm events and develop a continuous climate record. Use data to evaluate compliance of large single storm events with the 30-day moving average RFCA standard.	High	October 2002 Use Assumption	Use predicted sediment loading and actinide concentrations to drainages developed by the AME Project Team to relatively compare the performance of various engineering components and configurations.

ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-030	Identification of quantities and locations of legacy actinide-bearing sediments in the existing site surface water drainages (specifically Walnut Creek).	AME Project Team to evaluate existing data for the Pathways Report. Continue to review sampling data.	High	October 2002 Use Assumption	Implementation of additional actions in the lower reaches of Walnut Creek is not warranted based on existing information.
GAP-040	Location of POCs if terminal ponds are removed.	Revised locations to be negotiated between DOE and Regulatory Agencies. Need for terminal ponds to be addressed during detailed design.	Moderate	2006 Use Assumption	Only the Walnut Creek (GS03) and Woman Creek (GS01) monitoring points at Indiana Street will be POCs if the terminal ponds are removed.
GAP-050	Identification of long-term stewardship responsibilities that will require continued access (includes groundwater monitoring wells, surface water sampling locations, and air monitoring stations) to portions of the Site (IA & BZ) after closure and the resulting need for access roads.	Incorporate sampling and monitoring requirements of individual remedial actions into the final land configuration.	Moderate	2006 Use Assumption	Provide access to known sampling and monitoring points, remediation systems and significant land configuration features. Retain West and East Entrance Roads and North Perimeter Road. Current POC locations will be used for long term monitoring systems.
GAP-060	Identification of facilities and infrastructure that can be used to facilitate future land use of RFETS, including the need to upgrade the existing buffer zone roads.	Meet with Fish and Wildlife Service to discuss future needs and possibility of reusing existing buildings and structures.	Moderate	October 2002	None of the existing buildings and structures will be required. Existing buffer zone roads will be maintained in their current configuration.

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ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-070	Structures and other components that will remain in the IA area after completion of active remediation, including underground structures that influence the movement of existing GW plumes.	Adopt plans/strategy for IA closure developed by D&D/ER. Use SWWB results to assess potential impacts.	Moderate	2006 Use Assumption	All subsurface concrete structures will be removed to a depth of 3' below grade. Structures that do not meet the unrestricted release criteria will be removed regardless of depth or appropriately stabilized. Other assumptions are provided in Section 2.1.2 of Appendix B. Any remaining UG structures will not result in impacts to surface water. Additional remedial actions would be taken prior to completion of active remediation if required. The wastewater treatment plant will be closed.
GAP-080	Future operation of water supply ditches that convey surface water across the Site including Mower Ditch, Upper Church Ditch, South Boulder Diversion Canal, McKay Ditch, and Kinnear Ditch.	Use assumptions consistent with AME Project Team to evaluate bounding scenarios and initial conceptual design. Discuss future plans with City of Westminster and Broomfield.	Moderate	Use Assumption	Current mode of operation of McKay Ditch and pipelines as described in Section 2.3.1.1 of Appendix B will continue. Last Chance Ditch/Kinnear pipeline will be used to transfer the water rights associated with Kinnear Ditch. As such, Kinnear Ditch will be abandoned and the flow into Woman Creek would not occur. Institutional controls will be adopted to preclude use of Kinnear Ditch to convey water across the Site.
GAP-090	Need to retain West Diversion Dam in its current configuration.	Discuss future plans with City of Broomfield. Address during application of the Pond Reconfiguration Strategy.	Moderate	2004 Use Assumption	The West Diversion Dam will be retained in its current configuration. However, modifications may be required to provide long-term stability of this structure.

ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-100	Performance requirements and feasibility of converting the existing ponds to passive flow-through devices or other configurations.	Use sediment settling data compiled by AME Project Team to identify performance requirements. Evaluate adequacy of existing ponds and potential feasible modifications using available computer codes. Use Pond C-1 as a pilot test.	Moderate	October 2002	Passive flow-through ponds may not provide adequate performance to reduce actinide loads below 0.15 pCi/L during storm events. Modifying the existing ponds to flow-through or other configurations is feasible.
GAP-110	Long-term performance of constructed wetlands to remove sediments.	Conduct literature search. Use AME modeling results for channel erosion to determine critical erosive velocities that may result in sediment resuspension from wetlands. Conduct pilot study using Pond C-1.	Moderate	October 2002	With adequate maintenance, performance of wetland systems would remain effective.
GAP-120	Location of remediation systems that will need to be maintained after Site closure. Installation of unidentified additional remediation systems that are required to be maintained after completion of active remediation. Need for treatment capability of nitrates in surface water drainages after Site closure.	Need for remediation systems will be addressed in future decision documents. Conduct further characterization to define the nature and extent of the IA VOC Plume. Use SWWB results to assess potential impacts to existing GW plume systems. Continue to assess environmental sample and monitoring results.	Moderate	2006 Use Assumption	Additional remediation systems other than those currently planned will not be installed. Description of planned remediation systems is provided in Section 2 of Appendix B. System locations are shown on Figure B-03. A groundwater collection and treatment system will not be installed for the IA VOC Plume. Current nitrate concentration in North Walnut Creek is attenuating at a rate that will not require additional controls after Site closure.

ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-130	Post-closure configuration of the Present Landfill Pond and Seep Collection/Treatment System.	Regulatory agency approval of design drawings and plans developed for closure of the Present Landfill.	Moderate	2003 Use Assumption	Present Landfill Pond will be eliminated due to ET cover installation. Present Landfill seep collection and treatment system will be relocated and operated after closure.
GAP-140	Feasibility of installing ET cover over the Original Landfill.	ET Cover Project to address in feasibility study.	Moderate	October 2002	An ET cover will be installed over the Original Landfill to minimize infiltration.
GAP-145	Installation of an ET cover for the Solar Evaporation Ponds.	ET Cover Project to address in final decision document.	Moderate	October 2002	An ET cover will be installed over the Solar Evaporation Ponds to minimize infiltration.
GAP-150	Residual actinide locations and concentrations in the IA. Extent of remediation at the 903 Pad.	Compile ER sampling results from building and IHSS remediation activities. Incorporate applicable provisions from the final decision documents for the 903 Pad.	Moderate	2006 Use Assumption	Subsurface concentrations will be at RFCA Tier I Action Levels or below. Soils between the Tier I and II action levels will remain in place. Surface soil concentrations will be at background levels where imported fill and topsoil is used.
GAP-160	Location of culverts, check dams, ditches open channels, vegetative swales, filter strips, stream bank stabilization controls and erosion protection devices within the principal and minor drainage channels.	Identify locations of drainage features during detailed design. Significant changes / impacts to WEPP results will be assessed during detailed design.	Moderate	Use Assumption	Culverts, check dams, ditches, open channels, vegetative swales, filter strips, stream bank stabilization controls and erosion protection devices within the principal and minor drainage channels in the buffer zone will remain intact and unaltered unless their removal is included as a specific element during the initial conceptual design. The A-, B-, and C-Series ponds will remain in current configuration unless modifications are justified by Pond Reconfiguration Strategy.
GAP-170	Future mining activities, including assessing impacts of potential gravel mining in upper Walnut Creek.	The significance of this data gap is dependent on the components chosen for the final land configuration. If the potential impacts are significant, detailed evaluation or sub-study could be conducted.	Moderate	Use Assumption	Mineral rights within RFETS will not be exercised or mining permits will be rescinded/not issued by the State. Otherwise, institutional and administrative controls will be established to regulate mining activities to preclude adverse impacts to the final land configuration.

ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-180	Establishment of final remediation goals in the CAD/ROD. Revisions to action levels to incorporate National Wildlife Refuge worker.	Comprehensive Risk Assessment to address.	Moderate	2006 Use Assumption	The final remediation goals will not be more stringent than the RFCA Tier I Action Levels. Current RFCA Action Levels are protective of potential human (including National Wildlife Refuge worker) and ecological receptors.
GAP-190	Identification of additional federal and state T/E species that would impact the final land configuration.	Monitor changes to T/E list.	Moderate	2006 Use Assumption	No changes to the current federal or state T/E lists will occur.
GAP-200	Results of a future "Programmatic Biological Assessment" (prepared per the Endangered Species Act) to address land configuration changes and activities that may affect the Preble's mouse.	Incorporate applicable provisions from the final Programmatic Biological Assessment.	Moderate	Use Assumption	No impact from future Programmatic Biological Assessment.
GAP-210	Significance of storm water from Woman Creek to Mower Ditch during storm events. Contribution of runoff in the watersheds west of the South Boulder Diversion Canal. Contribution of runoff in the watersheds upstream of Upper Church Ditch.	Use assumptions consistent with AME Project Team to evaluate bounding scenarios and initial conceptual design.	Moderate	Use Assumption	Diversion of storm water from Woman Creek to Mower Ditch is small during storm events. Some runoff draining into Mower Ditch will cross over into the Woman Creek channel. Runoff in the watersheds west of the South Boulder Diversion Canal is either insignificant or intercepted. The runoff north of Upper Church Ditch will not crossover the elevated ditch banks. All runoff generated within the upper reaches of Walnut Creek will be intercepted and diverted, and are therefore not included.

ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-220	Prediction of long-term climate changes for temperature, precipitation, and storm event duration and severity.	Literature search indicates that long-term climatic changes are likely, however, there are no reliable predictions to quantify long-term climate changes. Continue to monitor for advances in predictive modeling or other research results.	Moderate	October 2002 Use Assumption	No significant climate changes will occur over the next 1,000 years.
GAP-230	Geomorphic process rates including mass wasting, channel incision and headward erosion in existing drainages and for IA after final configuration.	Conduct literature review to identify reasonable geomorphic process rates. Develop and conduct a sub-study to attain Site-specific information. Use predicted rates from erosion and hydrologic evaluations.	Moderate	October 2002	Use predicted rates from erosion and hydrologic evaluations.
GAP-240	Quantity of fill material needed to complete D&D/ER Projects. Source of imported fill materials. Geotechnical and soil properties for imported fill materials and imported topsoil (growth media). Feasibility of adding amendments to allow onsite soils to be used as a growth media for revegetation.	Prepare master cut and fill soil balance and database. Obtain test information from offsite borrow areas. Evaluate necessary adjustments (nutrients, constituents, particle size distribution) to existing soil to support growth.	Moderate	October 2002 Use Assumption	Offsite fill soil will need to be imported from local borrow areas (within 10 miles of the Site). If testing data for imported fill materials is not available, assume that existing data for onsite soils is representative of imported fill. Specification for imported soil will identify any required geotechnical and soil properties. Topsoil texture, fertility, and weed-free status will be acceptable. Amendments can be added to onsite soils for use as a growth media.
GAP-250	Geotechnical and soil properties for concrete rubble and other construction material that will be used for fill in IA.	Develop during closure of the IA.	Low	2006 Use Assumption	Use of concrete rubble will not adversely impact the final land configuration.

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ID	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-260	Extent of riparian/wetland habitat that is used by Preble's mouse due to hydrology changes after Site closure.	Use SWWB results to predict changes to wetland/riparian habitat.	Low	October 2002	If SWWB results indicate that there could be significant decrease in the amount of water available after Site closure, riparian and Preble's mouse habitats could be impacted.
GAP-270	The paucity of strong ground motion records for large earthquakes (magnitude > 6). Identification of faults that are capable of conducting movement along their traces within a relevant time frame. Propagation of earthquake motion.	Use data from recent investigations, including geologic and seismologic data near causative faults.	Low	Use Assumption	Faults and other seismic features are inactive and would not generate forces that require adoption of stringent design criteria.
GAP-280	Necessity for air dispersion controls in developing the final land configuration design.	AME Pathway Report to address airborne concentrations and load at Site boundary.	Low	October 2002	Air pathway to surface water is not significant. Historical air monitoring has not indicated that the air pathway needs to be addressed.
GAP-290	Location of any future easements, especially for new power line.	Easement restrictions and negotiations.	Low	Use Assumption	Current easements will be maintained after completion of active remediation. Any future easements will not interfere with implementing the final land configuration.

APPENDIX D
ANNOTATED OUTLINE FOR THE CONCEPTUAL DESIGN REPORT

Note:

This appendix has been revised since its last issuance dated July 2001 to incorporate responses to DOE/FWS Comment 4 (see Tab 1). The following components of the CDR are included in this Land Configuration Design Basis - Preliminary.

- **Section 4 (Initial Conceptual Design) – The description of the components for the initial conceptual design is provided in Tab 3, Attachment C. The Pond Reconfiguration Strategy to be applied to the initial conceptual design is provided in Tab 3, Attachment D.**
- **Appendix A (Design Basis for Final Land Configuration) – Provided in Tab 2, Appendix B.**
- **Appendix B (Remaining Data Gaps and Assumption) – Provided in Tab 2, Appendix C.**
- **Appendix C (Scenario Development and Evaluation) – Provided in Tab 3, Attachment A.**
- **Appendix D (Ecological Evaluation Report) – Results from the SWWB Project Team is provided in Tab 3, Attachment F. Ecological evaluation for the bounding scenarios and initial conceptual design are not included.**
- **Appendix E (Erosion and Actinide Evaluation Report) – The evaluation results for the bounding scenarios are provided in Tab 3, Attachment B.2. Results for the initial conceptual design have not been developed.**
- **Appendix F (Geomorphic Evaluation Report) – The evaluation results for general geomorphic processes and the bounding scenarios are provided in Tab 2, Appendix G.2. Long-term results for the initial conceptual design have not been developed.**
- **Appendix G (Drawings) – Drawings for the IA Grading and Drainage Concept are provided in Tab 3, Attachment E.**

The following items need to be completed to finalize the CDR.

- **Complete ecological, erosion, hydrologic, and geomorphic evaluations,**
- **Prepare design drawings and specifications,**
- **Develop project schedule and implementation plan, and**
- **Compile cost estimate.**

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EXECUTIVE SUMMARY

Provide a brief statement (single page) describing the intent of the CDR. Describe the design basis for the final land configuration of RFETS. Discuss the process used to develop and evaluate the bounding scenarios to achieve the design basis. Describe the rationale for choosing the specific components that comprise the initial conceptual design and their specific project benefits associated with initial conceptual design. Give the overall project schedule and cost information for implementing the initial conceptual design. State that the initial conceptual design may be developed into the detailed design for the final land configuration or appropriately modified.

1.0 INTRODUCTION

Briefly describe the purpose and scope of the LCDB Project. Project objectives will be discussed, and the approach used to reach these objectives will be presented.

2.0 GENERAL PROJECT DESCRIPTION

2.1 Site Description

Identify the location / size of the RFETS, brief historical background, current mission, and status.

2.2 Project Description

Describe the closure process and how the LCDB Project fits in.

2.2.1 Project Objectives

Identify the overall objective of the LCDB Project (i.e., determine what erosion control, runoff measures, and other land configuration provisions to comply with the RFCA Surface Water Quality Standards at the Points of Compliance following closure of the RFETS). The Project Objectives as identified in the work plan will be addressed. The approach to achieve these objectives will be discussed.

2.2.2 Project Scope

Address LCDB Project scope as identified in the work plan.

2.2.3 Project Boundaries

Provide project boundary description and rationale from work plan. This section will also address the anticipated configuration of the Site at the completion of active remediation (e.g., ER and D&D End States) including physical constraints for the LCDB Project. This section will provide an overall summary; the detailed

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information will be contained within the Design Basis Document (Appendix A). A reference to Appendix A will be provided.

3.0 SIGNIFICANT FACTORS

3.1 Site Information

Identify important site constraints such as local topography, geology, hydrology, remediation system locations, environmental monitoring, land use, etc. This section will summarize the Site information presented in Section 2.0 of the Design Basis (see Appendix A).

3.2 Functional Design Objectives

Address the primary objectives, balancing performance functions / criteria and other design criteria for the final land configuration. This section will summarize the specific functional design objectives presented in Section 3.0 of the Design Basis (see Appendix A).

3.3 Interfaces

Specify significant relationships to other RFETS programs and organizations. These programs include D&D Planning, Water Management Closure Plan, Site Wide Water Balance, and Actinide Migration Evaluation. This section will also describe the interactions of the ER project with the Department of Energy, regulatory agencies, citizen's advisory board, and other stakeholders.

4.0 INITIAL CONCEPTUAL DESIGN

Provide an overall description of the initial conceptual design. Drawings and specifications for the initial conceptual design will be provided in Appendices G and H, respectively.

Address potential ecological implications and describe how the initial conceptual design achieves a balance between compliance with surface water quality standards and minimization of ecological disturbance. The initial conceptual design will provide information that can be used to:

- Determine a suitable reconfiguration for the existing ponds and evaluate the adequacy of the current dams,
- Identify potential environmental impacts and mitigation options including maximizing onsite mitigation,
- Identify potential implications for off-site community water management operations,
- Identify potential implications with respect to operation of third party onsite water supply ditches, easements, and mineral rights.

- Define post-closure stewardship obligations, and
- Develop a final water management policy for the Site.

Discuss the individual components of the initial conceptual design including a justification for their inclusion. Provide a description of the Pond and Sector Strategies. Describe how these strategies were applied to refine the initial conceptual design. Include logic diagrams with descriptive text. (See Sections 6.1 and 6.2 of the work plan.) The discussion of individual components will be present by major design area (IA, BZ, and Walnut and Woman Creeks).

4.1 Industrial Area Actions and Features

4.2 Buffer Zone Actions and Features

4.3 Walnut Creek Actions and Features

4.4 Woman Creek Actions and Features

5.0 ASSESSMENTS

This section demonstrates that the initial conceptual design meets the project functional design objectives and will include the following specific assessments:

- Summary of erosion and actinide study results and evaluation for the initial conceptual design conducted by the AME Project Team.
- Summary of hydrology evaluation (including storm event integrity) for the initial conceptual design.
- Long-term evaluation of landscape evolution (geomorphology)
- An accounting of wetlands, habitat, and other natural resources.
- Evaluation of potential impacts to threatened and endangered species
- Prevention or elimination of subsurface pathways for potential contaminant migration.

Provide appropriate reference to Appendices D, E, and F.

6.0 PROJECT SCHEDULE

Provide an overall summary schedule for the implementation of the initial conceptual design. To include a Primavera formatted schedule providing time estimates for detailed design, mobilization, surface grading and contouring, construction of control features, revegetation, and eventual final land use. The schedule will also identify major data acquisition tasks required to attain the necessary information to implement the final configuration design.

7.0 SUMMARY OF COST ESTIMATE

Provide summary information regarding the cost for implementing the initial conceptual design including construction, initial and ongoing O&M, and long-term stewardship costs. This summary will build upon the preliminary cost estimates developed for each bounding scenario. Spreadsheets, material quantity estimates, and other information developed to support the cost estimate will be included in Appendix I.

8.0 REFERENCES

This section will provide a list of reference documents used in the development of the initial conceptual design and referenced by the appendices.

APPENDICES

The following information will be included as appendices to allow a significant amount of detailed information and back-up to be included in the CDR while maintaining a reasonable amount of simplicity and conciseness in the body of the document.

APPENDIX A - DESIGN BASIS FOR FINAL LAND CONFIGURATION

This Appendix presents an updated version of the Design Basis for the final land configuration presented in the LCDB work plan. The Design Basis identifies the Site information and functional design objectives that the engineer/designer needs to know in order to complete the detailed design. The Design Basis will address the anticipated conditions of the Site at the completion of active remediation, the primary objectives that the design must comply with, the balancing performance functions / criteria that the design should achieve, and the Site information that needs to be considered and utilized to develop the design for the final land configuration. This section will indicate that the design basis may need to be modified as the data gaps and corresponding assumptions identified in Appendix B are resolved.

APPENDIX B - REMAINING DATA GAPS AND ASSUMPTIONS

This appendix identifies the data gaps, uncertainties, tentative plans, unsubstantiated constraints and assumptions that could not be verified during development of the initial conceptual design. This information builds upon and will be formatted similar to Appendix C of the LCDB work plan. Any remaining data gaps that could not be resolved and associated assumptions will be carried forward into final design for resolution prior to completing the final design.

APPENDIX C - SCENARIO DEVELOPMENT AND EVALUATION

C.1 Scenario Development

Provide a description of the basic scenario options and describe how the bounding scenarios were identified, develop, and assembled. (See Section 5.3 of the work plan.)

C.2 Summary of Scenarios

Provide a description of each bounding scenario. Describe the general and specific strategies associated with development of that scenario.

Scenario 1

Scenario 2

Scenario 3

C.3 Scenario Evaluation

Discuss the evaluation results for each bounding scenario including a description of its performance in specific drainages or sectors. Provide appropriate reference to Appendices D, E, and F. This evaluation will be used to identify and assemble the appropriate scenario components as the initial conceptual design. The initial conceptual design satisfies all the primary objectives and provides the best value of the balancing performance functions / criteria.

Scenario 1

Scenario 2

Scenario 3

APPENDIX D - ECOLOGICAL EVALUATION REPORT

Present results of the ecological evaluation, including accounting of natural resources for the conceptual design.

APPENDIX E - EROSION AND ACTINIDE (AME) EVALUATION REPORT

Present results of the erosion and actinide evaluations that were performed by the AME Project Team on the bounding scenarios and the initial conceptual design.

APPENDIX F - GEOMORPHIC EVALUATION REPORT

Provide results of the geomorphic evaluation including a life cycle analysis of the effective life of the erosion controls, drainages, soil covers, and vegetation covers specified by the initial conceptual design.

APPENDIX G - DRAWINGS

Provide maps, sketches, and engineering drawings referenced throughout the main body of the CDR. Drawings will be adequate to convey the basic elements of the initial conceptual design and will include the current and proposed (based on the initial conceptual design) land configuration at the Site including cross sections and typical design details of the specified surface water control features.

APPENDIX H - SPECIFICATIONS

Provide detailed specification for vegetation (seed, mulching, and topsoil) and outline specifications for the remaining required CSI divisions.

APPENDIX I - COST ESTIMATE

Provide the spreadsheets, unit prices, quotes, references, factors, and other information used to develop the cost estimate for the initial conceptual design. This appendix will include estimated quantities materials, such as imported topsoil, fill material, and riprap.

APPENDIX E
ECOLOGICAL EVALUATION FOR
LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This appendix has been revised since its last issuance dated July 2001 to incorporate responses to DOE/FWS Comment 97 and Regulatory Agency Comment 55 (see Tab 1).

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1.0 INTRODUCTION

The potential impacts to ecological resources associated with each bounding scenario will be assessed to identify scenario components that achieve the best balance between achieving compliance with the surface water quality standards and minimization of disturbance to ecological resources. The ecological resources that will be evaluated include wetlands (which will incorporate aquatic habitats), riparian areas, Preble's Meadow Jumping Mouse (Preble's mouse) protection areas, wildlife, and vegetation. There is overlap among these resource categories that could be affected by each bounding scenario. For example, the Preble's mouse protection areas overlap areas associated with other resources such as wetlands. For the purpose of the ecological impacts evaluation, the potential impacts to each ecological resource will be evaluated separately.

The expected ecological conditions after the completion of active remediation and each bounding scenario will be evaluated to determine potential changes from current conditions. The differences identified between current conditions and at the completion of active remediation would be used to identify resource areas where adverse ecological effects would likely occur as a result of closure (including the elimination of imported water). Predicted changes associated with each bounding scenario will be evaluated with the anticipated conditions at the completion of active remediation to account for any adverse effects that may result from closure of the Site.

The evaluation of ecological resources will be an integral step in developing the initial conceptual design that best meets the functional design objectives (FDOs). The results of the evaluation will also be used to predict the long-term effects to ecological resources, thus helping to balance various options that will ultimately be incorporated into the initial conceptual design.

2.0 OBJECTIVES

The objectives of the ecological evaluation are to:

- Identify the effects to ecological resources that would occur at the completion of active remediation,
- Assist in identifying design elements for developing the bounding scenarios,
- Identify the effects to ecological resources that would occur under each bounding scenario, and
- Provide a basis for evaluating the potential effects to ecological resources at the completion of active remediation and under bounding scenario implementation.

3.0 EVALUATION TOPICS

Data of several types, including wetland, riparian habitat, Preble's mouse protection areas, vegetation, and wildlife habitat information, was collected to establish the current status of ecological resources at RFETS. These datasets will act as the baseline to which predicted changes can be evaluated.

The types of data that will be relied upon to support the evaluations include discussions with the Kaiser-Hill Ecology Group, historic and current aerial photointerpretation, ground-level photographs, GIS map files, existing technical and monitoring reports and technical reports, and opportunistic field observations. Results from the SWWB project will also be used as they become available.

The following sections outline the proposed approach for each specific resource.

3.1 Wetlands

The assessment of wetland effects is currently focused on using the details and approaches associated with each bounding scenario. This approach is proposed because detailed monitoring data describing the water sources, timing of availability, and relative proportion of water supply supporting each wetland site are currently unavailable for each wetland site.

Anticipated wetland conditions at the completion of active remediation and predicted impacts associated with each bounding scenario will be evaluated using the following methods. GIS analysis will be used to provide the final estimated predictions of the effects to the areal extent and location of wetlands.

Historic vertical, black and white, aerial photographs of the Site from 1937 and 1951 will be reviewed to identify wetlands that were present at those times. Wetlands shown in the 1937 and 1951 photographs are indicative of conditions before the facilities began operating and their associated effects on the surface and ground water regimes. The development of the IA, including the construction of ponds and the discharge of water from industrial processes and wastewater treatment, has altered the hydrology that previously supported Site wetlands. Using a simplistic view, one could assume that only those wetlands that were present prior to the development of RFETS will exist when the Site is closed and importation of water is stopped. However, the drainage patterns, infiltration rates and groundwater constraints (e.g., treatment systems) have changed since the photographs were taken and need to be taken into account. Nonetheless, the concept of a pre-RFETS wetland baseline is valuable in defining the likely minimum wetland extent that natural conditions could support.

The functions provided by existing wetlands at the Site will be evaluated to qualitative predict the changes in the capability of wetlands to provide those functions. Evaluation of the capability of wetlands to provide existing functions will be used as a tool to estimate the implications of wetland changes. This evaluation can be used as a complementary method to assess wetland changes associated with changes in the

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predicted areal extent. This assessment will address bounding concerns about whether two wetlands (existing and future) would provide the same environmental service (e.g., sediment trapping and retention) even though they may look physically different. The converse situation could also be the case.

Selected outputs from the SWWB model will be used as one of the tools to provide an estimate of groundwater conditions at the completion of active remediation. These conditions will be used to predict potential changes to the survival and extent of wetlands by identifying areas where decreases in groundwater elevations would no longer be able to sustain the existing wetlands. In those areas where wetlands currently exist, but where the modeled groundwater depths are deeper than 18 inches below the ground surface, it is unlikely that wetlands could be sustained in the long-term. The SWWB results would be assessed, in conjunction with the other evaluation tools, to determine the value and limitations of the results in supporting long-term predictions for the survival of wetlands.

The assessment will also account for changes in wetland extent associated with the anticipated conditions at the completion of active remediation and the lag time between the change in groundwater supply to a particular wetland and its future condition. The duration of this lag time and the nature of wetland changes would be site- and species-specific. For example, deep-rooted species such as cottonwood and willow would take longer to show adverse effects resulting from a lower water table than shallower-rooted species such as sedges or rushes. Additionally, the moisture-retaining characteristics of existing wetland soils would capture precipitation and other surface water that would sustain the wetland vegetation. This, and the persistence of the already established vegetation, would be sufficient to maintain wetland vegetation well after groundwater typically needed to support wetlands is depleted. The predicted change in wetland areal extent based on the SWWB model output would be used to forecast long-term (i.e., over a period of 30 years or more) changes and trends.

Knowledge of existing groundwater conditions is integral to the evaluation of wetlands because to predict changes, the current groundwater flow patterns must be understood. Groundwater maps and groundwater elevation monitoring information will be used to estimate predicted wetland changes by determining where changes in groundwater flow directions and elevations would have effects. The historical groundwater conditions and the SWWB modeling results will be used to identify potential affected areas and to verify wetland predictions.

Direct physical effects, such as regrading or removing ponds and the wetlands associated with them, would be assessed and included in the evaluation.

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3.2 *Riparian Habitats*

Riparian habitats are critical to support the Preble's mouse and are an important resource for many wildlife species at RFETS. Changes to riparian habitats will be evaluated using the methods described below. GIS mapping will be used to predict and quantify the areal extent of changes to riparian areas.

Historic and recent aerial photographs will be evaluated to identify changes to riparian habitats (including Preble's mouse protection areas). The influence of livestock grazing on the land that occurred prior to the construction of RFETS will be considered when reviewing the photographs. Grazing typically has a strong negative influence on riparian vegetation (i.e., reducing or eliminating establishment of tree and shrub species). Consideration of pre-RFETS riparian conditions would introduce an element that no longer affects vegetation at the site and is not likely to be a factor in the future for the designated final land use of open space. However, the historic photographs will provide information showing where riparian habitats, particularly stands of cottonwoods, found suitable conditions for establishment and success.

SWWB model output and generated groundwater maps will be reviewed to identify the existing riparian areas where hydrological conditions would still be adequate to support riparian vegetation after the conditions in the scenario are implemented. The primary difference in the use of model data between the wetland and riparian evaluations will be the rooting depths of the vegetation in the respective categories. Riparian vegetation will be more likely to survive than wetland species as a function of decreases in the groundwater table. As with wetlands, there will be a lag time between the loss of groundwater hydrological support and the demise of the riparian species. The established vegetation in riparian areas (i.e., cottonwoods, willows, and other trees and shrubs) will persist for quite some time before the lack of long-term groundwater support allows more upland species to become dominant. As a result, the predicted change in the areal extent of riparian habitats based on the SWWB model output would only be valid in the long-term (i.e., over a period of 100 years or more).

Knowledge of existing groundwater conditions is integral to the evaluation of riparian areas because to predict changes, the current groundwater flow patterns must be understood. RFETS groundwater maps will be used to independently verify predicted riparian area changes by determining where changes in groundwater flow would have effects. The historical groundwater conditions and the SWWB modeling results will be used to identify potentially affected areas and to verify riparian area predictions.

Direct physical effects, such as regrading drainage bottoms, or rechanneling streams and the adjacent riparian areas, would be assessed and included in the evaluation.

3.3 *Preble's Meadow Jumping Mouse Protection Areas*

The areas designated as Preble's mouse protection areas will be evaluated using the results of the wetland and riparian area evaluations, plus any predicted changes to upland vegetation that is included in the Preble's mouse protection areas. Preble's mouse habitat is primarily composed of a combination of wetland and riparian areas. The protection areas also include intervening parcels of upland habitat that may be used by the Preble's mouse. GIS mapping will be used to compile the intersection of predicted area changes and calculate the areal extent of changes that the Preble's mouse protection areas could experience.

3.4 *Vegetation*

The evaluation of effects to vegetation will be based on separately determining areas of temporary and permanent direct physical changes to existing vegetation that result from the completion of active remediation or each bounding scenario. Changes in the relative proportions of the existing vegetation communities under future scenario conditions will be determined as percent of total area and as total acres for each mapped vegetation community. Areas that are planned for revegetation as part of active remediation or the bounding scenarios will also be included in the evaluation. GIS mapping will be used to predict and quantify estimated acreage changes by vegetation type.

Different vegetation community conditions and mixes will be evaluated for their capabilities to be self-sustaining over the long-term under either general climatic changes trending towards warmer and drier conditions or cooler and wetter conditions; the ability of different plant communities to accelerate or retarding precipitation infiltration and evapotranspiration; and the general vegetation structural character and complexity. The assessment will also determine the net losses or gains in the areal extent and locations of plant communities that may be developed as a consequence of scenario implementation.

3.5 *Wildlife*

The evaluation of effects to wildlife will be based on assessing the direct physical changes to existing known sensitive wildlife habitats that could result from completing active remediation or each bounding scenario. Areas that are planned for revegetation as part of active remediation or the bounding scenarios will also be included in the evaluation. GIS mapping will be used to predict and quantify the effects to sensitive wildlife habitats.

4.0 EVALUATION OF BOUNDING SCENARIOS

The bounding scenarios will be evaluated to identify the potential impacts on ecological resources, using the methods described above, to predict changes that may occur by implementing each of the bounding scenarios. The evaluation results will be used to identify the scenario components that best meet the FDOs. If available, the SWWB results will be used to individually evaluate each bounding scenario.

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5.0 FORECAST OF INITIAL CONCEPTUAL DESIGN RESOURCE EFFECTS

GIS will be used to generate maps that would depict the predicted status of the respective ecological resources as a result of implementing the initial conceptual design. SWWB results, if available, will be used to evaluate the initial conceptual design. Additionally, the analyses will include predictions for the future ecological conditions. The CDR will contain information that will allow DOE to enter into consultations (including consideration of potential mitigation measures) with natural resource agencies to discuss the potential effects of the initial conceptual design and how to best manage any anticipated changes in ecological resources. This information will include:

- The identification of consultation requirements to mitigate any potential water depletions to the Platte River basin.
- The identification of potential wetland and floodplain impacts and other information to support the completion of an ecological evaluation per the requirements of 10 CFR 1022.

Any water depletion in the Platte River basin could represent a potential adverse effect to federally threatened, endangered, or proposed species that are located within the designated critical habitat reach of the central Platte River. The information being developed by the SWWB Project Team would be used as one of the tools to quantify water depletions associated with Site closure and implementing the initial conceptual design. If water depletions to the Platte River basin were anticipated, the information would be compiled in a manner to facilitate consultation with the U.S. Fish and Wildlife Service, including identification of potential mitigation measures. Making annual payments to the Platte River Basin Endangered Species Recovery Implementation Program is the common mitigation measure. The funds are used to purchase water to maintain minimum instream flows and to restore and maintain habitat in the critical habitat reach of the central Platte River. The annual payment of each individual contributor is based on a formula that takes into account the amount of the water depletion on a proportional basis.

The information being developed by the SWWB Project Team would also be used as one of the tools to quantify the potential effects to existing wetlands and floodplains associated with Site closure and implementing the initial conceptual design. This information would be compiled in a manner to facilitate consultation with the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency to determine what mitigation measures would be necessary, if any, to offset potential losses of wetland acreage or functions, or adverse effects to floodplains.

APPENDIX F

EROSION AND HYDROLOGIC EVALUATION FOR LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This appendix is located in Tab 3, Attachment B.1 for consolidation of information.

This appendix has been revised since its last issuance dated July 2001 to incorporate responses to Regulatory Agency Comment 56 (see Tab 1).

The dates provided in Figure F-01 have not been updated and may not be reflective of the current or future LCDB Project schedule.

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APPENDIX G

GEOMORPHIC EVALUATION FOR LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This appendix has been revised since its last issuance dated July 2001 to incorporate response to DOE/FWS Comment 99 (see Tab 1).

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1.0 INTRODUCTION

A qualitative and semi-quantitative geomorphic evaluation will be conducted to identify the dominant geomorphic processes at RFETS and to determine the rates at which they are occurring so that the long-term evolution of the landscape can be predicted. In order to understand the rates at which these processes occur, the driving forces that interact with these processes will be evaluated. The driving forces include climate, gravity, and other internal forces such as tectonics.

Historical information will be evaluated to identify the characteristics of the landscape changes that have occurred. This historical information in conjunction with the anticipated conditions at the completion of active remediation (including the elimination of imported water) will be used to predict the long-term geomorphic processes that would be expected after Site closure.

The predicted the long-term geomorphic processes will be used to assist in developing and evaluating the bounding scenarios. Scenarios will be qualitatively evaluated to identify the relative susceptibility of each bounding scenario to the predicted geomorphic changes.

The results of the geomorphic evaluation will also be used to predict the long-term evolution of landscape, identify long-term soil erosion characteristics, and assess the potential for damage to remediation systems and other anthropogenic influences (roads, dams, water conveyance structures, etc) due to mass wasting for the initial conceptual design. Engineered structures or other land configuration options that could be used to preclude or minimize any identified adverse impacts will be considered for potential incorporation into the initial conceptual design. For the purpose of the LCDB Project, the geomorphic evaluation period for the initial conceptual design is 1,000 years because predictions for longer periods may not be reliable with any confidence.

2.0 FIELD METHODS

2.1 Site Reconnaissance

A site reconnaissance was conducted during the week of February 26th to visually assess the type, extent, and magnitude of geomorphic processes that are occurring within the drainages and hillslopes of Walnut and Woman Creeks at RFETS. Field observations were recorded in a project notebook and areas of interest were marked on a topographic map for further investigation. Field photographs were taken to document the geomorphic processes at the Site.

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2.2 *Aerial Photograph Interpretation*

Historic vertical, black and white, aerial photographs from 1937, 1951, and 1994 of the Site were obtained and will be reviewed to identify landscape changes that have occurred due to seepage, mass wasting, and fluvial processes. The 1937 and 1951 aerial photographs will also be used to identify pre-site conditions. The landscape changes will be assessed to estimate the rate at which the geomorphic processes are occurring.

2.3 *Geologic Mapping*

The coordinates of significant features identified during the review of the aerial photographs were located during the site reconnaissance. Field observations, photographs, and mapping of significant features were made. The field observations, photographs, and maps will be used to identify areas within the LCDB Project boundary that are prone to erosion by mass wasting. If required, additional field observations and photographs will be taken to document the geomorphic processes in specific areas to assess each bounding scenario and components for the initial conceptual design.

3.0 EVALUATION OF DRIVING FORCES

Landforms represent interaction between driving forces and resisting forces. The following driving forces and their long-term implications on landform evolution will be evaluated.

- **Climate** – The current climatic conditions (100-year record for Fort Collins) will be used to assess storm events (frequencies, duration and occurrence). A literature review will be conducted to determine predicted changes in the future climate of the Front Range over the 1,000-year evaluation period and/or the 100-year historic record will be used as the basis to statistically predict future climate. If predictions cannot be made, the climate will be assumed not to drastically change over the next 1,000 years (see Data GAP-220).
- **Tectonics** - It is assumed that seismic events, which could alter erosion rates, will not occur over the 1,000-year evaluation period (see Data GAP-270).
- **Anthropogenic Influences** Only those anthropogenic influences and landscape changes that are included as part of each bounding scenario or the initial conceptual design will be evaluated. For evaluation of the initial conceptual design, it is assumed that these driving forces will remain constant over the 1,000-year evaluation period.

Resistance of the geologic framework to the geomorphic processes is well characterized through previous geologic investigations at RFETS.

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4.0 EVALUATION OF PROCESS RATES AND VARIABILITY

The geomorphic processes are the methods by which landforms are changed from an existing form or shape into a new one. The processes (including the rates that they occur) that will be evaluated include overland and rill erosion during precipitation events, headward erosion as channels advance upstream, stream down cutting or channel incision, and mass wasting such as slumps and landslides. Evaluation of the process rates, variability, and their long-term implications on landform evolution will be based on the following:

- **Overland and Rill Erosion** - Overland and rill erosion and deposition rates will be based on estimates developed by the AME Project Team and the Erosion and Hydraulic Evaluation (see Appendix F of the Work Plan).
- **Headward Erosion** – Site-specific data for headward erosion is not available. As such, an appropriate value will be determined from published literature.
- **Channel Incision** - Site-specific data for channel incision is not available. As such, an appropriate value will be determined from published literature.
- **Mass Wasting** – The following methods will be used to characterize mass wasting rates and volumes. First, pre-RFETS mass wasting volumes and frequencies will be qualitatively determined by comparing landslides and slumps present in the 1937 aerial photographs to those present in the 1951 aerial photographs. Post-RFETS mass wasting volumes and frequencies will be qualitatively determined comparing pre-RFETS conditions with current conditions. Second, current mass wasting at the Site will be characterized by reviewing available information (such as Modular Tanks stake survey data) and data obtained during field reconnaissance. Evaluation of pre-RFETS and current conditions will be used to semi-quantitatively estimate mass wasting rates and volumes in the future and the sensitivity of these processes with respect to each bounding scenario.
- **Deposition** – Deposition of sediment via mass wasting will be evaluated qualitatively by comparing older aerial photographs to current ones to get an estimate of volumes as described above.

5.0 EVALUATION OF BOUNDING SCENARIOS

The bounding scenarios will be qualitatively evaluated based on the methods described in Sections 3.0 and 4.0 to predict resulting landform evolution. Each bounding scenario will be compared to the anticipated topography at completion of active remediation to identify areas sensitive to geomorphic processes. The ability of each bounding scenario to withstand / accommodate long-term geomorphic changes will be evaluated relative to each other based on applying the current geomorphic processes occurring at RFETS to each bounding scenario. The evaluation will include consideration of anthropogenic influences (such as roads, dams, water conveyance structures, etc) associated with each bounding scenario.

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6.0 INITIAL CONCEPTUAL DESIGN

A more detail evaluation will be conducted for the initial conceptual design. This will include developing a topographic map using GIS for the initial conceptual design to depict the predicted future landform conditions over the 1,000-year evaluation time period. The evaluation will include consideration of the long-term evolution of the fluvial system at RFETS due to headward erosion, channel incision, and depositional processes. The predicted topography will be based on the current geomorphic driving forces and process rates estimated from the review of Site information, historical photographs, and published literature. Specific erosion rates will be applied to the area of the existing topography that relates to the mapped geomorphic process. For example, headward erosion rates will be applied using GIS at the headwaters of channels to show channel advancement. The result of channel advancement will be depicted by changes in elevation contours on the topographic map.

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APPENDIX G.2

GEOMORPHIC EVALUATION REPORT FOR LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This attachment is a compilation of in-progress work being performed to complete the tasks identified in Tab 2, Appendix G. This attachment does not include the following tasks:

- **Development of a topographic map for the initial conceptual design to depict the predicted future landform conditions over the 1,000-year evaluation period.**
- **Identification of sectors where additional engineering controls may be required to ensure long-term stability of the components included in the initial conceptual design.**

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GEOMORPHIC EVALUATION REPORT FOR LAND CONFIGURATION DESIGN BASIS PROJECT

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1.0 INTRODUCTION

A qualitative and semi-quantitative geomorphic evaluation was conducted to identify the dominant geomorphic processes at the Rocky Flats Environmental Technology Site (RFETS) and to estimate the rates at which they are occurring so that the long-term evolution of the landscape can be predicted. The scope and approach for the geomorphic evaluation is presented in Tab 2, Appendix G. In general, the scope for the geomorphic evaluation consists of the following tasks:

- Review historical information, documents, and reports to gain an understanding of the local and regional geological framework and existing landforms (Completed).
- Conduct a reconnaissance of the Site to visually assess the type, extent, and magnitude of geomorphic processes that are occurring within the drainages and hillslopes of Walnut and Woman Creeks (Completed).
- Prepare a map to identify the location of significant geomorphic features (Completed).
- Compare historical aerial photographs from 1937, 1951, and 1994 to identify landscape changes that have occurred (Completed).
- Estimate the rates at which the geomorphic processes are occurring (Completed).
- Identify driving forces that control the geomorphic processes occurring at RFETS and develop working assumptions for predicting long-term changes (Completed).
- Evaluate the bounding scenarios qualitatively to identify the strengths and weaknesses of the various scenario components (Completed).
- Developing a topographic map for the initial conceptual design to depict the predicted future landform conditions over the 1,000-year evaluation period (Incomplete).
- Identify sectors where additional engineering controls may be required to ensure long-term stability of the components included in the initial conceptual design (Incomplete).

In addition to the above tasks, a geomorphic workshop was attended by various Site Project Teams to integrate and coordinate several environmental restoration projects with respect to developing geomorphic information that will be used to evaluate the durability, longevity, and effectiveness of individual project designs. A summary of the geomorphic workshop discussion is provided as Attachment 1 and the conclusions have been incorporated into this appendix along with the results of the above geomorphic evaluation tasks.

2.0 DESCRIPTION OF GEOMORPHOLOGY

Geomorphology may be defined as the examination and classification of landforms and interpretation of the occurrence and characteristics of those landforms in order to generate conclusions regarding specific conditions within a system. Landforms represent some interaction between driving forces and resisting forces (this discussion is condensed from Ritter [1984]). *Driving forces* in geomorphology include climate, gravity, and other forces generated inside the earth. *Resistance* to driving forces is provided by the geologic framework. Driving forces and resisting forces interact via process mechanisms, which are the methods by which one thing is produced from something else, or are the vehicles by which a quantity of one system is transferred into, and participates in, the mechanics of another system. Because landforms represent the net result of interactions among processes and framework, examination and interpretation of landforms enables inferences to be drawn regarding the nature of the active processes.

All natural systems exist in a state of *dynamic equilibrium* – that is, all landforms within a system (such as a drainage basin) are mutually adjusted to reflect an equilibrium condition between geology and the prevailing processes. The equilibrium landforms will last as long as the controlling factors are not changed, because all elements of the surface will downwaste at the same rate. Thus, in the ideal case, landforms become independent of time. Changes do occur, but only in response to altered process or geology. Because a new equilibrium form will be established rapidly (in the sense of geologic time) whenever changes occur, most topography should be adjusted to present conditions. However, geomorphic responses to altered conditions do not always proceed at the same rate.

Landforms may be considered as part of an open system, in which energy and mass are constantly supplied and removed. Losses and gains of energy or mass are kept in a steady state by continuous adjustment of forms within the system. Landforms serve as regulatory agents to balance gains and losses.

For example, a drainage basin is a system composed of many parts (slopes, valleys, floodplains, soils, river channels, etc.), each of which can logically be considered as a separate subsystem. The subsystems may contain even smaller parts (soil profiles, stream channel cross-sections), which themselves function as identifiable systems. The Earth's surface thus consists of a hierarchy of systems, each in instantaneous equilibrium.

Each system or subsystem can be defined by measurable variables or parameters (velocity, slope angle, grain-size distribution, etc.) which, taken together, indicate the character of the system at the time of measurement. Under equilibrium conditions, these variables are totally adjusted to each other and to the external forces that provide or remove energy and mass. Realistically, exact equilibrium may never be attained in the steady state because each system responds to continuously changing external variables (variables outside the system boundaries), and most systems are interdependent. That is, changes in external variables cause reactions within systems, and a change of parameters in one system may require adjustments throughout the entire hierarchy. For example, assume that a long-term cooling in climate (an external force) causes accumulation of ice

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near the poles, at the expense of water in the world ocean. The resulting decline in sea level causes entrenchment to begin in the lower reaches of major rivers. The downcutting may gradually propagate upstream, causing a similar erosional response in each tributary basin. Slopes are re-graded to new elevations. Groundwater tables are lowered. In regions underlain by limestones, a lowered water table may cause a series of solution features, and eventually the surface may collapse. In short, one external change initiates a chain reaction of adjustments in the interrelated subsystems.

Any concept proposing equilibrium (or *stability*) inherently implies a contrasting state of disequilibrium (or *instability*). If variations in external factors demand a response within the system, there must be a period of readjustment during which geomorphic processes and landforms are not in equilibrium. Landslides, subsidence, and gully erosion are examples of disequilibrium generated when the variables of process and/or geology are altered so they can no longer maintain a balanced relationship. They represent events that occur as the interrelated systems attempt to reestablish a new equilibrium condition. Such events can happen suddenly or can proceed toward equilibrium over a long period, depending on how great the disequilibrium is, and how much energy is involved. Disequilibrium conditions, resulting from natural (e.g., climatic change) or anthropogenically-induced changes (e.g., channel reconstruction) can generate rapid responses in geomorphic systems as they move to re-establish equilibrium, producing potentially undesirable results (e.g., increased streambed erosion). Furthermore, the equilibrium state has limits, called *thresholds*, at which something tangible happens to the system. Threshold conditions may occur rapidly, or may develop in response to gradual, often imperceptible, changes within the system. In many cases, the threshold represents a deterioration of resistance, rather than an increase in driving forces. For example, a region characterized by periodic heavy rains may have stable slopes for a long time, but continuous freeze-thaw cycles or other soil-forming processes may gradually reduce the cohesion of the slope material. Eventually, one storm, no more severe than thousands that have preceded it, triggers slope failure. Therefore, it is often desirable to evaluate the relative proximity of a system to a threshold condition.

This type of geomorphic threshold may be inherent in the development of landforms. It is when thresholds are exceeded that things begin to happen, and many apparently deleterious events may be nothing more than nature's way of reestablishing a geomorphic equilibrium. Implicit in the concept of threshold are the ingredients of cause and effect in nature, a dual relationship that is basic to geologic thinking. Cause and effect are essential components of geologic history, where the effects are commonly preserved in rocks or sediments, and the cause becomes the target of investigation and interpretation. These general geologic principals were applied to assess the long-term nature and conditions of geomorphic systems at RFETS.

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3.0 IDENTIFICATION OF DRIVING FORCES

The pertinent driving forces at RFETS include climate, gravity, and tectonic forces. This section describes how these driving forces and other anthropogenic influences may alter landform development and assesses how these forces might change over the 1,000-year evaluation period.

3.1 Climate

Climate represents the net result of how solar energy is distributed in the earth-atmosphere system. Climatologic properties in combination with the surface soils control vegetative type and growth, hydrologic and erosional characteristics, and weathering and soil-forming processes.

A literature review was conducted to determine the extent of future climate changes (including precipitation, temperature and storm event duration and severity) that are predicted for the Colorado Front Range over the 1,000-year evaluation period. In general, the long-term climate predictions are restricted to a maximum of 100 years. Modeling results generally indicate that the future temperature will be higher, but vary significantly in terms of precipitation amounts.

Several computer models, called General Circulation Models (GCMs), have been developed to facilitate long-term (of the order of 100 years) climate predictions. These models typically use a large (200 mile by 200 mile) global grid system and have been generally developed to address how increases in greenhouse gasses (global warming) might affect future climate. The Colorado Front Range typically is included in the Great Plains or Rocky Mountain Regions depending on the study. Because the GCMs are developed on a large global grid basis, they are not directly suitable to predict local climate changes. Recognizing these limitations, the following summary information was compiled based on relevant future climate predictions related to the western United States.

- A National Assessment Synthesis Team report (2000) states that the rate of warming will be faster during the 21st century than it was in the 20th century. Over the next 100 years, temperatures are predicted to increase by 4 to 12°F based on application of the Canadian and Hadley GCMs. Precipitation in the region containing the Front Range is predicted to change by -30 to +10 percent over the same period.
- The GCM developed by the Goddard Institute of Space Science predicts that the future mean annual temperature and precipitation within the western United States will increase approximately 8°F and 8 percent, respectively (Strzepek, undated).
- The GCM developed by the Geophysical Fluid Dynamics Laboratory predicts that the future mean temperature and precipitation within the western United States will increase approximately 8°F and 30 percent, respectively (Strzepek, undated).

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Based on the literature review, it was concluded that the scientific knowledge associated with GCMs is currently not advance enough to provide reliable climate predictions on a Site-specific basis. In general, most of the reports reviewed indicate that GCMs cannot be relied on to accurately predict future climate changes. In particular, precipitation is the hardest component to simulate because it is dependent on a large number of climate variables (Legates, 1996). Because each climate variable contributes a source of variability and error, precipitation predictions can be highly inaccurate. In addition, the use and future evolution of energy systems is considered a significant factor in predicting future climate changes. As such, long-term climate predictions should be regarded as projections of what might happen rather than precise predictions of what will happen.

Metrological measurements and tree ring data provide a reliable historical climate record of relative precipitation for approximately the last 200 years. A reasonable simplifying assumption adopted for the LCDB Project is that future climate over the next several hundred years will be within the range of this historical climate record (see Data GAP-220). Therefore, the long-term evaluation of the landforms at RFETS will be based on consideration of the identified geomorphic processes and associated rate estimates derived from observation of current and historical conditions.

3.2 Gravity

Gravity is a significant controlling factor in the mass movement and other fluvial processes that occur on the hillsides. Gravitational force is taken to be constant over the 1,000-year evaluation period.

3.3 Tectonics

The seismic hazards near the Site are summarized in Section 2.4.5 of the Design Basis (see Tab 2, Appendix B). The Derby source zone dominates the seismic hazard to RFETS. The maximum seismic event is predicted to have a magnitude between 5.8 and 7 on the Richter scale with a return period of 1,000 to 50,000 years. Landform development or remediation systems are not likely to be adversely impacted by seismic activity over the 1,000-year evaluation period.

3.4 Anthropogenic Influences

Only those anthropogenic influences and landscape changes included as component in the bounding scenarios or initial conceptual design were considered. For evaluation of the initial conceptual design, it was assumed that these driving forces remain constant over the 1,000-year evaluation period.

4.0 HISTORICAL DOCUMENT REVIEW

Prior to and during Site reconnaissance, the following documents were reviewed to gain an understanding of the local/regional geological framework and existing landforms and to aid in evaluating Site conditions and assessing geomorphic processes.

- Aerial Photographs of RFETS taken in 1937, 1951, and 1994.
- *Geologic Characterization Report for the Rocky Flats Environmental Technology Site, Volume 1* (EG&G, 1995).
- *Surficial Geologic Map of the Rocky Flats Environmental Technology Site and Vicinity* (USGS, 1996).
- *Geologic and Seismologic Investigations for Rocky Flats Plant* (Dames and Moore, 1981).
- *Seismic Hazard Analysis for Rocky Flats Plant* (EG&G, 1994).
- *OU4 Solar Evaporation Ponds Interim Measure/Interim Remedial Action Environmental Assessment Decision Document* (DOE, 1995b).
- *Final Phase 1 RFI/RI Report, Woman Creek Priority Drainage, Operable Unit Number 5* (DOE, 1996b).
- *Draft Geotechnical Investigation Report for Operable Unit Number 5* (DOE, 1995a).
- *Final Phase 1 RFI/RI Report, Walnut Creek Priority Drainage, Operable Unit Number 6* (DOE, 1996c).

Resistance to driving forces is provided by the geologic framework, which has been well documented at RFETS. A detailed description of the regional geologic history and setting is presented in the Geologic Characterization Report for RFETS (EG&G, 1995), (Hanson and Crobsy, 1982), and the LCDB Project Design Basis (see Tab 2, Appendix B). For reference, a brief summary of the geology and current landforms is provided below.

RFETS is located in an area of the eastern Colorado Piedmont that is an old erosional surface bounded by the eastern front of the Rocky Mountains to the west and the High Plains section of the Great Plains to the east. Benches and valley uplands are the predominant landforms associated with this region. Figure G-1 presents a generalized cross section in the proximity of RFETS showing a bench and its underlying stratigraphy. The bench consists of an almost flat tongue of land that gently slopes eastward at a low angle from the hogbacks or mountain front. The benches typically widen away from the mountains, as is the case for RFETS, and many are marginally notched by gullies. The bordering slopes are gentle or steep and smooth or gullied. Bench heights may be up to 400 feet, but are typically less than 200 feet (Hanson and Crobsy, 1982).

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Most benches are capped with gravel, such as the Rocky Flats Alluvium. Valleys between benches have been stripped (partially or completely) of the gravel capping to expose the claystone bedrock of the Cretaceous Laramie and Arapahoe Formations (Hanson and Crobsy, 1982). Landsliding on these slopes probably commenced about the middle Pleistocene, shortly after the slopes were initially exposed (Shroba and Carrera, 1994).

5.0 SITE RECONNAISSANCE AND GEOMORPHIC MAPPING

A reconnaissance of the Site was conducted during the week of 26 February 2001 to visually identify and document the type, extent, and magnitude of geomorphic processes occurring within the drainages and hillslopes of Walnut and Woman Creeks at RFETS. Field observations were recorded in a project notebook and areas of interest were marked on a topographic map for further investigation. Follow-up visits were conducted between March and September 2001 to further assess field conditions and to note any observable changes from the initial Site reconnaissance. Photographs taken to document the geomorphic processes occurring at the Site are included in Attachment 2.

Figure G-2 presents the significant geomorphic features that were identified during the review of historical documents and observed during the Site reconnaissance. The geomorphic mapping was performed to help define areas of landsliding, shallow groundwater, and gullying that could be prone to mass movement. Scarps and areas of hummocky ground were mapped to define exposed landslide areas. Areas with active seeps/springs and thick, tall grass were mapped to delineate areas that are presumably underlain by shallow groundwater. Gully formation was identified by arcuate cracks associated with landslide scars. The geomorphic features were initially hand mapped on copies of the 1994 ortho-photographs at a 1"=100' scale with a 2-foot contour resolution. These mapped features were used to develop the topographic base map shown on Figure G-2.

6.0 AERIAL PHOTOGRAPH EVALUATION

The following Site aerial photographs were attained and evaluated.

- A single large format (approximately 36-inches by 44-inches) black and white mosaic print at a scale of 1 inch = 600 feet taken in 1937 was attained from American Reprographics, Inc. This mosaic print covers the entire Site and shows the area prior to construction of RFETS. The exact date that the photographs were taken was not available. Based on leaf development on trees and wetland vegetation growth depicted on the photographs, it is estimated that they were taken in the late summer (July/August).
- Six overlapping 9-inch by 9-inch black and white prints dated 14 July 1951 were attained from Colorado Aerial Photo Service. The specific photographs used are frames DV34-18, DV34-19, DV34-20, DV34-31, DV34-32, and DV34-33. These aerial photographs cover approximately 85 percent of the Site; the eastern most portion of the Site is not included. Although these photographs show some

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preliminary grading for roads, they were taken before any major construction activity occurred.

- A digital, monochrome GeoTIFF seamless mosaic ortho-photograph taken on 17 July 1994 was attained from Kaiser-Hill's GIS Department. This mosaic image shows the entire RFETS area as fully developed.

6.1 Photogrametric Analysis

The spatial analytical technique of principal component analysis was used to identify variations between the three aerial photographs. The 1994 digital image was used as the standard for comparison. The 1937 and 1951 photographs were digitally scanned as gray-scale images. The digital scans were co-registered to 1994 digital image by aligning discernable geographic features common to each set of images.

Because the 1937 aerial photograph consists of uncorrected mosaic photographs, the distortion and mismatched edges between individual photographs could not be fully corrected by the scanning and co-registration process. Seams between the individual photographs are also evident and the tonal variation among the individual mosaic photographs is significant. Although 93 control points were used to co-register the 1937 and 1994 images, control points within the IA and Present Landfill could not be identified because of the significant alternations that have occurred in these areas. Of the control points used to co-register the two images, the total root mean squared error between the two sets of control points was less than 1 foot.

The six overlapping aerial photographs taken in 1951 were scanned and combined into a single digital mosaic image. Histogram matching was applied to minimize tonal differences between the individual scanned photographs. The 1951 aerial photographs were co-registered with both the 1937 and 1994 images. More control points between the 1937 and 1951 images could be established because both of these images were taken prior to any significant disturbance. The control points for the 1951 image were also verified against the 1994 image to minimize errors due to the distortion inherent with the 1937 image. The total root mean squared error control for the points used to co-register the three images was less than 1.5 foot.

Figure G-3 presents the results of the principal component analysis. The composite view provides a multi-layered image that was created by stacking the three co-registered images into a single image show changes over time. Three other computer images (Numbered 1, 2, and 3) were generated using principal component analyses to extract variations among the multi-layered image. Variations are noted by the degree of shading. Darker or lighten portions of the image depict a more extreme variation. The three computer generated images are as follows.

- Image 1 highlights the tonal variation between the 1937 and 1951 aerial photographs. Although vegetative changes and texture are highly correlated, variations may also be due to lighting (time of day or angle that the aerial photographs were taken), seasonally variation, or photograph processing.

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- Image 2 presents variations between the 1994 image and the other 2 images. In this image, the IA is highlighted which is highly correlated with areas of construction and Site development.
- Image 3 presents textural variations between the 1937 and 1951 aerial photographs. Morphological changes were highly correlated which includes changes due to erosion, deposition, and mass movement.

Based on the variations identified by application of the principal component analyses, it is generally concluded that the landforms at the Site have noticeably changed over the 57 year period evaluated. The images show that mass movement and stream meander shifts have naturally occurred during this period. In the composite view of Figure G-3, it can be seen that the meander of the historical North Walnut Creek streambed has been replaced by the engineered channel and culverts along and under the North Perimeter Road. Additionally, substantial fill and construction activity has replaced the North Walnut Creek Tributary with a much smaller culvert and engineered ditch system where it runs from east of Building 116 in a north-east direction down the pediment face between Buildings 371 and 771. The light tones in Image 3 along these channels can be illustrative of mass movement and stream meander shifts occurring naturally in these drainages during the period between 1937 and 1951.

6.2 Comparison of Topographic Surfaces

In addition to the aerial photographs, topographic survey information from 1951 and 1994 was obtained and evaluated. Geospatial techniques were applied to the 1951 and 1994 topographic maps to determine the change in ground level elevation for selected regions at RFETS. Regions of information from the original hardcopy contour maps (approximately 1600 feet by 1600 feet areas showing 2-foot contour intervals) generated by Austin Engineers based on the July 1951 aerial flyover were digitized into an AutoCADD format and then imported into ArcGIS Version 8.1. The information was then projected into the Colorado State Plane coordinate system to co-register them with the 1994 digital contour map (2-foot contour intervals) into the same geographic projection. Both maps were converted into continuous surface elevation grids using the 3D Analyst Extension. The Spatial Analyst Extension was used to determine the change in elevation within each region by subtracting the 1937 grid elevations from the 1994 grid elevations. Adequate information was available to evaluate four separate regions.

Figure G-4 graphically shows the elevation changes for each of the four regions. The cooler colors (displayed as blues) indicate a lower ground surface and the warmer colors (displayed as yellows and oranges) indicate increases in elevation. For reference, the 1994 contour lines are presented on this figure. In general, the largest elevation changes are attributed to Site development (cut and fill). Other elevation changes noted on Figure G-4 may reflect landform changes due to erosional/depositional and mass movement. The minor elevation changes could also be artifacts of the accuracy of the topographic information and co-registration of the electronic files. The following observations are noted for each region evaluated.

- **Region 1** – Elevation increases shown on Figure G-4 correspond to the Present Landfill, McKay Bypass Canal, and the firing range. The larger decreases in elevation can be attributed to construction of the North Perimeter Road.
- **Region 2** – Elevation increases appear to be associated with construction of the North Perimeter Road, perimeter security fencing, and modular tanks. Filling within the North Walnut Creek drainage channel is likely due to construction of the A-series ponds. The topographic comparison does show a general elevation decrease associated with the hillslopes. Such an elevation decrease may be evidence of erosion and/or mass movement.
- **Region 3** – All of the elevation increases and decreases are likely due to construction of the IA; in particular the perimeter security fencing, Solar Evaporation Ponds, and Building 991.
- **Region 4** – The primary elevation increases may be associated with the Original Landfill; however, some of the elevation increases seem to correspond to areas where evidence of landslides were noted during the Site reconnaissance. Other anthropogenic features (SID and access roads) may account for some of the noted elevation changes. Scattered, localized elevation changes are present to the south of Woman Creek that could be representative of natural landform changes.

While this analysis highlights the anthropogenic changes between 1951 and 1994, it is of limited value in the evaluation and quantification of natural geomorphic processes.

7.0 GEOMORPHIC PROCESS MECHANISMS AND RATE ESTIMATES

The Rocky Flats Alluvium, just east of the mountain front, is indicative of mature soil development. The alluvium soils mapped in this area include the Flatirons series, a clayey-skeletal, montmorillonitic, mesic Aridic Paleustrol (Price and Amen, 1984). The alluvium was probably deposited during a glacial period. The clast composition is dominated by quartzite (70 to 80 percent) with lesser amounts of granodiorite and gneiss (10 to 20 percent) (USGS, 1996). Soil profiles in these deposits have very well developed prismatic and blocky structure in illuvial horizons (Bt and Btk), with thick and sometimes indurated, Stage IV carbonate morphology (Machette et al., 1976). The soil mapping around RFETS indicates that K-horizon of the carbonate development is unusually strong suggesting an old formation. Based on the time it takes for the soil morphology found at RFETS to form, the minimum age of the Rocky Flats Alluvium is estimated to be 1.35 million years (Birkeland et al., 1996). As such, the conceptual model for the landforms at RFETS assumes that the bench surfaces (pediments) are stable. This conceptual model is consistent with observations made during the Site reconnaissance (see Figure G-2), which indicate that the major geomorphic processes occur on the hillsides and in the valleys.

Based on the published literature, previous Site investigations, and Site reconnaissance observations, the geomorphic processes evaluated and the methods used to develop corresponding rate estimates include:

- **Mass Movement** of soils down hillsides via earthflows, slumps and landslides. Mass movement volumes and frequencies were qualitatively determined by

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comparing landslides and slumps identified in the 1937, 1951, and 1994 aerial photographs for two specific study areas along a north hillslope of North Walnut Creek (east of the modular tanks) and a north hillslope of Woman Creek (south of the Building 440/460 area). These general areas are shown in Photographs 1 and 2 (see Attachment 2). The rate of mass movement was also estimated from survey data collected for the slump block located at the Modular Tanks and adjoining area.

- **Fluvial Processes** including channel incision as the stream down cuts into underlying geologic formation, and headward erosion and stream elongation as the drainage channel advances upstream. Because Site-specific rate estimates could not be found in the documents reviewed, topographical maps from 1951 and 1994 were compared to evaluate channel incision.
- **Overland and Rill Erosion/Deposition** including gully formation occurs during precipitation events. The soil erosion modeling data developed by the AME Project Team was used to estimate a rate for this geomorphic process.

The above geomorphic processes are primarily responsible for developing the valleys and hillsides to their current elevations and slopes. In general, fluvial development occurs through stream erosion primarily by channel incision and headward erosion as channels advance upstream. The hillsides slowly becomes steeper due to channel incision and headward advance, which results in mass movement along the hillside as threshold events to relieve the stress that occurs as the channel cuts downward. Photograph 3 shows fluvial development (stream meander, incision and bank instability) in No Name Gulch, which is at an earlier stage of development than either Walnut or Woman Creeks. Soil erosion due to runoff also occurs, which can lead to gully formation in response to locations of mass movement. Each of these processes is further described in the following sections.

7.1 Mass Movement

7.1.1 Description of Mass Movement Mechanisms

In general, mass movement occurs when the shear stress caused by the downward pull of gravity exceeds the shear strength of the soil (Montgomery, 1989). Shear stress is a function of soil mass and the slope angle. Shear strength is dependent on the physical properties and frictional resistance of the soil. The geomorphic processes that cause mass movement can be grouped into the following three categories (Ruhe, 1975):

- Processes that increase shear stress. For example, (1) steeping of hillsides due to channel incision or removing support material at the toe of a slope; (2) addition of mass due soil saturation by water, vegetative growth, or construction activities such as stockpiles; (3) temporary transitory stresses such as earthquakes, explosions, or storm events; and (4) uplift or tilting caused by tectonic activity.
- Factors contributing to low strength. For example, (1) inherent physical characteristics of the landform, and (2) presence of discontinuities (e.g. faults, bedding planes, and joints) within the formation.

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- Processes that reduce shear strength. For example, (1) weathering, (2) water saturation, and (3) other physicochemical processes.

In general, various types of mass movement are a combination of slide, flow, and heave mechanisms as shown in Figure G-5 (Ritter, 1984). In a pure slide, cohesive blocks of material move on a well-defined surface of sliding and no concurrent internal shearing occurs within the sliding block. In contrast, a pure flow moves entirely by differential shearing within the transported mass and no clear plane can be defined at the base of the moving debris. In a pure heave, the disrupting forces act perpendicular to the ground surface by expansion of the material. This movement does not itself provide a lateral component of transport, but facilitates slow, downslope movement by gravity and can serve as an important precursor to other rapid mass movement. The proximity of the mass movement to the triangle corners shown in Figure G-5 indicates the dominant mechanism associated with the mass movement. Superimposed on the diagram are lines that (1) represent the relative time that the mass movement occurs, and (2) depict the typical water content of the material being moved.

At RFETS, earthflows, slumps, and landslides appear to be the most significant landform shaping processes. Numerous mass movements are evident along margins of drainages that cut into the Rocky Flats Alluvium. These mass movements range in age from middle Pleistocene (greater than 150,000 years) to the present, but most are relatively young with crescentic head scarps and lobate toes (Birkeland et al., 1996; USGS, 1996). Many landslides likely began soon after the incision of the drainage channels cut through the Rocky Flats Alluvium to expose the underlying Upper Cretaceous bedrock. Factors contributing to the propagation of mass movements at RFETS include:

- Slumps and slides have developed on the hillsides along Woman and Walnut Creeks where the hillside slope is typically greater than 12% and shallow groundwater has saturated the weathered claystone of the Arapahoe and/or Laramie Formation, causing an increase in soil pore pressure and reducing soil strength until the slope fails.
- Slumps have occurred in locations where stream flow from Woman and Walnut Creeks has undercut the toe of slope, which decreases slope stability and results in eventual slope failure.
- Unstable slopes underlain by bedrock prone to failure because of numerous bedding planes that can serve as slip surfaces. Local saturation and perched water table at the interface between the Rocky Flats Alluvium and bedrock (as evidence from the seeps along the contact) can enhance these slip plane features (Cararra and Shroba, 1994).
- Abundant claystone with expansive clays can cause weakening of resistant forces (Cararra and Shroba, 1994).
- Infiltration from the pediment through valley walls causing soil saturation, which increases the mass of soil causing its movement downslope (see Photograph 4 and 5, Attachment 2).

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- Anthropogenic activities, such as the Original Landfill and the Modular Tanks, have locally increased shear stress and resulted in slope failure (Photographs 2 and 6). In several locations, fill material placed during construction activities has resulted in soils with weaker cohesive strengths that are more susceptible to slides. Photograph 7 shows an earth fall at the base of the hillside north of Building 371.

The hillsides of North and South Walnut Creek and Woman Creek valleys are covered with numerous old and a few recent landslides (see Photographs 5 and 8). In some cases, erosion has nearly obliterated the characteristic landforms of these slides but in other cases they are plainly apparent. The slides are relatively shallow, on the order of 10 to 15 feet deep (Materials & Substructures, 1971).

7.1.2 Estimated Rates for Mass Movement

Survey data compiled for the slope active slump block associated with the Modular Tanks and GIS analysis of historical aerial photographs were used to develop rate estimate for mass movement.

7.1.2.1 Modular Tank Survey Data

The slope movement associated with the Modular Tanks is shown in Photograph 6. In 1992, 15 temporary monuments were installed to monitor the rate of movement of the active slump block and adjoining slope at the Modular Tanks. These monuments were surveyed on a quarterly basis until 1998. Based on the survey results, the average downslope movement of the slump block is estimated to be approximately 0.044 feet per year. This mass movement was likely caused by anthropogenic influences (including construction fill, added weight, and a probable increase in water saturation of the underlying fill). Although the above estimated rate may not be representative of other mass movement observed in the drainages, it is the only area onsite where actual survey data is available.

7.1.2.2 Estimation of Mass Movement using Historical Aerial Photographs

The digital images for the 1937, 1951, and 1994 aerial photographs were assessed to estimate mass movement characteristics and rates with the following two areas:

- Area 1: Southern facing slope along Woman Creek located to the south of the Building 440/460 area.
- Area 2: Southern facing slope along North Walnut Creek located to the north of Ponds A-1 and A-2.

These two areas were chosen because they are representative of the Woman and Walnut Creek drainages and each area was determined to have active mass movement features based on observations made during the Site reconnaissance (see Figure G-2).

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The aerial photographs and principal component analysis images (see Section 6.1) were used to delineate the head, scar, and toe boundaries of the mass movement features located within each of the two selected assessment areas. Figure G-6 provides a schematic and an example aerial photograph that illustrates the delineation of the head, scar, and toe features caused by mass movement. The "head" boundary represents the breakpoint where the topslope transitions into a sideslope. The "scar" boundary was delineated by areas that were not fully vegetated at the time the photograph was taken, which were used as an indication of areas where subsurface soils had been exposed by recent mass movement. The "toe" boundary was delineated by identifiable scallop shaped scars above with darker shades of vegetation below, which are typical indications of historical mass movement that shift soils down the slope.

Figures G-7, G-8, and G-9 show the delineated head, scar, and toe boundaries developed for the 1937, 1951, and 1994 images, respectively. Multiple scar and toe features are indicative of an area with active mass movement. As shown on these figures, evidence of active mass movement is present in both of the assessment areas. More mass movement features were delineated in the 1951 photograph than the 1937 photograph. The analysis of the 1994 image is limited because construction activities have obliterated historical head, scar, and toe features present in the 1937 and 1951 images. Areas that have been altered by Site development (including development, recontouring, excavation, slope stabilization, placement of fill, and dumping) are identified as "Altered Areas" on Figure G-9. The alterations, including construction of roads and ditches (e.g. SID), in Area 1 (Woman Creek) are more extensive than Area 2 (North Walnut Creek). Scars on the altered surfaces areas are identifiable on the 1994 aerial photograph, which indicates that mass movement has actively occurred on this slope since being altered.

The surface area for each toe feature was determined using GIS. The resulting values for the 1937, 1951, and 1994 delineations are presented in Tables G-1, G-2, and G-3. In addition, the mean slope of each delineated feature was computed using the topographic data derived from the 1994 image. The delineated scar and toe features are the best indication of mass movement because a majority of the soil displacement from the hillside would be confined to these boundaries. The volume displacement for each scar and toe feature was estimated using the following equation.

$$V_n = \left[(A_n * D) - \left(A_n * D * \frac{S_n}{200} \right) \right] \quad (1)$$

Where,

V_n = Displacement volume of each delineated scar/toe feature in acre-feet.

A_n = Surface area of each delineated scar/toe feature expressed in acres.

D = Vertical height of displacement in feet.

S_n = Average slope of each delineated scar/toe feature (unitless).

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In order to calculate the displacement volume, the following assumptions were made.

1. Vertical displacement of a mass movement event ranges from 10 to 50 feet.
2. Horizontal shift near the head will not be the same as the horizontal shift at the base of the toe.

Tables G-1, G-2, and G-3 provide the estimated minimum (based on a 10 foot vertical height) and maximum (based on a 50 foot vertical height) displacement volumes using Equation (1) for the 1937, 1951, and 1994 images, respectively. Figure G-10 graphically presents the surface area and minimum calculated displacement volumes for all the Area 1 and 2 scar/toe features over the evaluation period. This figure indicates that the displacement associated with Area 1 in Woman Creek is slowing at an approximate rate of 4.5 acre-feet per year, while the displacement for Area 2 in Walnut Creek is increasing at approximate rate of 1.1 acre-feet per year. The estimated mass movement rate may vary locally (characterized by rapid movement during and immediately following initial slope failure or movement, then slowing and eventually stabilizing). Typically, the rate of mass movement slows down as the hillside evolves toward a stable slope angle and eventually stops moving when equilibrium is attained. Thus, mass movement along these slopes will continue until a stable grade is achieved. This process causes a gradual widening of the stream valley. The affects of valley widening can be seen in the upper portion of Woman Creek in Photograph 9.

The aerial photographs were used to estimate the width of each delineated scar feature to define the horizontal displacement of the most recent mass movement events. The scar widths are presented in Tables G-1, G-2, and G-3. The calculated mean scar width associated with each aerial photograph is plotted on Figure G-11. Linear regression indicates that the data points are not well correlated.

7.2 Fluvial Processes

7.2.1 Description of Fluvial Process Mechanisms

Fluvial processes are responsible for determining the overall shape of landforms across much of the Earth (Thornbury, 1954). Drainage systems typically consist of the following three zones.

- A sediment production zone,
- A sediment transfer zone, and
- A sediment deposition zone.

The sediment production zone is typically located at the upstream portion of the drainage basin and is usually a mountainous or upland region. The depositional zone is generally located along a coast and takes the form of a delta or lowland coastal plain. However, the depositional zone may be located at the center of an interior basin. Localized areas of significant deposition may also occur in a piedmont environment, like RFETS, where the drainage emerges from a mountain front. The sediment transport zone is predominantly

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located in the intervening portion of the drainage basin and is characterized by a general mass balance of sediment that flows into and out of this portion of the drainage basin. Long-term storage of sediments may occur within the transfer zone before being carried downstream into the final deposition zone (Summerfield, 1991). The North and South Walnut Creek drainages are further affected by the A- and B-series ponds. These ponds create localized deposition areas within the transfer zone of the drainage and exacerbate the potential for long-term storage and transfer of sediments (see Photograph 11).

7.2.1.1 Stream Elevation Profiles for Walnut and Woman Creeks

Elevation profiles of the stream channels were developed for selected portions of the Walnut and Woman Creek basins. Figure G-12 provides a plan view showing the locations of the individual stream channels that were profiled with reference numbers for the various reaches of the streams where slope information was calculated. Figures G-13 and G-14 provide the elevation profiles for stream channels located in the Walnut and Woman Creek basins, respectively. The routing and elevation information for the stream profiles was extracted from the RFETS digital terrain model obtained from the Kaiser-Hill GIS Department. The elevations provided in the digital terrain model represent land or water surfaces along the stream channel profile route at the time of the 1994 fly-over. The profiled elevations depict ground surface and are therefore not representative of the stream channel where culverts are present.

Walnut Creek Profile

The Walnut Creek drainage basin starts at the base of the foothills near the mouth of Coal Creek Canyon. The natural portion of the basin upstream of Indiana Street encompasses approximately 2,370 acres. Although the natural portions of the drainage channel consist of meander belts, portions of Walnut Creek have been extensively altered and straightened since the construction of RFETS. The overall average slope of Walnut Creek from Indiana Street (Reach Point 31) to North Walnut Creek at the West Diversion Dam (Reach Point 67) is approximately 2.4 percent. Walnut Creek was broken into the following four primary segments from east to west for evaluation.

- **Walnut Creek** – The Walnut Creek segment was profiled from Indiana Street to a point that is approximately 4,700 feet upstream of Indiana Street, which is at the confluence of North and South Walnut Creeks. This segment is primarily undisturbed and characterized as a floodplain section. The average gradient for this segment is approximately 1.4 percent and it will generally function as a sediment transport zone (see Photograph 10).
- **South Walnut Creek** - The South Walnut Creek segment was profiled from approximately 4,700 feet to 12,700 feet upstream of Indiana Street. Most of this segment has been altered by Site development with the installation of engineered drainage channels, culverts, and detention ponds. The average gradient for this segment ranges from 2.6 to 3.9 percent with an overall gradient between Reach Points 32 and 47 of approximately 3.2 percent (see Photograph 5). The upper reaches of Walnut Creek (both north and South) have a slightly steeper gradient and function as both sediment production and transport zones (and localized deposition within the ponds).

- **North Walnut Creek** – The North Walnut Creek segment was profiled from approximately 4,700 feet to 16,900 feet upstream of Indiana Street. Most of this segment has been altered by Site development with the installation of engineered drainage channels, culverts, and detention ponds. The average gradient for this segment ranges from 2.4 to 3.7 percent with an overall gradient between Reach Points 32 and 67 of approximately 2.8 percent. Similar to South Walnut Creek the steeper gradient creates a production/transport zone (normally transport with production during high flow periods).
- **North Walnut IA Tributary** – The North Walnut IA Tributary segment was profiled from approximately 12,800 feet to 18,800 feet upstream of Indiana Street. Most of this segment has been altered by Site development with the installation of engineered drainage channels and culverts. The average gradient for this segment ranges from 2.4 to 3.3 percent with an overall gradient between Reach Points 66 and 78 of approximately 2.6 percent.

In addition to the above segments, two hillside gullies that extend from the drainage channel to the pediment top were profiled. These gullies are significantly steeper than the main channel and would support flow only during storm events. During large storm events significant erosion and sediment production could occur.

- **South Walnut Gully** - The South Walnut Gully was profiled from approximately 7,900 feet to 10,100 feet upstream of Indiana Street. The average gradient for this segment ranges from 2.4 percent on top of the pediment to 11 percent down the hillside. The overall gradient between Reach Points 44 and 56 is approximately 6.5 percent.
- **North Walnut Gully** - The North Walnut Gully was profiled from approximately 9,900 feet to 10,900 feet upstream of Indiana Street. The average gradient for this segment is approximately 11 percent down the hillside from the North Perimeter Road to North Walnut Creek near Gauging Station SW091.

Woman Creek Profile

The Woman Creek drainage basin also starts near the mouth of Coal Creek Canyon. The natural portion of the basin upstream of Indiana Street encompasses approximately 2,870 acres. Alterations to Woman Creek are less extensive than Walnut Creek. These alternations are primarily limited to the SID drainage basin and other components associated with the installation of Pond C-2. Natural portions of the Woman Creek drainage channel consist of meandering belts. Altered portions include straightening of the channel and installation of earthen/rock check dams. The average slope of Woman Creek from Indiana Street (Reach Point 11) to North Woman Creek at the South Boulder Diversion Canal (Reach Point 15) ranges from approximately 1.9 to 2.9 percent with an overall gradient of approximately 2.3 percent (see Photograph 9).

The stream profile developed for the SID is included on Figure G-14. This constructed drainage channel is approximately 8,000 feet in length and starts at Pond C-2. The slope of the SID is highly variable and water flow is controlled by several earthen/rock check dams. The average slope of the SID (Reach Points 21 to 26) ranges from approximately

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0.9 to 4.5 percent with an overall gradient of approximately 3.1 percent. Stream channel profiles for other Woman Creek segments including Smart Ditch, Antelope Springs Gulch, and South Woman Creek were not developed.

7.2.1.2 Erosional Development for Walnut and Woman Basins

Geomatrix Consultants, Inc. (1994) compiled various measured values and calculated indices to assess the erosional development for the Walnut and Woman Creek drainage basins. A summary (including definitions) of the measured values and calculated indices is provided in Table G-4. The values and indices are similar for both Walnut and Woman Creeks indicating that there is little to no discernible difference in the development of these two drainage basins. However, sub-basin characteristics were not developed to assess the relative erosional development for various stream segments.

Preparing a hypsometric curve is another method to assess the erosional development of a basin. The hypsometric curve represents a continuous function relating relative height and area within a basin. Figure G-15 shows two generalized hypsometric curves to illustrate basin development. For drainage systems that originate on an upland surface, the early stages of basin development are typically characterized by rapid transformations. This inequilibrium is usually marked by rapid changes in the area-height relationship and results in a convex hypsometric curve, as depicted by the upper curve shown on Figure G-15. As the basin matures, the shape of the hypsometric curve becomes sigmodal (depicted by the lower curve shown on Figure G-15) as more of the basin is consumed by erosion. Erosion of the basin continues until equilibrium is reached, which typically occurs when approximately 40 percent of the original basin volume is removed. (Ritter, 1984).

The hypsometric curves presented in Figure G-16 were generated by Geomatrix Consultants, Inc. (1994) to evaluate the erosional development of the Walnut and Woman Creek drainage basins. The curves have different shapes suggesting that the stages of erosional development for the Walnut and Woman Creek basins are different despite having similar measured values and indices. The curve for Walnut Creek shows a concave upward curve, which is more characteristic of a drainage basin in a mature stage of development.

The hypsometric integral (HI) is a measure of the distribution of relief and volume in the drainage basin and represents the erosional development of the drainage basin. Large HI values represent youthful drainage basins with high relief, whereas lower values are indicative of low relief with more material removed from the basin. The calculated HI index for Walnut Creek basin is 0.487, which indicates that slightly more than half of the soil material has been removed from the basin. The curve for Woman Creek has an HI of 0.568 and a convex shape, which indicates that more material remains in the basin than has been removed through erosion. Differences in curves may also be attributed to the size and extent of the drainage basin evaluated and influences due to Site development. As both basins mature in their erosional development, the following landform changes are likely to occur:

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- The number of tributaries to the trunk streams will be fewer.
- The valleys of each basin will become broader with gentle lateral and longitudinal slopes.
- The floodplain of each basin will become more developed with each valley expanding in width to several meander belts wide.
- The interstream areas will be reduced in height and stream divides will become less sharp.
- Mass movement will become more dominant over fluvial processes and extensive areas of the landscape will be at or near the base level of erosion.

7.2.2 Estimated Rates for Fluvial Processes

7.2.2.1 Channel Incision Rate Estimate

The topographical survey data from 1951 and 1994 were compared to quantify elevation changes within portions of the Walnut and Woman Creek drainage channels. The stream routing used to generate the 1994 profiles for Walnut and Woman Creeks (see Section 7.2.1 and Figure G-12) was transposed onto the 1951 digitized topographical maps that were developed as described in Section 6.2. The 1951 drainage channel profiles were restricted to Regions 2 and 4 (see Figure G-4) because of the limited availability of scanned and digitized topographic information for 1951. For the 1994 stream routing, x and y-coordinates within Regions 2 and 4, together with a corresponding z-elevation (to the nearest 1-foot contour interval) were extracted from the scanned 1951 topographic information. The same reach points and distances as measured from Indiana Street was used to develop the stream profiles for the 1951 data to allow direct comparison to the 1994 stream profiles provided on Figures G-13 and G-14.

For visual reference, the 1951 stream profiles are included on Figures G-13 and G-14. A more detailed comparison of the 1951 and 1994 profiles for Region 2 (North Walnut Creek) and Region 4 (Woman Creek), including associated elevation changes along the stream profile, is provided on Figures G-17 and G-18, respectively. Although the 1951 and 1994 profiles are similar, these figures indicate that the average channel elevation for both Walnut and Woman Creek has increased by 2.3 and 1.2 feet, respectively, over the 43-year period.

The most significant elevation change is located in North Walnut Creek upstream of Reach Point 65. This location appears to have been filled to construct the North Perimeter Road. It also appears that the 72-inch concrete culvert was installed at or near the elevation of North Walnut Creek present in 1951. Because this area was significantly altered by Site development, the associated changes in elevation were not included in the evaluation. It is also noted that the 1951 stream channel profile upstream of Reach Point 65 is probably not representative because the 1994 stream routing used to generate the profiles was significantly straightened from the natural meandering channel that would have been present in 1951.

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The increase in the channel elevations is not consistent with the conceptual model for the geomorphic processes. Possible explanations for the increasing results include:

- Differences in horizontal and vertical control points.
- Accuracy of survey method and measurements.
- Changes in the routing of the drainage channels due to natural meandering of the drainage channel. No attempt was made to adjust the routing to match the 1951 channel because this would have introduced differences in the calculated profile distances making direct comparison of the elevation data impossible. As such, the elevation differences are representative of fixed coordinates that may or may not have been the actual stream channel that existed in 1951. Drainage channel route differences are noted in the 1951 and 1994 aerial photographs for Woman Creek within Region 4. Such routing changes and elevation differences may be due mass movement of soils from the adjacent hillsides, which is consistent with observations made during the Site reconnaissance in Region 4 (see Figure G-2).
- Increased soil erosion from construction of RFETS may have been deposited within the drainage channels. This could account for the larger average elevation change noted in Walnut Creek.

Based on the limitations of the survey data and that it was not specifically collected to measure changes within the drainage channels, meaningful estimates for stream channel incision rates could not be determined.

7.3 Surface Soil Erosion and Deposition

Surface soil erosion and deposition at RFETS is being evaluated by the AME Project Team using the Water Erosion Prediction Project (WEPP) continuous simulation computer model. The following significant findings are provided in AME's *Report on Soil Erosion and Surface Water Sediment Transport Modeling for the Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site* (Kaiser-Hill, 2000).

- WEPP results indicate that approximately 0.79 to 1.2 inches of precipitation are needed to produce significant amounts of runoff and sediment yield on vegetated hillslopes.
- The average annual erosion rates for a 100-year continuous simulation are estimated to be 0.171 tons/acre for the SID, 0.145 tons/acre for Walnut Creek, and 0.099 tons/acre for Woman Creek. These predicted average annual erosion rates are equivalent to an annual erosion depth roughly from 0.001 to 0.002 inches on a Site-wide basis.
- Hillslopes with improved gravel roads are predicted to produce one to ten times more sediment yield than undisturbed hillslopes over the 100-year simulation. Hillslopes with improved gravel roads account for 29 to 49 percent of the total sediment yield for each watershed. Revegetation of these roads could reduce overall sediment yields from the Site by up to 25 percent.

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Gully formation occurs in both the Walnut and Woman Creek drainage basins. The gullies are typically located in areas along the stream banks where slumps and deep fractures exist, seeps are flowing, and the toe of the slope intersects an outside meander loop of the drainage channel. Many of the gullies at RFETS, however, have formed as the result of Site anthropogenic activities. For example, gullies have formed on the north and south sides of the IA where runoff is directed through ditches and culverts over the edge of the bench. The mean gradient of the North and South Walnut Gullies profiled on Figure G-14 is approximately 11 percent along the slope of the hillside (see Photograph 12). Available information and methods were not sufficient to estimate a rate for gully advancement.

8.0 BOUNDING SCENARIO EVALUATION

Three bounding scenarios were developed and evaluated to assess the relative ability of each bounding scenario to withstand / accommodate expected long-term geomorphic changes. The evaluation included consideration of anthropogenic influences (such as roads, dams, water conveyance structures, etc) associated with each bounding scenario. The components of each bounding scenario were evaluated against the following six criteria.

- Extent of consequences in the event of catastrophic failure of scenario components resulting in an immediate endangerment of life or property.
- Long-term ability of the scenario to withstand probable seismic events.
- Long-term effectiveness, durability, and permanence of the scenario in the event of significant long-term (1,000 years) climatic changes.
- Extent that scenario provides long-term stability of Site to prevent significant erosion and mass movement in areas containing actinide-bearing soils that could result in exceedence of surface water quality standards at the POCs.
- Long-term ability of the scenario to prevent or mitigate exposure of currently confined subsurface soils or groundwater plumes that could cause an exceedence of surface water quality standards at the POCs.
- Long-term ability of the scenario to prevent mass movement, slumping, or other conditions that could negatively impact remediation systems or drainage / erosion controls.

The evaluation results are provided in Tab 3, Attachment A, Section 4.3.3 and Table A-10.

9.0 INITIAL CONCEPTUAL DESIGN EVALUATION

The geomorphic evaluation results were used, in part, to identify appropriate components for inclusion in an initial conceptual design. Due to the nature of the identified uncertainties, a complete initial conceptual design was not developed. As such, the planned geomorphic evaluation of the initial conceptual design is deferred until additional design details are developed. The detailed geomorphic evaluation will include

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developing a topographic map using GIS for the initial conceptual design to depict the predicted future landform conditions over a 1,000-year period. Any adverse impacts to existing remediation systems, and/or engineered structures will be identified. Engineered structures or other land configuration options that could be used to preclude or minimize any identified adverse impacts will be considered for potential incorporation into the initial conceptual design. Based on the geomorphic evaluation completed to date, the following findings, conclusions, and recommendations are provided for development of the initial conceptual design.

- The soil morphology of the Rocky Flats Alluvium, and particularly the Stage III and IV carbonate development, indicates that the surface of the pediment has been stable for greater than 1.3 million years.
- Numerous historical and recent landslides along the drainage hillsides are evidence of their instability. Engineering controls and remediation systems placed along these hillslopes may be vulnerable to geomorphic processes, especially mass movement, which may require stabilization of appropriate hillsides.
- Increased erosion and mass movement is most likely to occur with the North Walnut IA Tributary and the upper reaches of South Walnut Creek as these drainage channels and associated filled hillside stride to gain an equilibrium state as a meandering stream system.
- The landform at RFETS will continue to evolve in response to the natural geomorphic processes. These landform changes include continued stream incision and headward advance followed valley widening through mass movement. These processes, absent of external intervention, could eventually uncover subsurface structures within the drainages.

10.0 REFERENCES

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TABLES

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Table G-1
1937 Mass Movement Quantification

Reference Number	Mass Movement Feature	Area (Acres)	Mean Slope (%)	Min Volume Displacement (acre-feet)	Max Volume Displacement (acre-feet)	Mean Width (feet)
Area 1 – Woman Creek						
10	Head	6.9	17.6	---	---	---
12	Scar	0.6	16.9	5	27	60
13	Toe	0.5	19.1	4	20	---
16	Scar	0.3	28.4	3	13	136
20	Toe	1.1	19.7	9	47	---
22	Scar	1.9	23.3	17	85	111
24	Toe	0.9	17.3	8	40	---
25	Toe	0.4	35.4	3	17	---
26	Scar	0.9	34.6	7	37	86
27	Toe	2.6	14.5	24	121	---
30	Scar	5.9	18.9	53	267	212
34	Toe	2.6	16.9	24	119	---
36	Toe	7.0	12.7	65	326	---
38	Scar	0.7	9.7	7	34	39
40	Scar	2.1	15.6	19	97	154
43	Toe	2.8	9.7	27	134	---
45	Toe	15.4	14.1	143	715	---
Area 1 Totals	**Head** **Scar** **Toe**	**6.9** **12.4** **33.2**	**---** **---** **---**	**---** **112** **308**	**---** **560** **1,541**	**---** **114** **---**
Area 2 – Walnut Creek						
1	Head	3.8	19.6	---	---	---
5	Toe	10.7	19.0	97	486	---
7	Scar	0.4	16.9	4	18	50
8	Scar	1.4	19.2	12	61	204
9	Scar	0.6	24.6	5	27	133
11	Toe	0.3	23.7	3	14	---
14	Toe	0.1	26.0	1	5	---
15	Scar	0.3	29.1	2	11	88
Area 2 Totals	**Head** **Scar** **Toe**	**3.8** **2.6** **11.2**	**---** **---** **---**	**---** **24** **101**	**---** **118** **505**	**---** **119** **---**
1937 Totals	**Head** **Scar** **Toe**	**10.7** **15.1** **44.4**	**---** **---** **---**	**---** **136** **409**	**---** **678** **2,046**	**---** **116** **---**

Table G-2
1951 Mass Movement Quantification

Reference Number	Mass Movement Feature	Area (Acres)	Mean Slope (%)	Min Volume Displacement (acre-feet)	Max Volume Displacement (acre-feet)	Mean Width (feet)
Area 1 – Woman Creek						
9	Head	4.8	18.8	---	---	---
10	Scar	3.5	18.2	31	157	244
11	Toe	5.6	17.7	51	255	---
13	Scar	3.1	11.6	29	147	201
14	Toe	1.3	28.0	11	55	---
15	Scar	0.2	18.9	2	9	112
16	Toe	6.0	14.5	56	279	---
20	Scar	2.1	19.3	19	95	364
21	Toe	0.7	16.7	6	31	---
23	Scar	1.0	19.8	9	46	251
25	Scar	2.7	11.0	25	125	207
27	Toe	0.4	12.1	3	17	---
29	Scar	1.2	23.5	10	52	153
32	Toe	2.1	14.7	19	95	---
33	Toe	5.1	13.6	47	235	---
34	Toe	0.2	16.2	2	11	---
36	Toe	1.2	21.0	11	55	---
41	Toe	0.1	13.6	1	4	---
43	Head	3.9	10.2	---	---	---
46	Scar	0.9	9.5	8	41	88
48	Toe	0.1	31.2	1	5	---
50	Toe	0.5	31.7	4	21	---
51	Toe	2.6	19.5	23	115	---
56	Scar	0.7	14.1	7	33	43
63	Toe	0.9	9.8	8	42	---
65	Scar	0.7	11.1	6	32	118
67	Scar	0.2	11.5	2	9	35
Area 1 Totals	**Head** **Scar** **Toe**	**8.7** **16.2** **26.6**	**---** **---** **---**	**---** **149** **244**	**---** **746** **1,221**	**---** **165** **---**
Area 2 – Walnut Creek						
1	Head	4.3	18.6	---	---	---
2	Toe	0.1	26.3	1	4	---
4	Scar	1.9	19.6	17	84	298
5	Toe	1.0	15.5	9	44	---
6	Scar	0.3	28.0	2	11	45
7	Toe	10.4	19.3	94	470	---
8	Toe	0.1	17.1	1	5	---
12	Toe	0.3	29.6	2	11	---
Area 2 Totals	**Head** **Scar** **Toe**	**4.3** **2.1** **11.8**	**---** **---** **---**	**---** **19** **107**	**---** **95** **535**	**---** **172** **---**
1951 Totals	**Head** **Scar** **Toe**	**13.0** **18.3** **38.5**	**---** **---** **---**	**---** **168** **351**	**---** **841** **1,756**	**---** **168** **---**

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Table G-3
1994 Mass Movement Quantification

Reference Number	Mass Movement Feature	Area (Acres)	Mean Slope (%)	Min Volume Displacement (acre-feet)	Max Volume Displacement (acre-feet)	Mean Width (feet)
Area 1 – Woman Creek						
6	Head	3.0	20.0	---	---	---
7	Altered	0.6	16.4	---	---	---
8	Scar	2.0	19.1	18	90	84
9	Altered	5.6	14.4	---	---	---
11	Toe	0.7	10.6	7	34	---
14	Toe	2.0	28.3	17	85	---
16	Head	0.6	16.4	---	---	---
19	Toe	1.2	10.5	12	59	---
21	Altered	9.7	16.1	---	---	---
24	Altered	9.6	16.1	---	---	---
25	Scar	1.4	11.1	13	64	145
27	Scar	4.3	11.2	40	201	370
31	Head	0.3	16.0	---	---	---
33	Scar	0.8	15.8	7	36	151
34	Toe	1.3	14.5	12	62	---
36	Scar	3.3	23.4	29	144	268
38	Toe	1.9	17.5	17	87	---
Area 1 Totals	**Head Scar Toe Altered**	**3.9 11.6 7.2 25.5**	**--- --- --- ---**	**--- 107 65 ---**	**--- 535 327 ---**	**--- 203 --- ---**
Area 2 – Walnut Creek						
5	Toe	18.3	18.7	166	828	---
10	Toe	0.3	27.5	3	13	---
15	Scar	1.2	24.0	11	54	65
39	Scar	0.3	29.1	3	15	47
Area 2 Totals	**Head Scar Toe Altered**	**--- 1.6 18.6 ---**	**--- --- --- ---**	**--- 14 168 ---**	**--- 69 841 ---**	**--- 56 --- ---**
1994 Totals	**Head Scar Toe Altered**	**3.9 13.2 25.8 25.5**	**--- --- --- ---**	**--- 121 234 ---**	**--- 603 1,168 ---**	**--- 161 --- ---**

Table G-4
Summary Characteristics for Walnut and Woman Creek Drainage Basins

Drainage Basin	Measured Values								Calculated Indices						
	Aspect (%)	L (km)	A (km^2)	P (km)	H_b (m)	M	N	C_t (km)	S_c	S_e	S_b	Rr	HI	F	Dd
Walnut Creek	ENE (64)	6.6	8.3	16.3	178	71	141	36.8	32	0.438	0.192	0.027	0.487	16.9	4.4
Woman Creek	ENE (50)	6.7	7.0	16.7	198	78	155	33.8	40	0.391	0.153	0.029	0.568	22.2	4.8

Description of Measured Values

Aspect – Dominant slope exposure direction expressed as compass direction and percent.

L - Basin length as the distance in a straight line from farthest point in basin to the basin outlet.

A - Basin drainage area.

P - Basin perimeter length as measured along the drainage divide.

H_b - Basin relief expressed as the largest elevation within the basin minus the elevation at the basin outlet.

M - Shreve magnitude expressed as the number of tributary branches upstream from any point in a basin to provide a method to order stream networks.

N - Total number of stream segments in the basin.

C_t - Total length of stream channels in the drainage basin.

Description of Calculated Indices

S_c - Relative crenulation of basin perimeter is calculated as P^2 / A. This index provides a relative indication of basins development and dissection of the drainage divide.

S_e - Basin elongation is calculated as $A^{0.5} / L$. This index provides an indication of structural control to assess lithologic or tectonic influence on drainage basin development.

S_b - Basin shape is calculated as A / L^2. This index also provides an indication of structural control to assess lithologic or tectonic influence on drainage basin development.

Rr - Relief ratio is calculated as L / H_b. This index is used to provide an overall indication of the basin slope.

HI - Hypsometric integral is a distribution of relief and volume of the basin. This index represents the erosional development of the drainage basin. The larger HI values represent youthful drainage basins with high relief whereas lower values are indicative of low relief and large volumes of material removed from the basin.

F - Stream channel frequency is calculated as (2M - 1) / A. This index gives the number of stream channels per unit area, which is an indication of drainage network development.

Dd - Drainage density is calculated as Ct / A. This index gives the length of stream channel per unit area, which provides an indication of drainage network development.

Source: Geomatrix, 1994.

FIGURES

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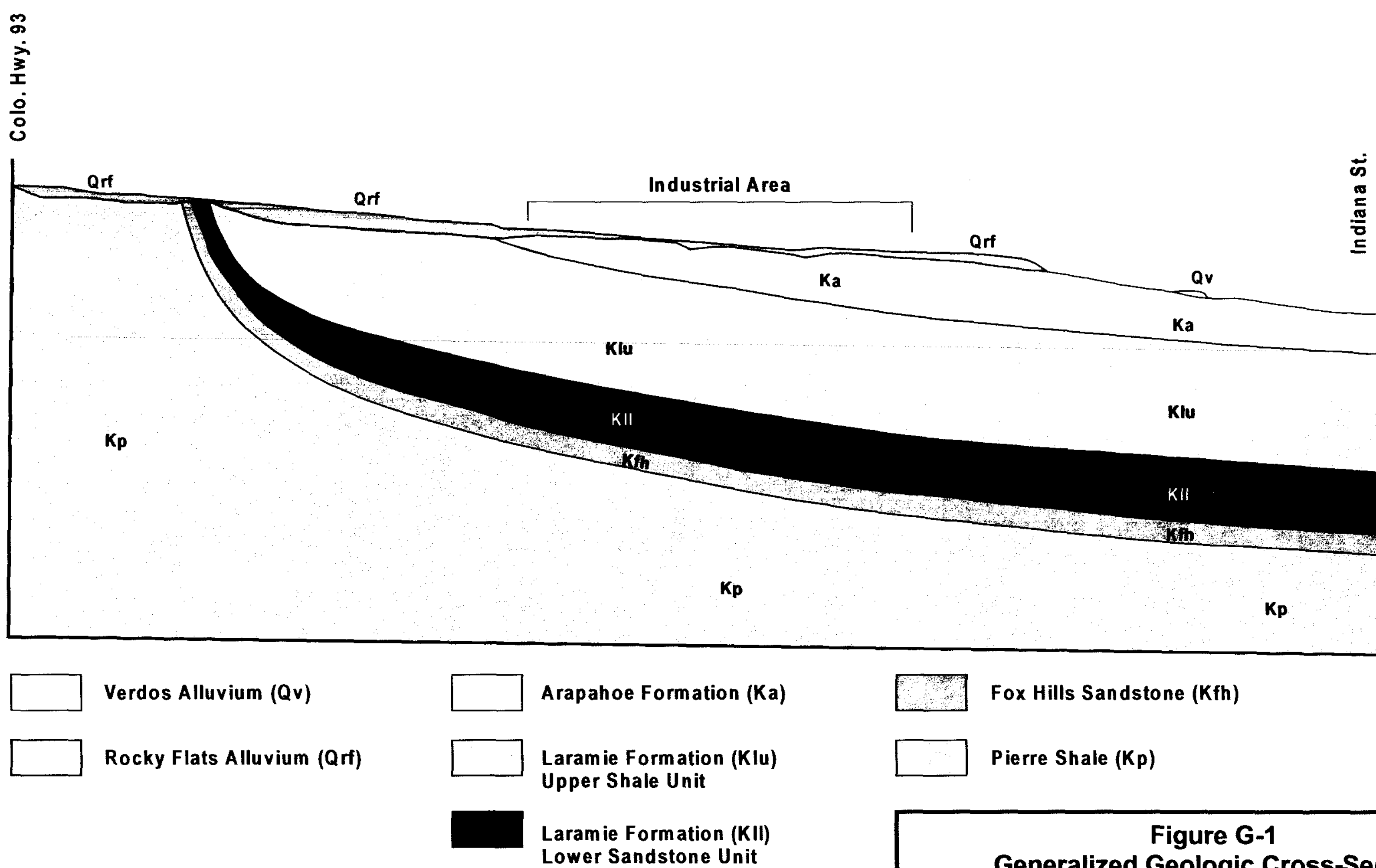

Source: EG&G, 1992.

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Figure G-1
Generalized Geologic Cross-Section

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

Prepared By: **Parsons Infrastructure and Technology Group, Inc.**
1700 Broadway, Suite 900
Denver, Colorado 80290
303-831-8100

Decmeber 12, 2001

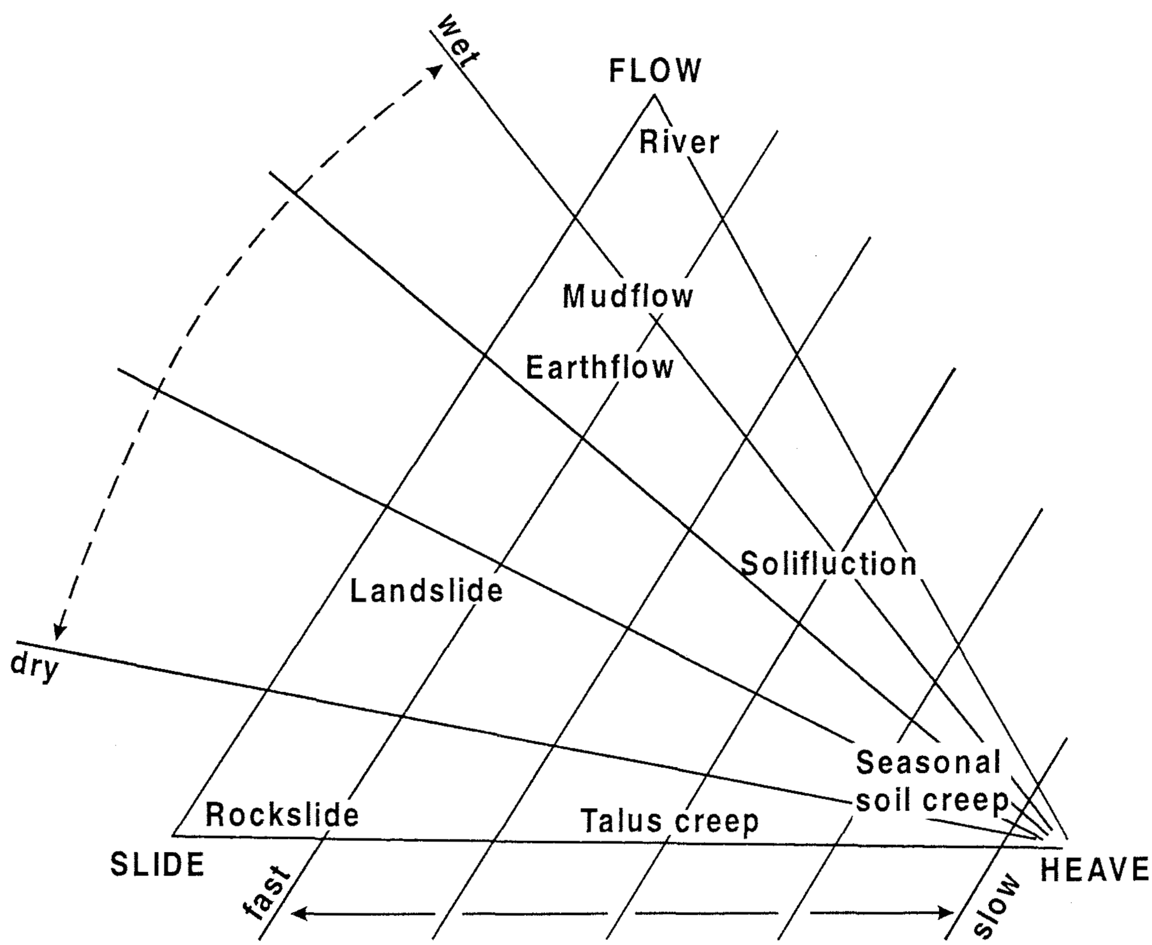

Figure G-5
Classification of Mass Movements in Terms of Pure Flow, Slide and Heave

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Source: Carson and Kirby, 1972.

Drawing Name: draw\RF Land Config.cdr p2 bbs 12/04/01

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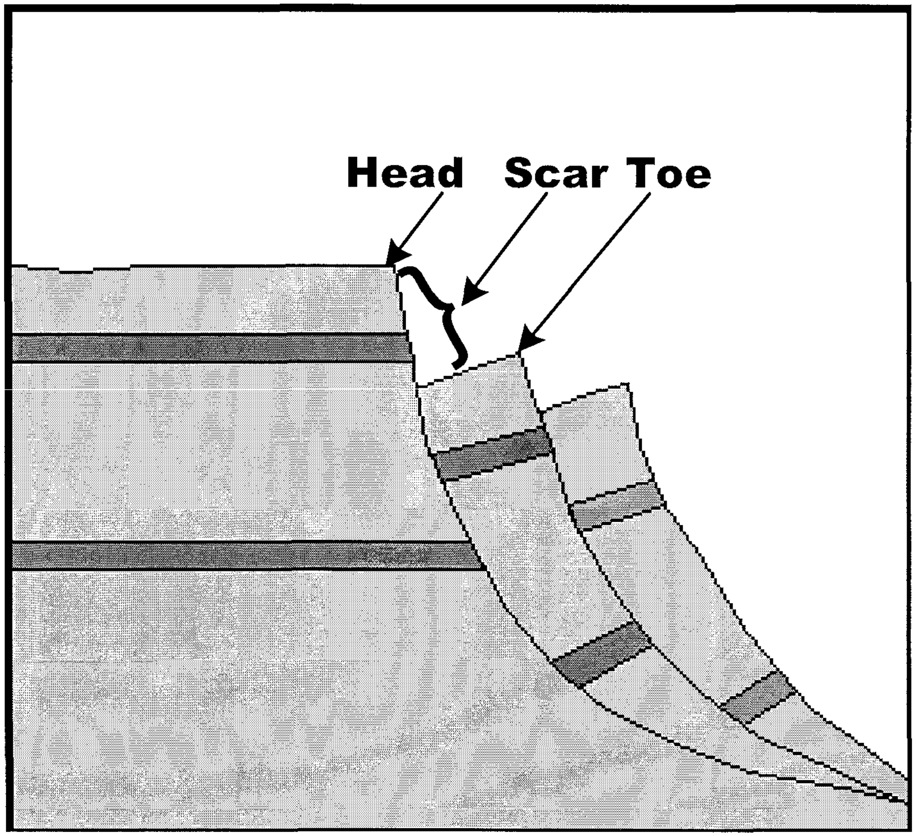

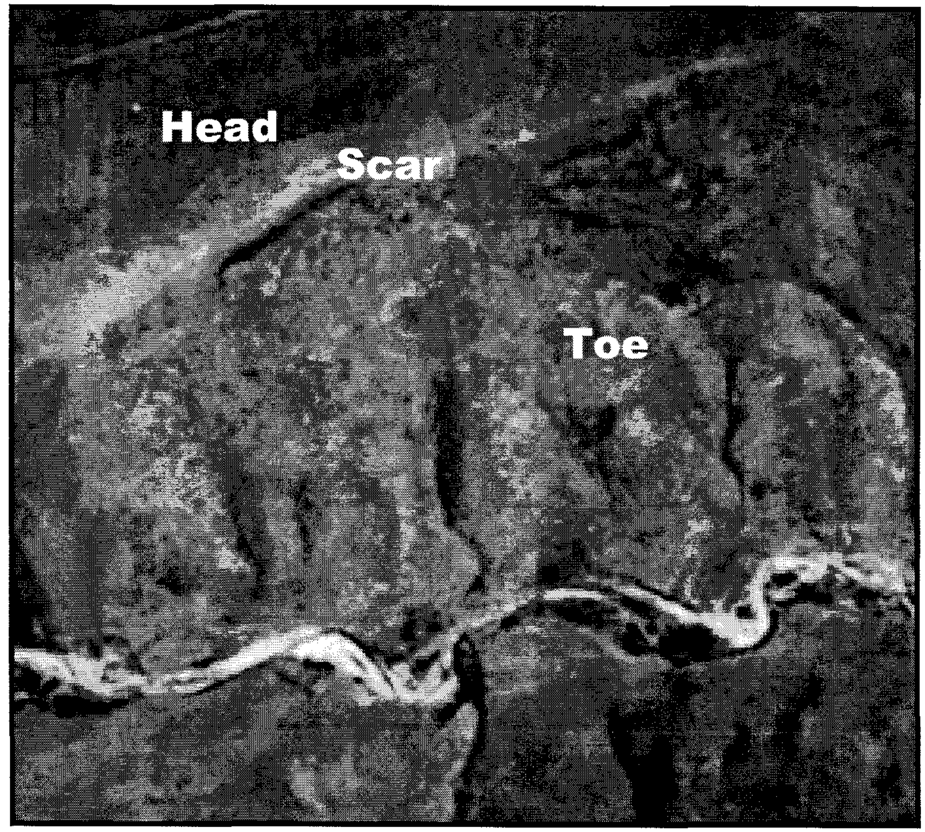

Figure G-6
Schematic and Example Aerial Photograph Depicting Mass Movement

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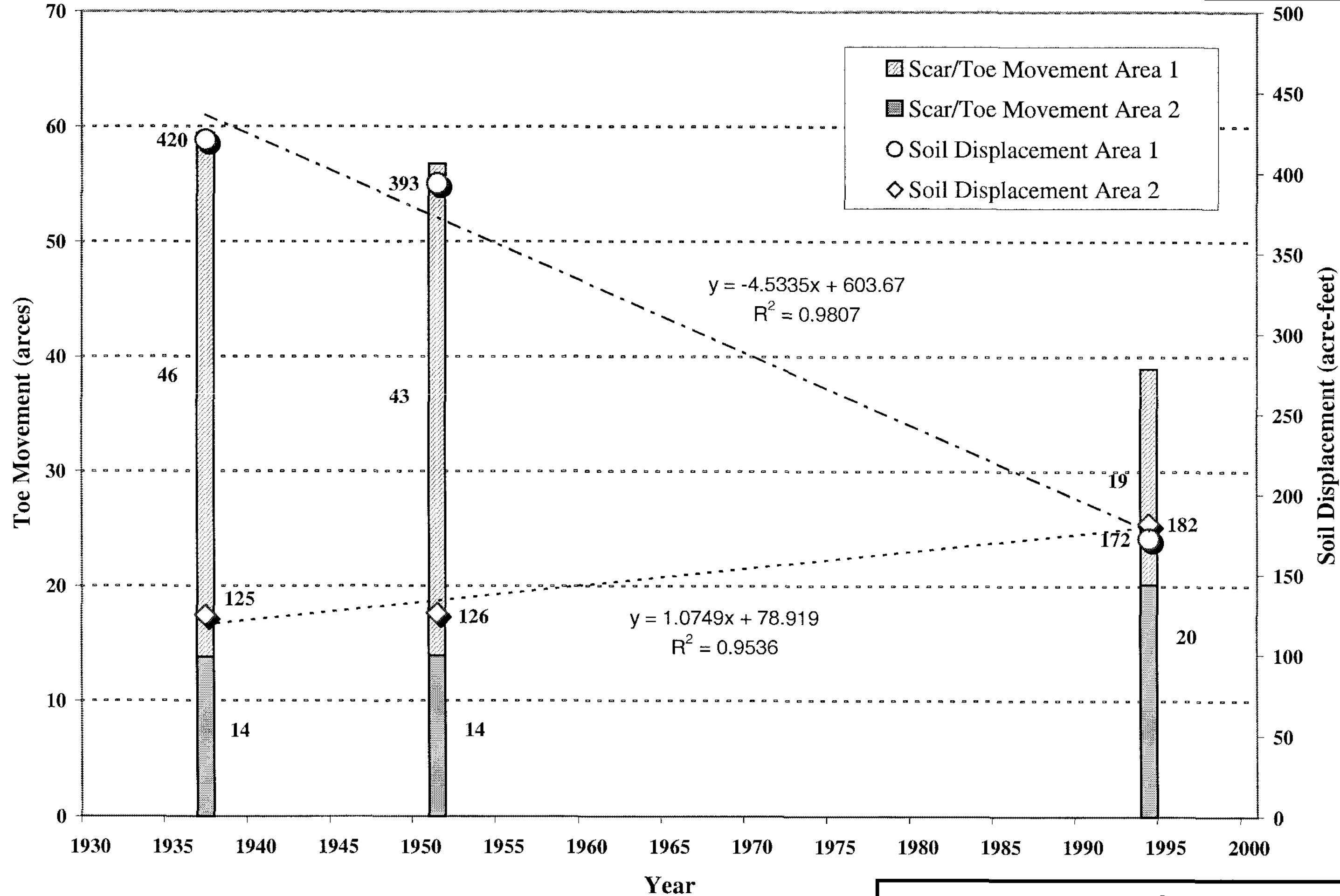
Drawing Name: Tab 2, App G.2, Fig 5-2, Combined.wmf



Area 1 is located on Walnut Creek as shown on Figures G-7, G-8, and G-9.
Area 2 is located on Woman Creek as shown on Figures G-7, G-8, and G-9.

Figure G-10
Mass Movement Rate Estimate

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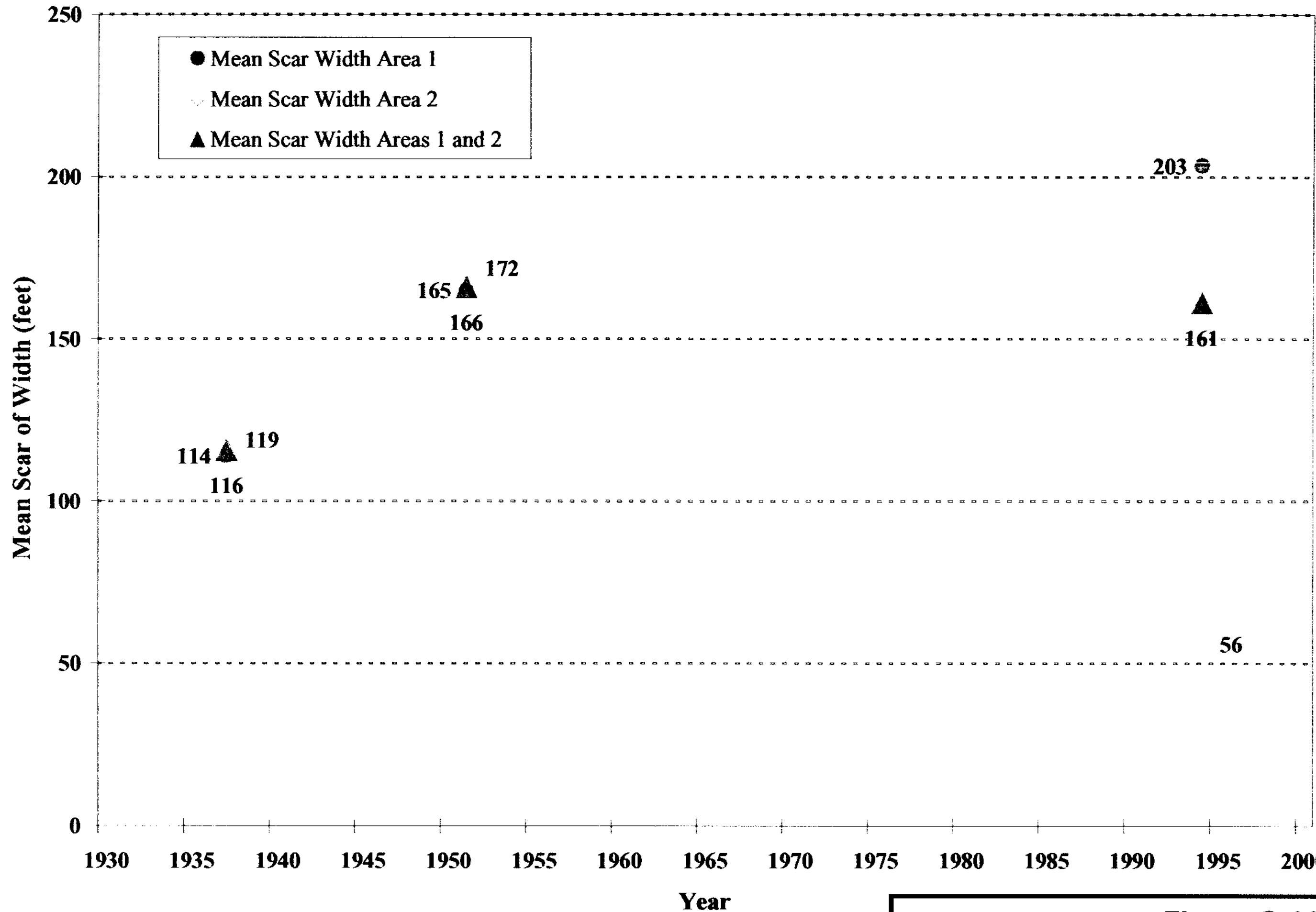

Area 1 is located on Walnut Creek as shown on Figures G-7, G-8, and G-9.
Area 2 is located on Woman Creek as shown on Figures G-7, G-8, and G-9.

Figure G-11
Mean Scar Width

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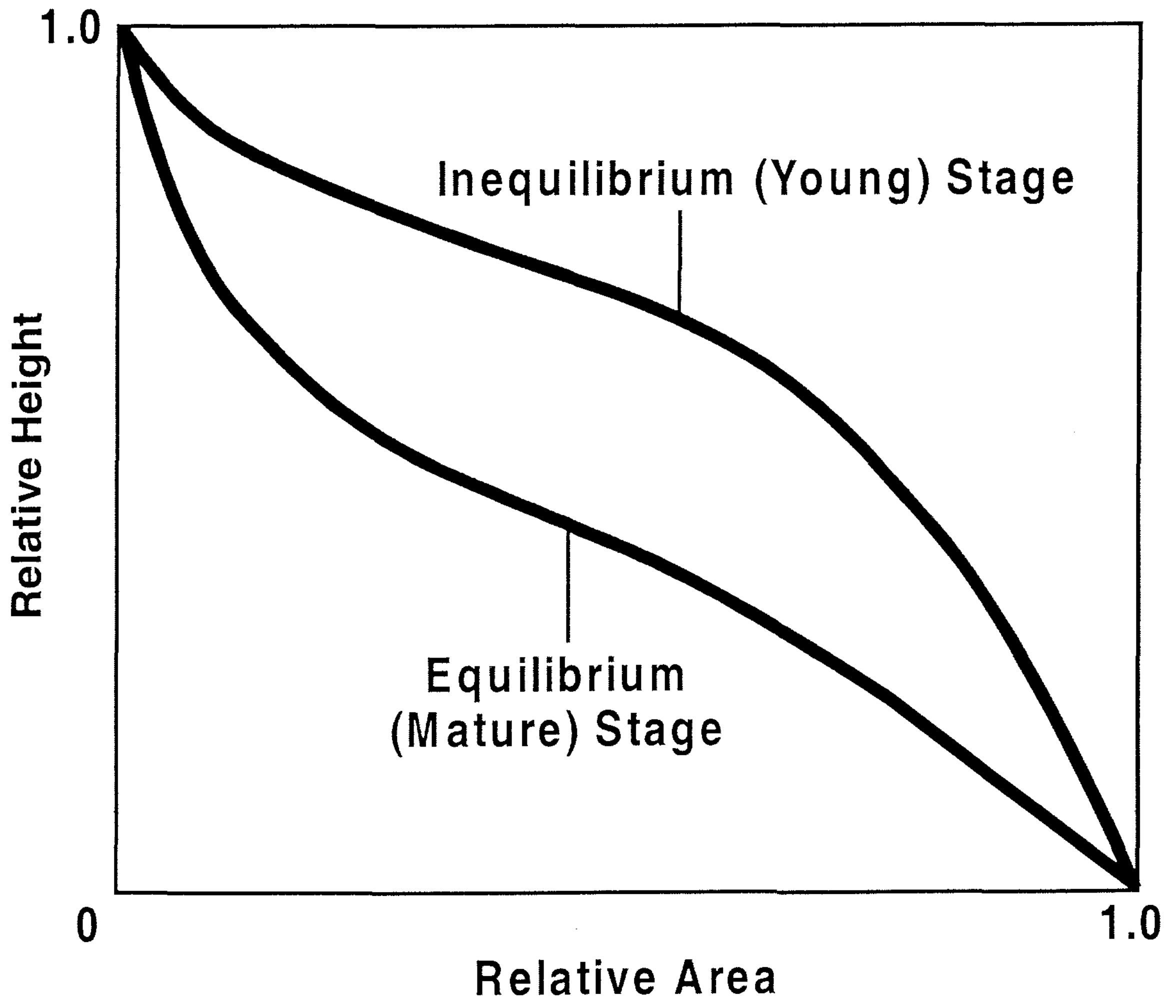

Source: Ritter, 1984.

Drawing Name: draw\RF Land Config.cdr p1 bbs 12/11/01

Figure G-15
Generalized Hypsometric Curves

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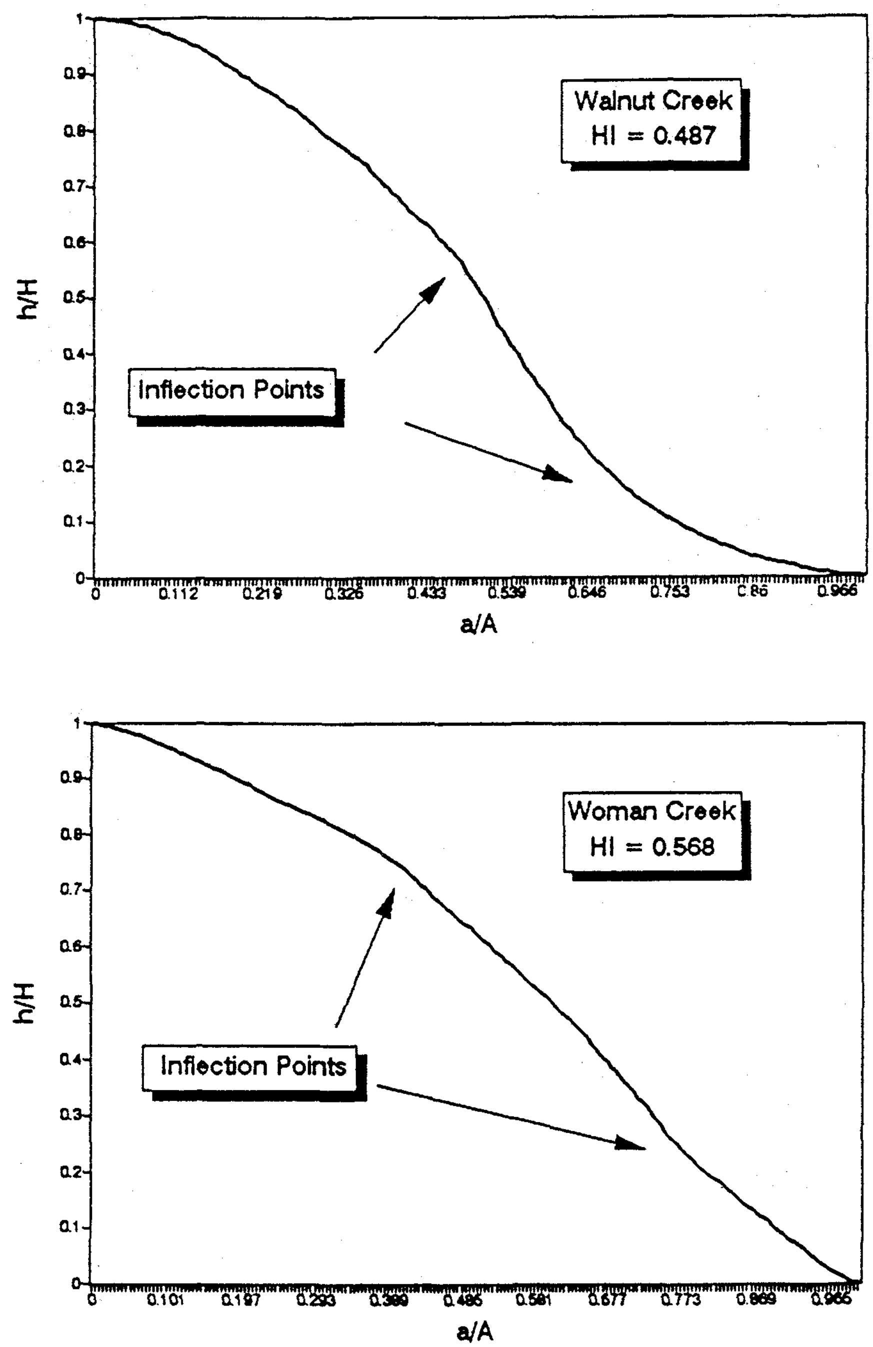

Figure G-16
Hypsometric Curves for
Walnut and Woman Creek Drainage Basins

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Land Configuration Design Basis Project

Source: Geomatrix, 1994.

Drawing Name: draw\RF Land Config.cdr p3 bbs 12/04/01

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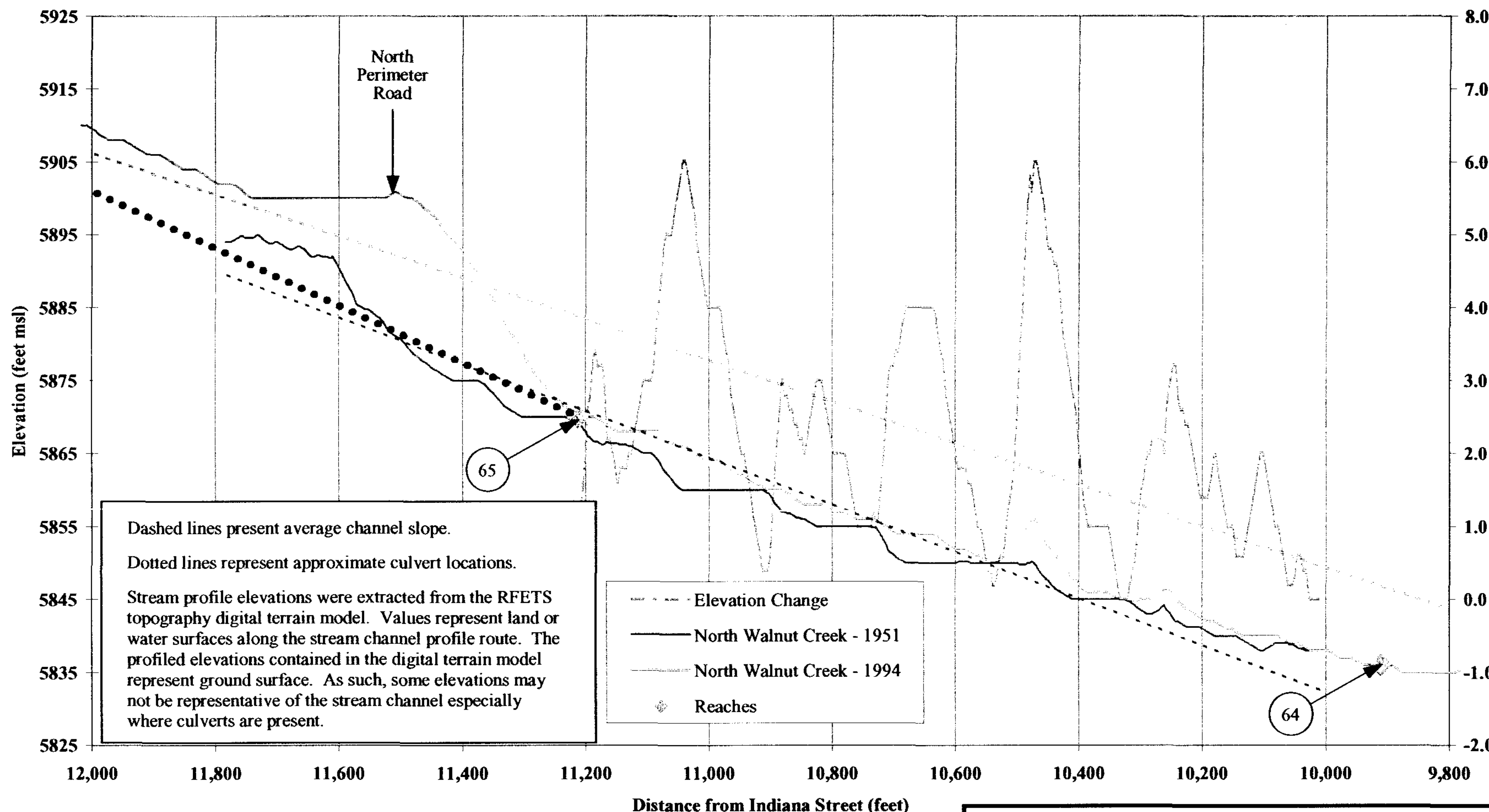

North Walnut Creek - 1951

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 64 to 65 - 1951	31	1201	2.6%
Average	**31**	**1201**	**2.6%**

North Walnut Creek - 1994

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 64 to 65	34	1301	2.6%
Average	**34**	**1301**	**2.6%**

Elevation Change 1951 - 1994

Segment	Average Elevation Change (feet)
Reach 64 to 65	2.3

Figure G-17
North Walnut Creek Profile Change 1951 - 1994

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

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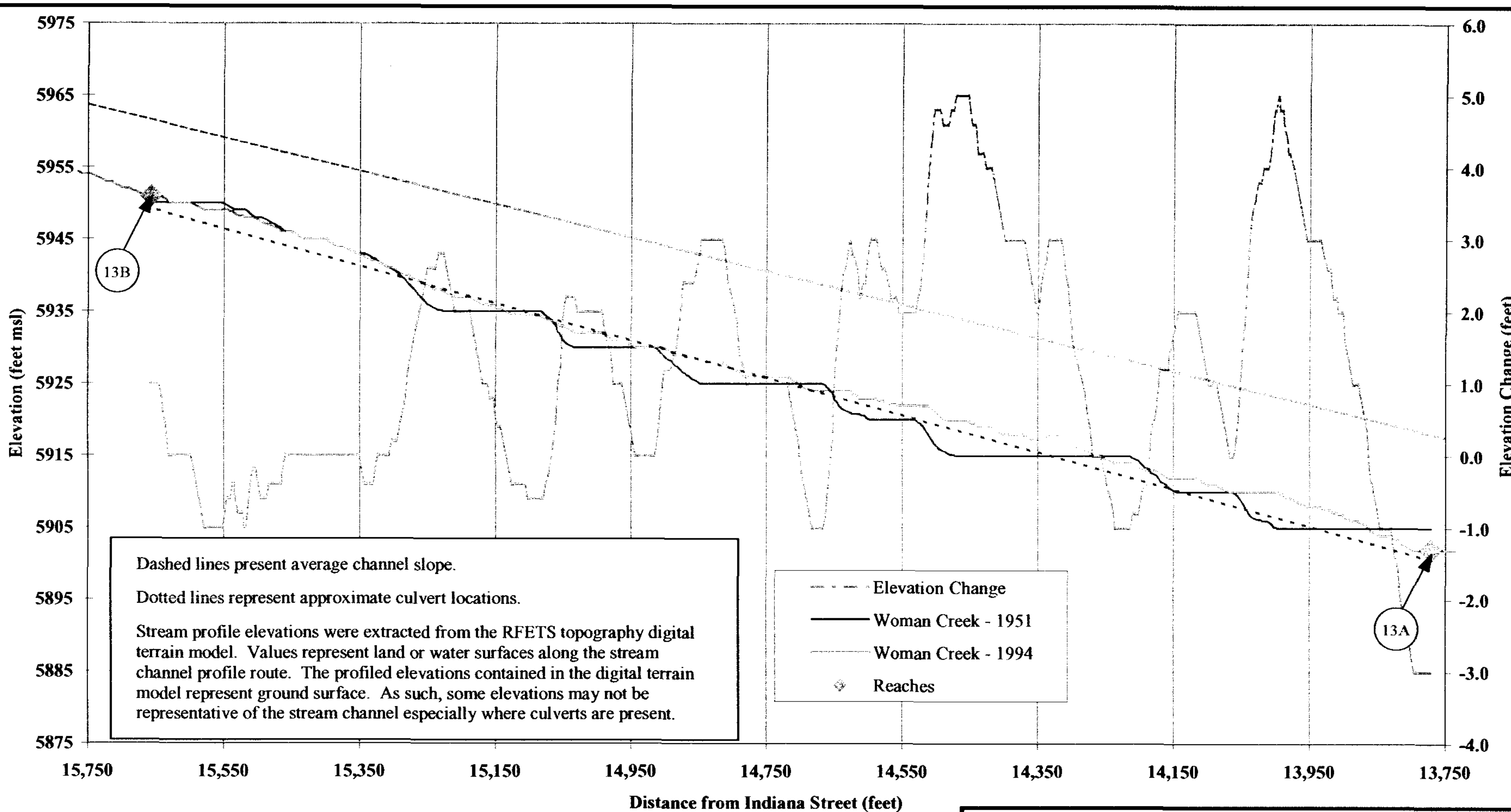
January 10, 2002



Woman Creek - 1951

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 13A to 13B - 1951	45	1886	2.4%
Average	31	1201	2.6%

Woman Creek - 1994

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 13A to 13B - 1994	49	1886	2.6%
Average	34	1301	2.6%

Elevation Change 1951 - 1994

Segment	Average Elevation Change (feet)
Reach13A to 13B	1.2

Figure G-18
Woman Creek Profile Change 1951 - 1994

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

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PARSONS

January 10, 2002

TAB 2, APPENDIX G.2

ATTACHMENT 1
GEOMORPHOLOGY WORKSHOP SUMMARY

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Geomorphology Workshop Summary

INTRODUCTION

On Thursday, September 20, 2001, a Geomorphology Workshop was held with the goal of integrating and coordinating across several environmental restoration projects at RFETS. These projects include the following:

- ET Covers Project Original Landfill - Feasibility Study currently being prepared by SAIC.
- ET Covers Project Present Landfill - Conceptual Design currently being prepared by Daniel B. Stevens.
- ET Covers Project Solar Evaporation Ponds - Conceptual Design currently being prepared by Daniel B. Stevens.
- Land Configuration Design Basis Project being performed by Parsons.
- Actinide Migration Evaluation being performed by Wright Water Engineers.

The LCDB, AME, and ET Covers projects are developing information to evaluate the durability, longevity, and effectiveness of their final closure and to assess the useful life of the resultant designs. Several of these projects have evaluation timeframes approaching 1000 years. Because of the extended design lives, the techniques commonly used for erosion modeling have less confidence, while the predictions based on geomorphology, pedogenesis, climatology, and long-term ecology become more relevant for addressing long-term performance issues. The information presented and exchanged at the workshop was intended to:

- Identify and quantify the primary factors influencing design longevity and geomorphic processes at RFETS.
- Present technical approaches and experience in designing-for and assessing long term changes.
- Enhance the credibility of all the projects and eliminate contradictions in reports from one report to the next.
- Develop a consistent approach to answer the question of, "How long will it last?"
- Support specific tasks on the individual RFETS projects.

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PRESENTATIONS

The workshop participants made a series of presentations. A description of each presentation is provided below:

Evapotranspiration Project - Mark Ankeny (Daniel B. Stevens & Associates)

Mr. Ankeny provided an overview of the ET Covers projects and some of the design concerns associated with closing the Present Landfill and the Solar Evaporation Ponds. He expressed a need for a systems approach to long-term design and related his experiences relevant to the development of site-wide design criteria.

Original Landfill IM/IRA - Sandi Doty/Gerald Zimpfer (SAIC)

Mr. Zimpfer presented an overview of the development of an IM/IRA for the Original Landfill. Ms. Doty described her previous experience of evaluating geomorphic processes occurring at the West Valley Site in New York where many of the concerns and processes are similar to RFETS.

Land Configuration Design Basis Project - Georgia Vondra (Parsons)

Ms. Vondra described the geomorphic evaluation being conducted under the LCDB project. Those activities include the analysis of geomorphic processes at the site and an evaluation of these process rates over time based on aerial photographs and topographical information.

Actinide Migration Evaluation Project -Dave Jubenville (Wright Water Engineers)

Mr. Jubenville provided an overview of the AME group activities at RFETS and results to date. He also discussed the local geology, aspects of existing surface water control structures at the site, and provided his views on the devolvement of long-term design criteria for the Site.

Long-Term Covers: Ecological Engineering Paradigm - Jody Waugh (Mactec)

Mr. Waugh discussed the need for and subsequent evolution of long-term covers. He also discussed the application of long-term assessment tools including numerical models, field monitoring, and analogous studies.

Anticipated Climate Variations at RFETS - Martyn Clark / Andrew Barrett

Mr. Clark provided an overview of several types of climate models and how a climatic model specific to the Front Range and RFETS might be developed.

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DISCUSSIONS AND CONCLUSIONS

Following the presentations, a general discussion was held to further exchange ideas and information. The following general conclusions relating to design longevity and geomorphology at RFETS were developed for consideration by the various RFETS projects.

Earth Processes

- A reasonable technical approach to follow in evaluating long-term erosion control and evolution of Site landforms:
  - Identify dominant geomorphic processes,
  - Quantify and measure geomorphic process rates,
  - Develop erosion control strategy and design measures, and
  - Conduct long-term performance assessment (modeling).
- The goals and objectives of the final closure landscape over the next 1000 years need to be established and understood.
  - Satisfy open space use requirements
  - Provide for sediment retention
  - Sustain engineered structures (ET covers)
- The dominant geomorphic processes are channel incision (headward advance and stream elongation), slope movement (mass wasting and slumping), and gully formation. A good conceptual model assumes that the bench tops (pediments) are stable. The major geomorphic processes occur on the hillsides and in the valleys. Mass wasting appears to be the most significant process in shaping the land surface and could have significant impact on sediment loading to the streams. Infiltration down through the pediment and through valley walls appears to be the main driver for slumping. There is a need to develop overall geomorphic process rates at RFETS.
- The pediments are narrowing; and therefore, long-term structures should be sited away from unstable hillsides. Need to identify hill slopes at RFETS that are unstable and susceptible to mass wasting. Need to evaluate if failure of these slopes will adversely impact engineered features or increase contaminant migration in order to determine if these slopes need to be stabilized or if they can be left to natural processes.
- A reasonable simplifying assumption is that future climate over the next several hundred years is likely to lie within the range of climate observed over the past several hundred years that is available from sources like water year precipitation data for the South Platte (60 years of data) and Front Range annual tree ring data (200 years of data).

Engineering Criteria

- Need to develop a single set of design criteria for the Site. This coordination will help avoid setting precedents for a specific project where that precedent may negatively impact other projects at the Site (For example, use of recycled concrete from Stapleton for bio-barrier layer at RMA).
- Erosion on the surface of covers is currently evaluated using the Revised Universal Soil Loss Equation (RUSLE). The AME Group uses WEPP software for evaluating erosion and actinide migration. It was suggested that an analysis using WEPP software would provide an alternative method of evaluating erosion that could be compared to the RUSLE results
- Need to develop requirements and specification for topsoil, fill, and other geotechnical properties. Need to develop an integrated approach to manage and stockpile soil for use as backfill in support of D&D and remedial activities with the goal of minimizing the need to import (shortage) or dispose (excess) soils. A Site-wide cut/fill balance could be developed.
- The Urban Storm Drainage Criteria Manual provides guidance specific to the Front Range and should be considered for the design of surface water control features at the Site.
- In general, during development of engineering approaches for the Site, disturbance to existing habitat should be avoided if possible. If engineered controls are required and their location will impact habitat or wetlands, it may be necessary to implement the control while minimizing the impact.

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TAB 2, APPENDIX G.2

ATTACHMENT 2
SITE RECONNAISSANCE PHOTOGRAPHS

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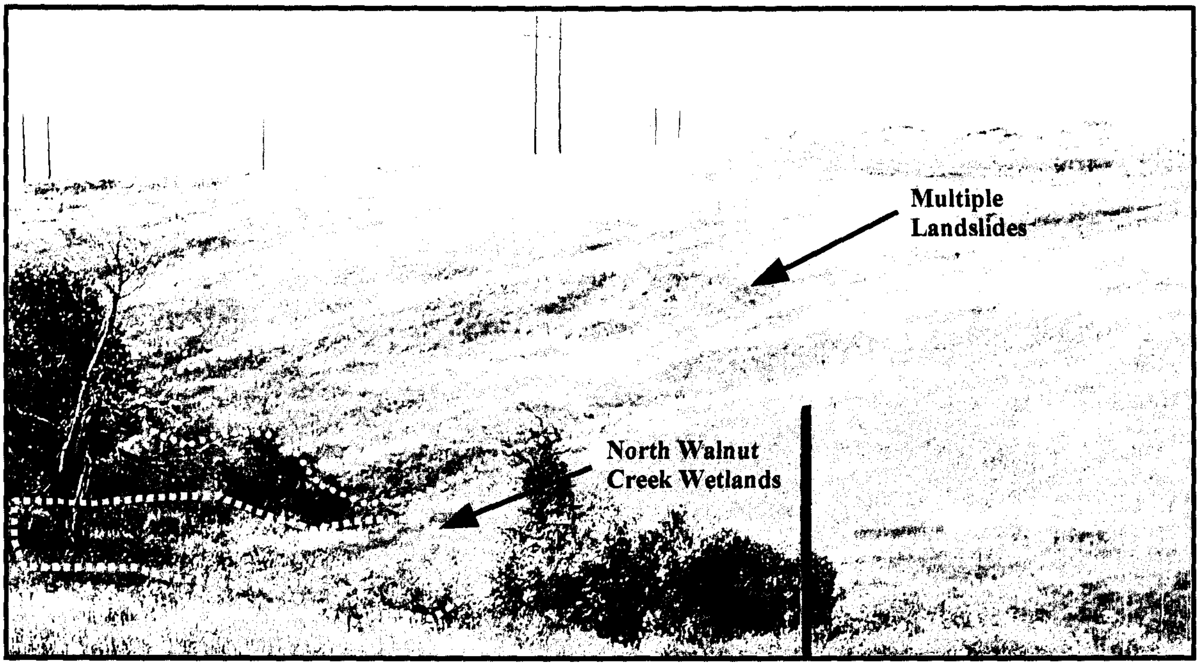
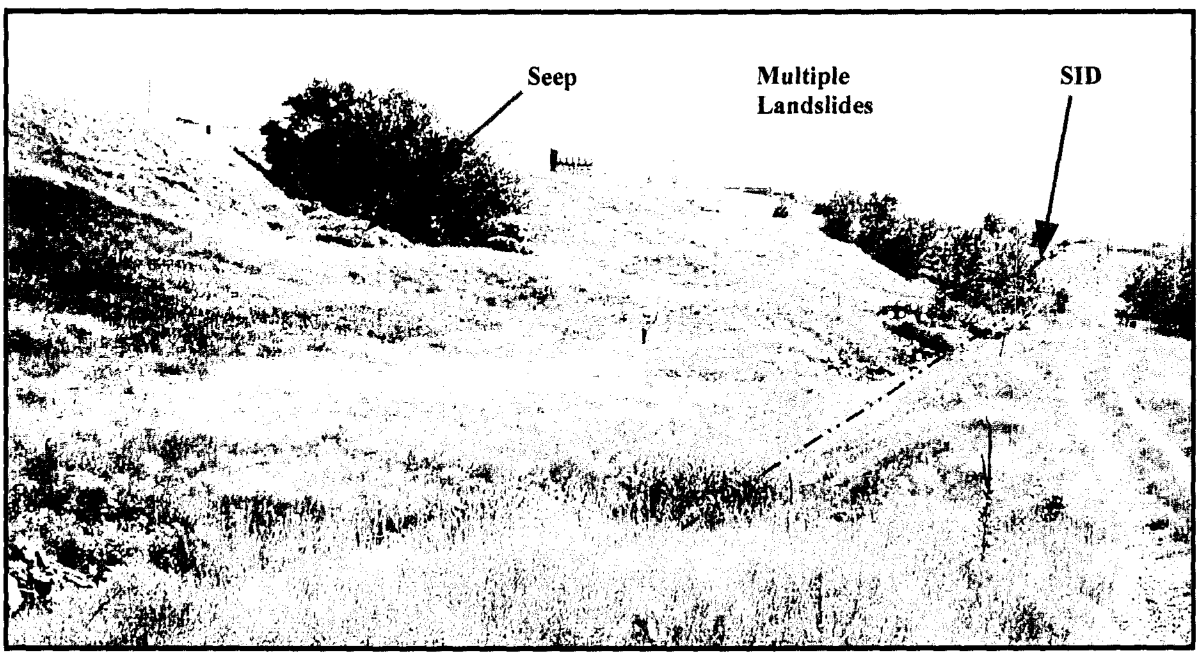


Photograph 1
Multiple Slump Block Mass Movement
North Walnut Creek West of Pond A-1 – Looking Northwest, 09/18/01



Photograph 2
Seep, Mass Movement, and Encroachment into SID
South Side of Industrial Area near Original Landfill – Looking East, 09/06/01

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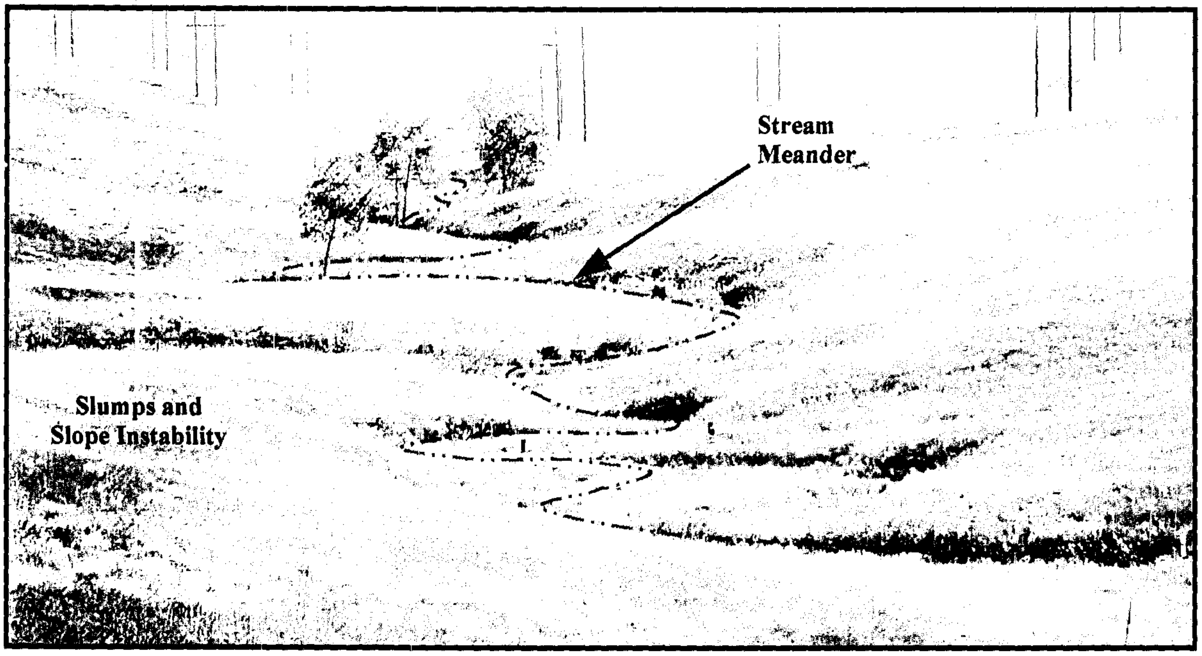
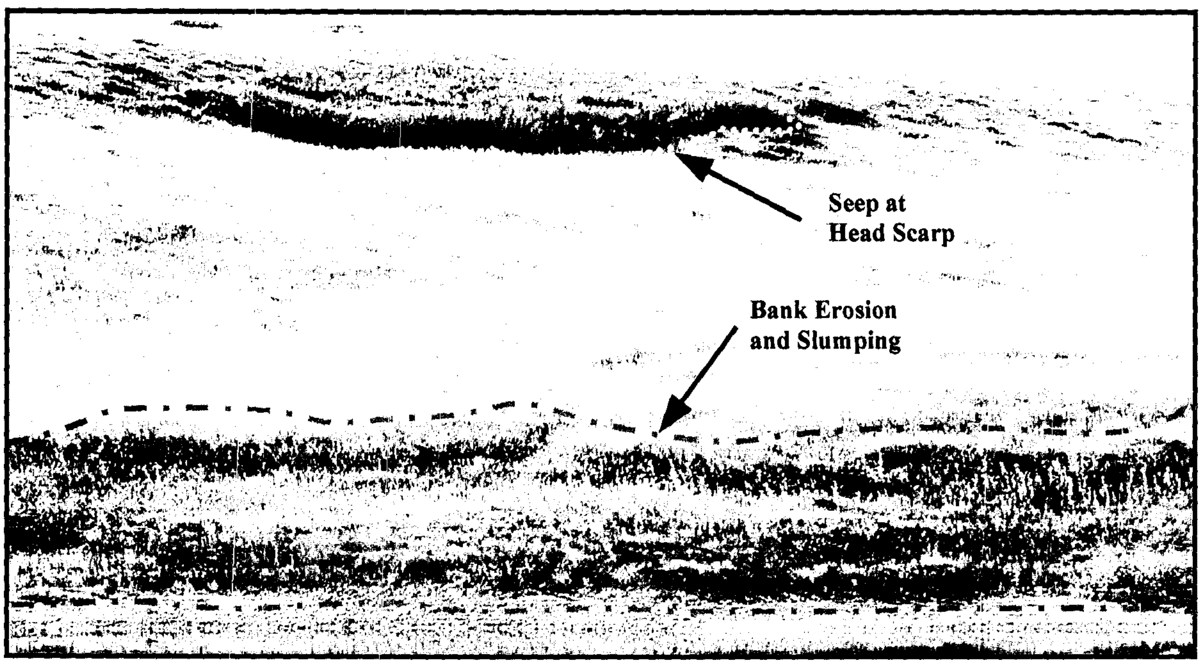
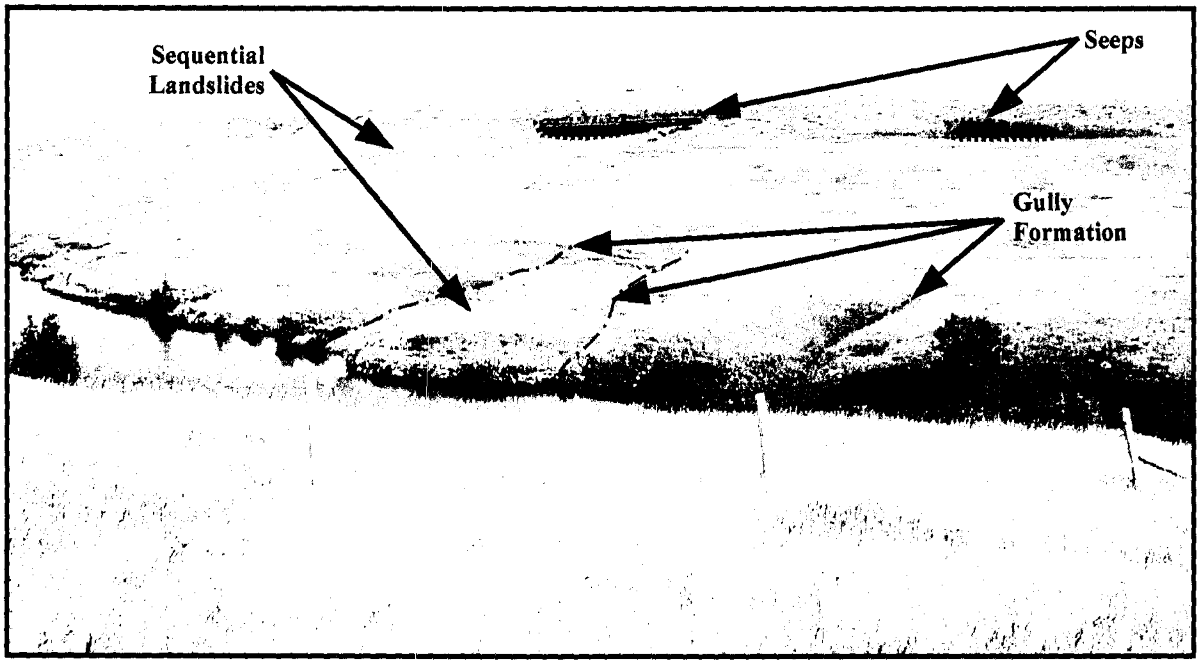


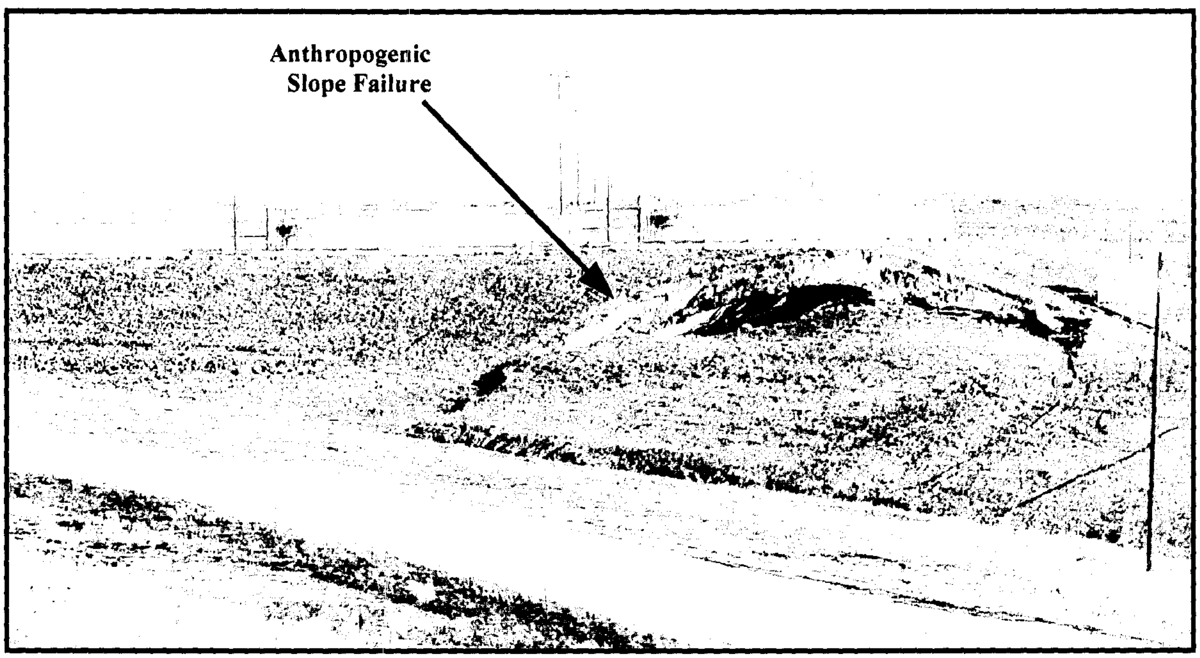
Photograph 3
Stream Meander and Slope Instability
No Name Gulch – Looking East from Present Landfill Pond Dam, 09/06/01



Photograph 4
Seep Location at Head Scarp of Landslide and Bank Erosion
South Walnut Creek South of Pond B-5 - Looking South, 09/06/01



Photograph 5
Multiple Landslides with Seeps at Head Scarps
South Walnut Creek at Pond B-5 – Looking Southeast, 09/18/01



Photograph 6
Recent Slump Block Mass Movement at Modular Tanks
Taking from North Perimeter Road – Looking Northwest, 03/05/01

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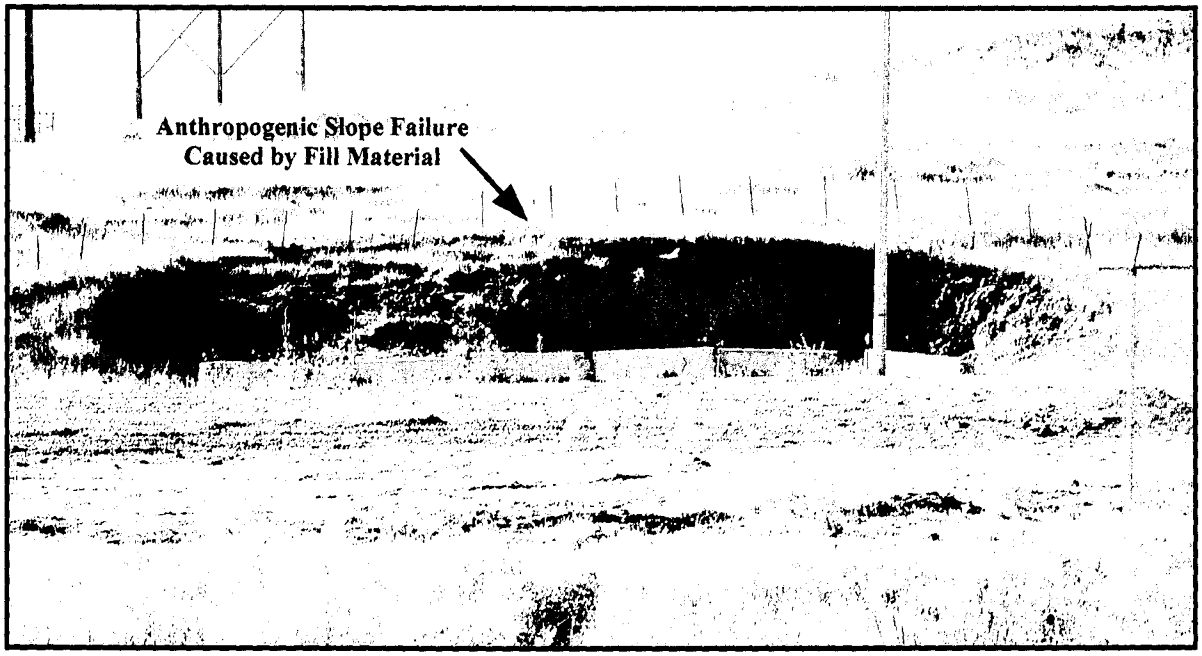
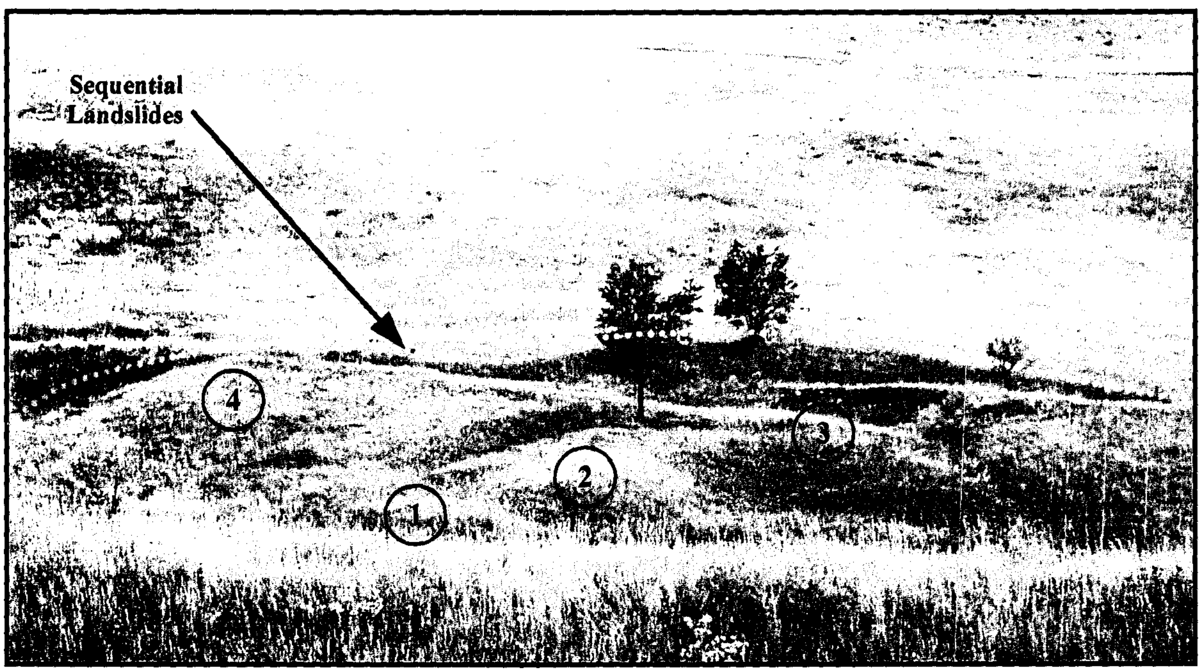


Photograph 7
Rapid Mass Movement of Fill Material North of Building 371
Taken from North Perimeter Road – Looking South, 09/06/01



Photograph 8
Sequential Landslide Activity Located Below Buffer Zone Road
Woman Creek West of Pond C-2 – Looking South, 09/18/01

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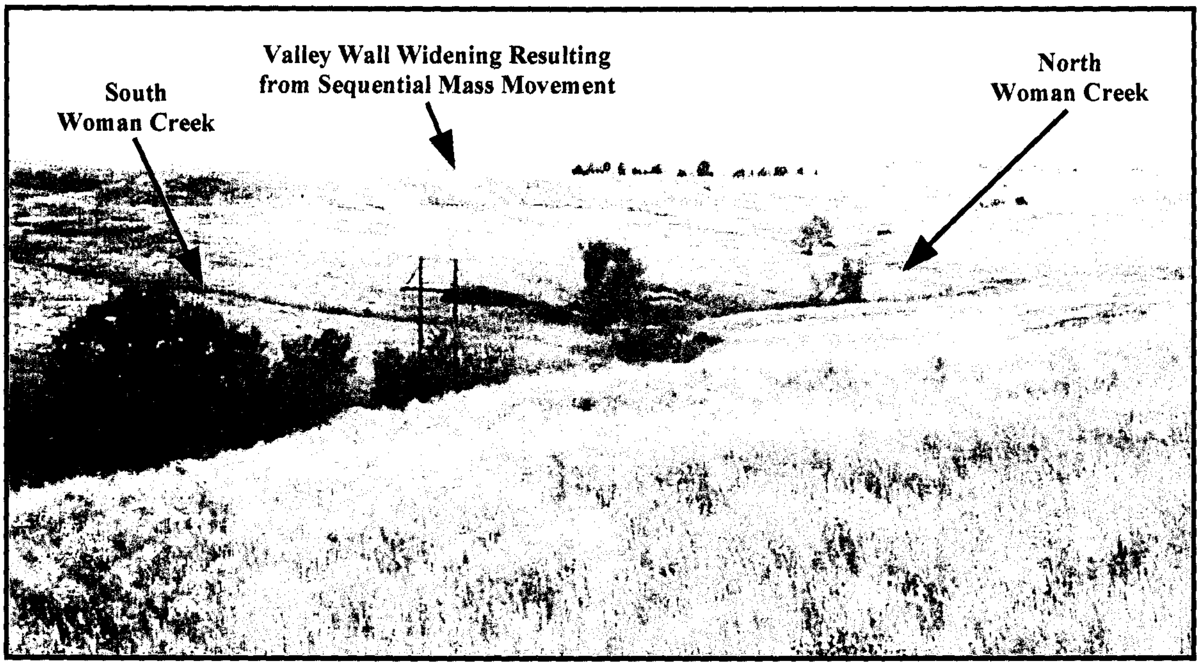
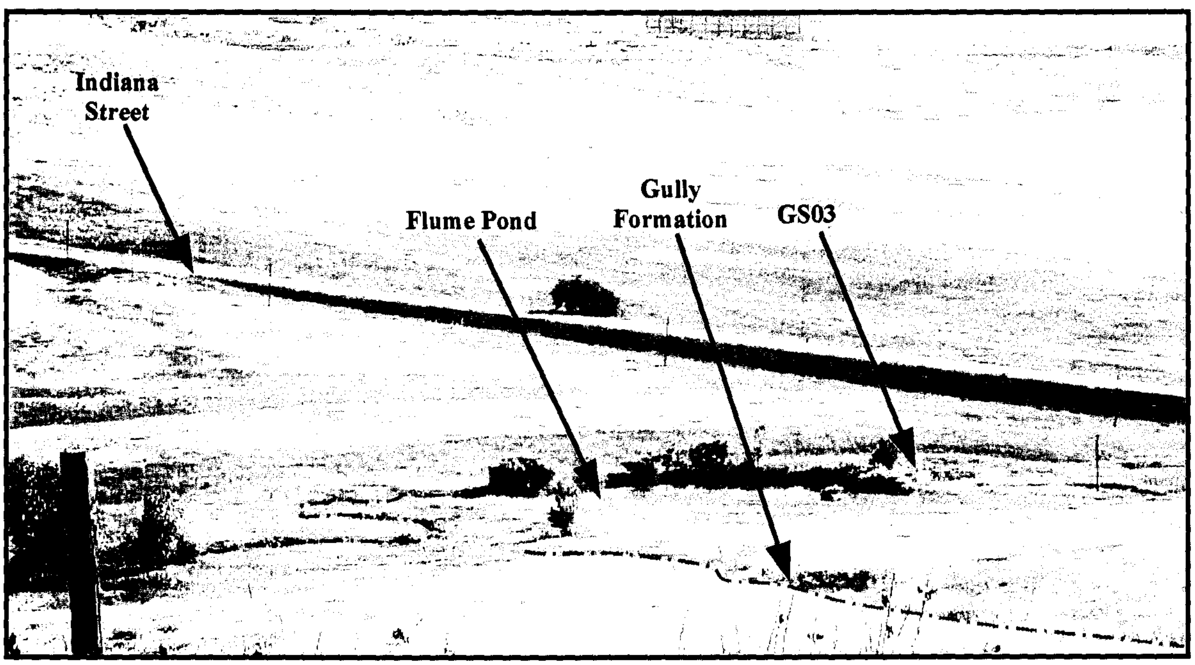


Photograph 9
Valley Widening and Mass Slope Movement in Upper Reaches of Woman Creek
Taken South of West Entrance Road – Looking West, 09/18/01



Photograph 10
Walnut Creek at Indiana Street
Taken from Pediment – Looking Northeast, 09/06/01

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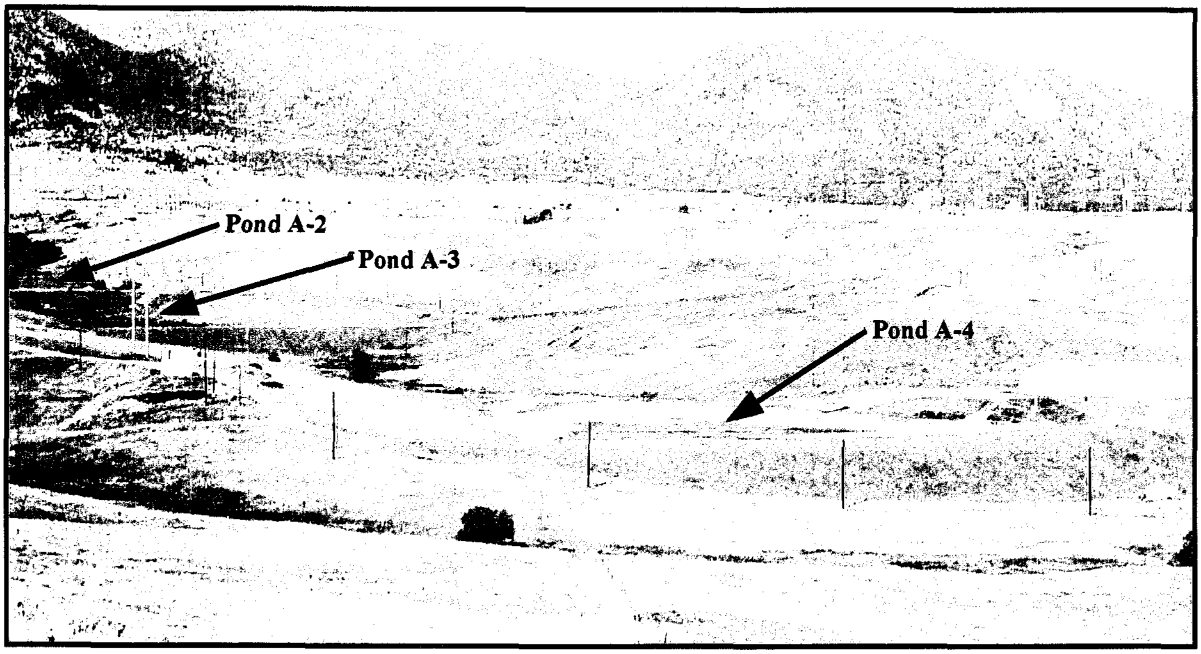
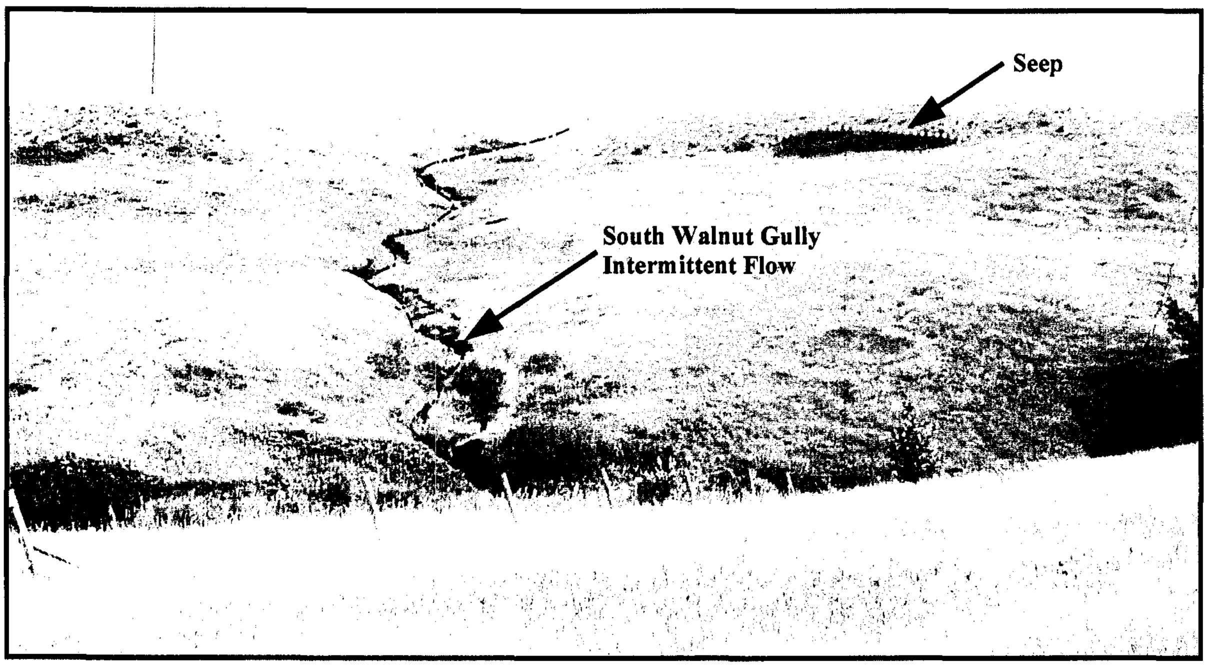


Photograph 11
Ponds A-2, A-3, and A-4 on North Walnut Creek
Taken from Pediment - Looking Northwest, 09/06/01



Photograph 12
South Walnut Gully Formation Along Landslide Scarps
Taken near Pond B-5 – Looking South, 09/18/01

TAB 3
ATTACHMENT A

BOUNDING SCENARIO DEVELOPMENT AND EVALUATION FOR LAND CONFIGURATION DESIGN BASIS PROJECT

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SCENARIO DEVELOPMENT AND EVALUATION FOR LAND CONFIGURATION DESIGN BASIS PROJECT

TABLE OF CONTENTS

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1.0 INTRODUCTION

Three bounding scenarios were developed and evaluated to identify the components for incorporation into an initial conceptual design. A brief description the process followed is presented in this section and summarized in Table A-01. Instead of evaluating a multitude of potential alternatives, three bounding scenarios were identified and developed considering the design basis and potential options for land configuration presented in the Draft LCDB Project Work Plan to bound the range of feasible, reasonable, and cost-effective approaches that could be implemented as the final configuration at RFETS. These "bounding" scenarios are intended to represent relative extremes of three distinct approaches to meeting the objectives of the project. The three bounding scenarios were evaluated against each other to highlight the relative strengths and weaknesses to the scenario components with respect to particular drainages or sectors (geographical areas).

1.1 Define Objectives and Design Basis for LCDB Project

The LCDB Design Basis was developed concurrently with the Draft LCDB Project Work Plan. The Design Basis presents the general and site-specific information that is required to develop an adequate final land configuration design for RFETS. This information includes:

- Identification of the conditions and other physical constraints of the Site that are anticipated to be present at the completion of active remediation,
- Preparation of the design basis for the final land configuration including Site information, project objectives, balancing performance functions, conditions, limitations, and other provisions that bound the scope for the final land configuration, and
- Identification of the engineering codes standards, guidelines, and other design criteria to be incorporated into the design for the final land configuration.

The primary objective of the LCDB Project is to maintain compliance with surface water quality standards at the Points of Compliance (POCs) after Site closure. The major secondary performance functions include:

- Minimizing disturbance to ecological resources (wetlands, Preble's mouse habitats, special-interest plant communities, and other sensitive wildlife areas).
- Minimizing construction impacts and cost,
- Minimizing long-term stewardship obligations and operational cost,
- Precluding interference with remedial actions taken under RFCA and expansion of groundwater plumes, and
- Incorporating open space values to the extent practicable (minimizing use restrictions, aesthetic distractions, etc.).

The design basis is included in Tab 2, Appendix B.

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1.2 Develop Potential Options for Land Configuration

Potential Land Configuration Options were also identified concurrently with the Draft LCDB Project Work Plan. The potential land configuration options represent an initial assessment of the general methods, techniques, and approaches to maintain compliance with surface water quality standards at the POCs. The land configuration options represent methods to remove sediments and other contaminants from surface water and methods to prevent the transport of contaminants into surface water. The potential land configuration options are presented in Section 4 of the Draft LCDB Project Work Plan (see Tab 1).

1.3 Develop Bounding Scenarios

The design basis and potential land configuration options were used to develop three bounding scenarios. Each bounding scenario utilizes a unique approach to illustrate a reasonable range of approaches to meet the reconfiguration objectives and FDOs established for the project. Each bounding scenario is intended to portray an idea / approach for evaluation, not to be included (in total) as an initial conceptual design. As such, it is recognized that each bounding scenario may have disadvantages that would make the bounding scenario unsuitable as an initial conceptual design. The rationale for developing the three bounding scenarios is presented in Section 2.

1.4 Evaluate Bounding Scenarios

The three bounding scenarios were evaluated against a wide-range of evaluation criteria developed from the project FDOs and supplemented with other performance measures to further highlight the relative weakness and strengthens associated with components included in each bounding scenario. The evaluation protocols were established to:

- Determine the strengths and weaknesses of the scenario components,
- Highlight the significant differences between the scenario components,
- Assess the relative performance of the scenario components, and
- Identify specific drainages or sectors where individual scenario components are well suited to be applied.

The evaluation process was not intended to assess absolute performance of the bounding scenarios against the evaluation criteria or to use a single bounding scenario as the overall "winner". Evaluation criteria, protocols, and results are documented in Section 4.

1.5 Identify Scenario Components for Initial Conceptual Design

The evaluation results were used to identify scenario components that could be combined together as an initial conceptual design. The scenario components were identified based on their relative performance as applied to different Site drainages and sectors. These scenario components are intended to develop an initial conceptual design that:

- Provides a high degree of confidence in satisfying the primary project objectives (achieving compliance with the surface water quality standards at the POCs);
- Minimizes or reduces, to the extent feasible, negative aspects or impacts of the design on secondary performance functions;
- Achieves a cost-effective and reliable final land configuration for the Site; and
- Contributes to a robust design capable of accommodating uncertainties in the future conditions of the Site.

2.0 DEVELOPMENT OF BOUNDING SCENARIOS

Various potential land configuration options were identified based on the Site information and FDOs compiled for the final land configuration. These options are presented in Section 4 of the Draft LCDB Project Work Plan (see Tab 1). The land configuration options include both methods to control contaminants in surface water and to prevent the transport of contaminants into surface water.

A multitude of potential alternatives could be developed to address every combination of the land configuration options. Rather than identify, describe, and evaluate an infinite number of possible configurations, three scenarios were identified to bound the range of feasible, reasonable, and cost-effective approaches that could be implemented as the final configuration at RFETS. These "bounding" scenarios are intended to represent relative extremes of three distinct approaches to meeting the objectives of the project. There are additional plausible scenarios that are contained within the range of the bounding scenarios while others are not included as bounding scenarios.

The bounding scenarios, in conjunction with the evaluation protocol, were developed not to identify a single scenario as the "winner", but rather were used to identify the strengths and weaknesses of individual scenario components and to identify where specific components may be well suited for a particular drainage or sector. As such, the bounding scenarios were not developed to meet all FDOs, to represent the most effective approach, or to specifically cover every possible approach. Instead, the bounding scenarios and evaluation results were developed to allow general observations and conclusions to be drawn, which in turn was used to guide development of an initial conceptual design that effectively meets the reconfiguration goals and FDOs.

With these objectives in mind, the following three scenarios were developed to bound the reasonable approaches associated with one or more of the potential options for land configuration:

- **Scenario 1: Flow-Through Detention Ponds and Wetlands.** This bounding scenario uses water controls to allow passive gravity settling that relies on limited operation and maintenance (O&M) during long-term stewardship. This scenario also takes advantage of components designed to enhance existing wetlands and critical Preble's mouse habitats.
- **Scenario 2: Batch Release Detention Basins.** This bounding scenario uses large capacity detention basins to temporarily hold accumulated runoff for verification

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testing prior to batch-release. This scenario relies on administrative controls to maintain compliance with the surface water quality standards.

- **Scenario 3: Source Isolation, Drainage Diversion, and Erosion Controls.** This scenario is intended to diminish migration of contaminants into surface water at its source. As such, this scenario does not rely on any surface water controls and returns the Site to more natural condition to eliminate restrictions on open-space land use to the extent practicable.

A more detailed description of each bounding scenario is provided in Section 3 and the evaluation results for the bounding scenarios are presented in Section 4. The rationale for inclusion or exclusion of each potential land configuration option in the identification of the three bounding scenarios is presented below. Descriptions for each potential land configuration option are included in Section 4 of the Draft LCDB Project Work Plan (see Tab 1) and are therefore not repeated here.

1. **Surface Water Retention (Zero Discharge)** - This option was not carried forward because the size of the retention component makes this option very costly to construct. The cost of this option along with significant negative impacts on downstream water usage, habitat, and visual aesthetics make it less desirable than batch release (Configuration Option 2B). Because the batch release option provides similar positive components (high confidence) and minimized most of the negative impacts associated with zero discharge, surface water retention was not included as a bounding scenario.

2A. **Surface Water Detention, Passive Settling (Flow-Through)** - This option was combined with wetlands (Configuration Option 4) as bounding Scenario 1. The flow-through detention ponds in conjunction with wetlands would be used to desynchronize runoff from storm events and increase settling efficiencies. The combination of these two options provides a scenario that is significantly more reliable and adequately bound both options. Habitats and aquatic communities in Walnut Creek that are downstream of the terminal ponds could benefit continuous discharge from a flow-through type of operation versus the current practice of batch release.

2B. **Surface Water Detention, Batch Release** - This option is included in bounding Scenario 2 for the settling of suspended actinide-bearing soils prior to testing and release of any surface water. This option serves to bound other scenarios that utilize intercept ditches to capture surface water for settling prior to release from the Site (e.g., Super SID concept).

2C. **Surface Water Detention, Active Treatment** - This option was not included as a bounding scenario because other more cost-effective options are available. Current information and known settling characteristics of transportable actinide-bearing particulates indicate that passive settling techniques (either wetlands or basin settling) are effective in maintaining the surface water quality standards without incurring the high operation costs and stewardship responsibilities associated with active treatment.

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3. **Removal of Surface Water Controls** – This option was included as part of bounding Scenario 3 since this scenario does not rely on using water controls to maintain compliance with surface water quality standards. Removing the existing ponds and other surface water controls is considered to be bounding and would be evaluated to determine its feasibility and the potential impacts with their removal.

   This option may also be applied to the other bounding scenarios as part of the Pond and Sector Reconfiguration Strategies to refine the scope of the initial conceptual design (see Tab 3, Attachment D). In general, the Pond and Sector Reconfiguration Strategies allow removal of existing ponds, culverts, drains, and other drainage components that do not have a continuing and legitimate purpose. These strategies also allow modification or replacement of components that need to be retained.

4. **Wetlands** - This option was combined with passive settling / flow through (Configuration Option 2A) as bounding Scenario 1. Wetlands were included as part of this scenario to take advantage of their natural processes to remove and filter sediments while enhancing existing wetlands to minimize mitigation requirements and impacts to Preble's mouse habitats.

5. **Drainage Diversion / Land Recontouring** - This option was combined with Source Isolation and Erosion Controls (Configuration Options 6 and 7) as bounding Scenario 3. This scenario is considered to bound a wide variety of configurations that utilize engineered components and controls to prevent migration of contaminants at their source to maintain compliance with surface water quality standards. Land recontouring would also be utilized with the IA to eliminate unnecessary drainage ditches. This option could also include redirecting runoff from one drainage to another (e.g., Woman to Walnut Creek) recognizing its potential limitations with respect to downstream water uses.

6. **Source Isolation and Removal** - This option was combined with Drainage Diversion and Erosion Controls (Configuration Options 5 and 7) as bounding Scenario 3. However, Site wide removal of all actinide-bearing surface soils and sediments that is above-background and could contribute to an exceedence of the surface water quality standards is not considered a bounding scenario due to its considerable expense and extensive ecological disturbance. As such, source isolation and removal would be applied to specific sectors, in conjunction with other planned remedial actions.

7. **Erosion Controls** - This option was combined with Drainage Diversion and Source Isolation (Configuration Option 5 and 6) as bounding Scenario 3. Erosion controls (check dams) were also included in Scenario 1 as an alternative to constructed wetlands in areas where adequate water may not be available to support the wetland. In addition to being a primary component of Scenarios 1 and 3, erosion controls would be incorporated through application of the Sector Reconfiguration Strategy during refinement of the initial conceptual design.

8. **Vegetation Restoration** - This option is included as a secondary component for each bounding scenario to address disturbed areas.

9. **Evapotranspiration (ET) Provisions** – Although ET provisions are beneficial to minimize infiltration, this option has limited applicability to preclude soil erosion during storm events. ET provisions would also negatively impact downstream water usage and reduced groundwater flow to seeps that support existing wetlands. As such, ET provisions would not be used as a primary component, but could be included in any of the bounding scenarios in specific sectors to further prevent expansion of groundwater plumes. ET provisions were specifically included as a component of Scenario 3 for evaluation.

10. **Infiltration Provisions** – This option would be applied to the IA by default regardless of the bounding scenario due to the removal of impervious surfaces (buildings, roads, parking lots, etc.) during closure of the IA. The need to apply additional infiltration provisions would be considered during the refinement of the initial conceptual design based on the evaluation results (WEPP and HEC-6T modeling) for the bounding scenarios. Depending on runoff characteristics, infiltration provisions may play a limited role in preventing soil erosion to surface water during large storm events. Land recontouring (Configuration Option 5) could be utilized to promote infiltration in specific sectors. However, application of infiltration provisions to areas such as the IA may be limited in consideration of potential expansion of existing groundwater plume and increased hillside instability due to increase groundwater flows. Therefore, the use of infiltration provisions is considered bounded by Scenario 3.

11. **No Action** - The no action option was not included as a bounding scenario because a separate evaluation of the anticipated conditions at the completion of active remediation was already completed. Furthermore, the decision document for the Site would include no action as one of the alternatives to be considered. As such, the no action option is not considered to be bounding.

3.0 BOUNDING SCENARIO DEVELOPMENT AND DESCRIPTIONS

Discussions for each bounding scenario (including design functions, physical description, construction considerations, operational considerations, and cost estimates) are provided in Sections 3.1 through 3.3. Each bounding scenario was developed to a level that adequately portrays the concepts associated with each bounding scenario, allows relative comparison of the scenario components to one another across various evaluation criteria, and to evaluate significant difference to the performance of each bounding scenario. The bounding scenarios were not developed or optimized with the intent that they would be included (in whole) as an initial conceptual design. Instead, appropriate components from each bounding scenario would be combined together as an initial conceptual design based on the evaluation results.

The major components associated with each bounding scenario are graphically depicted on Figures A-01, A-05, and A-09 and summarized in Table A-02. The descriptions, details, and figures developed for each bounding scenario are not intended to imply that these are the preferred or selected design for the scenario components. The locations of components on the figures are shown only to graphically illustrate the scenario concept. The locations are subject to modification during the initial conceptual design should that scenario component be included. Scenario components would be sited to avoid construction disturbance to any existing wetlands and known Preble's mouse habitats. The selected sites would include a suitable buffer zone between construction activities existing wetlands and known Preble's mouse habitats.

In addition, the design information provided in the scenario descriptions is preliminary and would be verified during the design process through the preparation of sizing/design calculations. It is recognized that some design parameters are based on identified data gaps and other design parameters (such as 100-year storm yields) will vary with closure configuration. Although the design calculations would be based on reasonable assumptions, they may need to be verified or revised during the detailed design phase to accommodate any major revisions to the planned closure configuration. Recommendations for sub-studies are included in Appendix C of Tab 2 to resolve any major data gaps prior to proceeding with final design.

3.1 Scenario 1 –Flow-Through Detention Ponds and Wetlands

This bounding scenario utilizes flow-through detention ponds in conjunction with wetlands to passively detain runoff, settle and retain actinide-bearing sediments and improve surface water quality. The distinguishing characteristics of this bounding scenario that achieve the FDOs include:

- All scenario components would rely on passive, gravity water conveyance to minimize operations and reduce long-term stewardship requirements and cost.
- Existing ponds and components are included in the design and minimally modified to reduce construction costs.
- Flow-through detention ponds and wetlands aid in the preservation of existing wetlands, Preble's mouse habitats, and other wildlife areas.
- The natural systems included under this bounding scenario would also promote and be consistent with open space usage of the Site.

The scenario components and information presented in this description are preliminary and would be refined during the design process if flow-through detention ponds or wetlands are included as a design component. The results from the SWWB Project Team would be incorporated into the design of the wetlands to ensure that adequate water supplies would be available for the wetlands after Site closure. The components and locations included in this bounding scenario are shown on Figure A-01. These preliminary locations were developed only to allow evaluation of this bounding scenario. Should any scenario component be included, the preliminary locations (including use of existing ponds and wetlands) would be further evaluated and refined during the design process.

3.1.1 Design Functions and Considerations

Wetland systems have effectively reduced pollutants including sediment, nutrients (nitrogen and phosphorus), certain heavy metals, and organics from surface water through adsorption, plant uptake, filtration, volatilization, precipitation, and microbial decomposition (EPA, 1993; Livingston and McCarron, 1992; Schueler et al., 1992). Pond/wetland systems can also be used to attenuate and desynchronize peak flow from storm events, which minimizes flooding, channel scour, and stream bank erosion (EPA, 1993).

Wetland designs vary in the amount of permanent shallow (≤2 feet) and deep (>2 feet) water provided. The functions and limitations for various wetland designs are presented in Center of Watershed Protection's (CWP) *Stormwater Management Fact Sheet, Stormwater Wetlands* (undated) and summarized below.

- Shallow marshes consist of a high portion of shallow water areas. They require a relatively large area compared to the drainage basin and do not provide runoff detention during storm events. Shallow marshes also require a larger base flow to maintain the larger area of wetland vegetation.
- Extended detention wetlands consist of shallow marshes with an above surface detention zone to accommodate runoff from storm events.
- Pond/wetland systems consist of two or more cells of varying shallow and deep water to reduce the amount of land required.
- Submerged gravel systems consist of subsurface water flow through a gravel media to increase treatment capacity. These systems are extensively used to treat municipal wastewaters that have constant loading and flow. They are not designed to handle increased flow associated with storm runoff.

The typical removal effectiveness for these wetland designs is presented in Table A-03. The pond/wetland system was included as the approach to manage storm water runoff at RFETS for this bounding scenario given the topography constraints and space availability within the drainages, need to accommodate run-off from large storm events (100-year, 6-hour), and to overcome base flow fluctuations that occur in semi-arid climates. Figure A-02 provides a conceptual depiction of a typical pond/wetland system that is used for storm water management. This figure is provided for illustrative purposes only and is not intended to represent the design that would be adopted for RFETS.

The effectiveness of a pond/wetland system is dependent on its proper design and maintenance. Relevant design criteria presented in Center of Watershed Protection's (CWP) *Stormwater Management Fact Sheet: Stormwater Wetland* (undated), EPA's *Storm Water Technology Fact Sheet: Storm Water Wetlands* (1999), and the UDFCD's *Urban Storm Drainage Criteria Manual, Volume 3* (1999) are summarized in the following sections.

3.1.1.1 Flow-Through Detention Ponds

For evaluation of this bounding scenario, the locations of existing terminal ponds (Ponds A-4, B-5, and C-2) are included as the locations of the flow-through detention ponds as indicated on Figure A-01. Currently, the terminal ponds are essentially mud flats with limit ecological value due to the batch release operation presently used for surface water management. As such, these terminal pond locations were chosen to minimize construction impacts to surrounding ecological resources. Should flow-through detention ponds be incorporated in the initial conceptual design, the adequacy and configuration of the existing terminal ponds would be assessed through application of the Pond Reconfiguration Strategy to determine if additional modifications to the existing structures are required and can be cost-effectively implemented.

The most significant hydraulic characteristics that affect gravity settling of suspended material in a pond system include detention time, inlet-outlet conditions, turbulence, and depth. The hydraulic characteristics of the flow-through detention ponds would be designed with adequate surface area, length, and depth to provide the required detention time for settlement. The surface area of a detention pond used for storm water control is typically 0.5 to 2 percent of the drainage basin (UDFCD, 1999). The pond inlet and outlet would be placed at opposite ends to minimize short-circuiting[1/]. The recommended minimum length to width ratio to prevent short-circuiting is 2:1 (EPA, 1999). If this ratio cannot be achieved, baffles, islands, and peninsulas can be included in the design to increase the flow travel distance.

The operating capacity of the pond would be designed to retain the excess volume of runoff resulting from the design storm event (100-year, 6-hour storm event). Additional freeboard (approximately 5 feet) would be provided to meet State of Colorado regulations contained in 2 CCR 402-1, Rule 5A(5)(b)(X).

Each pond would be equipped with an outlet structure designed to limit the discharge flow to allow sedimentation within the pond and to minimize sediment resuspension from the downstream portions of the drainage channel. The excess flow would be detained within the pond. With this type of design, discharge from the pond may occur for several hours or days after a storm event.

For illustrative purposes, Figure A-03 provides standard designs for an outlet structure from the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual, Volume 3* (1999) and a design adopted from the Soils Conservation Service *Engineering Field Handbook* (1992). These standard designs are only intended to depict the concept for a typical outlet structure. The actual details (including dimensions and materials of construction) would be developed during the design process taking into account the current configuration of outlet structures should the existing terminal ponds be suitable for converting to flow-through detention ponds. Materials of

1/ Short-circuiting is when runoff flows directly through the basin from the inlet to the outlet without being detained for the required time to allow settling.

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construction would be selected to provide long-term reliable and effective operations, facilitate maintenance or replacement, and minimize cost.

The outlet structure would be designed to maintain a minimum water depth using a vertical riser with flashboards or some other device. The wet operation of the pond would serve to minimize potential for short-circuiting, reduce potential for scour and sediment resuspension, and the airborne release of sediments due to drying. The ponds could incorporate an aquatic bench (a shallow shelf with wetland plants) around the edge of the pond, which would stabilize the pond bank, enhance habitats, add to the aesthetic appearance, and allow contaminant reduction by plant uptake.

The flashboard design is included in this bounding scenario description due to its operational flexibility, ease of replacing worn flashboards, and ease of increasing or decreasing the water level in the pond by adding or removing flashboards. Design enhancements such as using perforations or drilled holes in the flashboards or riser pipe to improve the sedimentation and retention characteristics of the pond would be considered during the initial conceptual design. A submerged inlet, reverse slope drain pipes to prevent clogging by floating debris would also be considered. Energy dissipation and erosion protection measures (such as riprap) on the downstream face of the discharge pipe would be incorporated into the design.

Under normal conditions, storm flow entering the detention pond would leave through the outlet structure. An emergency spillway would be provided, consistent with State of Colorado regulations, to allow peak flows from abnormal conditions to safely by-pass the outlet structure. The emergency spillway would be designed to preclude damage to the dam embankment due to erosion.

The detention pond could be lined with low-permeable soils to further reduce the likelihood of accumulated contaminants migrating into the underlying groundwater. However, infiltration through the pond bottom would tend to naturally decrease over time as fine soil particles settle and accumulate within the pond. However, infiltration rates could temporarily increase following the removal of sediments (if required) for maintenance.

3.1.1.2 Wetlands

In general, wetlands are characterized by the presence of surface or near-surface water that saturate the substrate long enough during the growing season to generate a reducing (oxygen-deficient) environment. These conditions limit the development of vegetation to those species that are specifically adapted to low-oxygen environments (GPO, undated – Volume 1). Studies and investigations performed by the AME Project Team indicate that Pu is not mobilized or disassociated under reducing conditions (Honeyman, 1999). As such, wetlands would not be expected to increase the mobility of actinide-bearing sediments that are captured within the wetland.

The potential remobilization of Pu due to the presence of humic and fulvic acids was investigated by the AME Project Team (Santschi 1999 and 2001). Both humic and fulvic acids could be released from decaying organic matter associated with wetland vegetation. Humic acids can impart a negative surface charge to particles and colloids, which can promote disaggregation and dispersion of aggregates, and thus, increased mobility and concentrations of colloidal species in surface waters. The experimental results of radiolabeled colloidal organic and inorganic matter extracted from RFETS soils revealed that colloidal Pu from sediment resuspension is mostly associated with organic (humic or fulvic acids) rather than the more abundant inorganic (iron oxide and clay) colloids (Santschi 2001). The investigation results indicate that Pu remobilization increases as a function of a) suspended particulate matter concentration, b) resuspension time, and c) humic acid (DOC) concentration (Santschi, 1999). Contact with humic acids only increases actinide enrichment in runoff by a fraction of a percent (Santschi, 1999).

On the other hand, large, surface-active, organic molecules such as exopolymeric acid polysaccharides from bacteria and algae, act to bind colloidal and particulate species together. Soil resuspension experiments conducted by Santschi (1999) revealed that the bacteria-derived acid polysaccharide Xanthen exhibited particle aggregation effects (e.g., strong filter clogging). Pu release from resuspended particles slightly decreased as a function of alginic acid (an excretion product of algae and bacteria) concentrations in the water. Experimental results indicate that these colloids could be removed within a pond/wetland environment.

Other key factors that influence the effectiveness of the wetland system include:

- Substrate,
- Vegetation and Habitat,
- Hydrology and Water Availability,
- Configuration and Geometry, and
- Sediment Resuspension.

The design criteria and information provided below is based on current technical data contained in published literature (CWP, undated; EPA, 1993; EPA, 1999; and GPO, undated – Volume 1) and previous project experience for wetland development projects that have been successfully completed within the Front Range and other Colorado locations.

Substrate

The substrate provides structural stability and nutrients for vegetation, and provides active exchange sites for adsorption of constituents like phosphorus and metals. Sandy, coarse-textured soils have a low potential for pollutant retention but little or no restriction on root growth. These soils hold plants well but are low in nutrients. Additions of organic matter to coarse textured soils have been shown to improve plant survival and growth during the first several years while the organic litter is beginning to build up within the wetland. Medium textured or loamy soils are a good choice, as these soils have high retention of pollutants and little restriction on plant growth. Loamy soils are especially good because they are soft and friable, allowing for easy rhizome and root penetration. Dense soils, such as clays and shales, should be avoided because they may inhibit root penetration, lack nutrients, and have low hydraulic conductivities. (GPO, undated – Volume 1).

Vegetation and Habitat

The primary goal for an effective wetland is to establish dense stands of vegetation for sediment filtration and reduction of flow velocity to allow sedimentation. The vegetation needs to be self-sustaining and hearty to withstand fluctuations in water supply, local seasonal climate changes, and storm flows without suffering permanent damage that would impede performance.

The secondary goal is to establish a diverse assemblage of plants, which is more resistance to invasive species/pests and tends to recover better after disturbance. Diverse assemblages also tend to attract a wider variety of wildlife and would be more aesthetically pleasing.

Wetland vegetation for the expanded areas and new sites would consist of predominant wetland species that are already present in the drainages. The use of native plant species would avoid negative impacts to nearby natural wetland areas. The native, local species are also well adapted to the local climate, soils, and surrounding plant and animal communities. The potential species that would be considered include broadleaf and narrowleaf cattail, coyote or sandbar willow, plains cottonwood, and softstem and hardstem bulrush. The specific types and amount of vegetation used would be further evaluated during the initial conceptual design based on detailed evaluation of water availability through the results of the Site-Wide Water Balance (SWWB) and consideration of secondary performance objectives such as maximizing Preble's mouse habitats or limiting runoff by maximizing evapotranspiration (ET).

Hydrology and Water Availability

The most important variables in designing a constructed wetland are the hydrology and the availability of a dependable water supply to compensate for ET and other losses. The wetland would be designed to accommodate climate extremes (floods and droughts) to the extent practicable. As long as the soil stays moist, most wetland vegetation can survive for dry periods without standing water extending up to approximately 2 months. Hence, the water balance should demonstrate that drying would not extend longer than 2 months. However, extended dry periods may alter the composition of the vegetation species. It is also noted that under State of Colorado water laws, replacement water equal to the ET losses may need to be provided to compensate downstream water users for any depletion of natural runoff from the Site.

The SWWB results would be used (when available) to ensure that an adequate and dependable amount of water available under average and dry year conditions is based on the following equation.

$$I + P + D + S > O + ET + R$$

where,

I = surface water inflow into the wetland
P = direct precipitation on the wetland
D = discharge/exfiltration of groundwater into the wetland
S = wetland storage at beginning of period
O = surface water outflow from the wetland
ET = evapotranspiration
R = recharge/infiltration from the wetland into groundwater

ET values vary widely. Technical literature[2/] for other sites located in the western United States was used to estimate the following ET design values for the major wetland and riparian communities prevalent at RFETS.

- Cattail-bulrush marsh: Approximately 50 inches per acre per year.
- Willow-cottonwood riparian area: Approximately 45 inches per acre per year.
- Wet meadow: Approximately 24 inches per acre per year.

Typically, wetlands are designed to intercept shallow groundwater to ensure sufficient base flow to ensure survival. The shallow groundwater should not be more than a maximum of 18 inches below the ground surface during the driest period of the year. As such, accurate groundwater level measurements could be obtained from candidate sites to assess their suitability. Usually, 12 to 24 months of monitoring information are adequate to identify seasonal fluctuations in groundwater depths. If the natural water supply were determined to be inadequate, then following options (in decreasing order of preference) would be considered:

- Seal wetlands below the vegetative substrate layer to provide water storage needed to support the wetland between storms,
- Eliminate or reduce the size of the wetlands.
- Use wetland vegetation with lower ET values.
- Discard wetlands as a component of the final land configuration to maintain compliance with surface water quality standards.
- Import offsite water to augment natural sources.

2/ Technical literature used includes: Bowie 1968; Burba, 1999; Chalk, 1979; Christiansen 1970; DeBano, 1989; Kadlec, 1988; Robinson, 1970; Eisenlohr 1972; Novitzki 1978 and 1982; and Shjeflo, 1968.

The wetlands would also be designed to avoid conditions that would allow unvegetated sediments to dry out and become airborne. With the use of outlet control structures and availability of a dependable water supply, sediments would remain either moist or saturated during the year. If the sediments were to become temporarily dried, the high plant-stem density (estimated to provide 85 to 95 percent vegetative ground cover) would significantly reduce the wind velocity at the sediment surface, thus decreasing the chance for airborne fugitive emissions.

Configuration and Geometry

The size and shape of the constructed wetland will influence the detention time, flow velocity, and removal effectiveness. The following factors would be considered:

- Water management techniques and controls would be designed to minimize operations and maintenance requirements.
- The bottom slope for standing-water wetlands would be relatively flat. The target slope for constructing new and enlarged standing-water wetlands is 0.5 percent. Areas with existing slopes up to 2.0 percent are considered potential locations based on local hydrologic regime, vegetation, and substrate stability. These areas would be excavated and appropriate dam embankments with outlet control structures would be constructed to obtain the desired configuration and design bottom slope for the wetland.
- Wetlands would consist of a mixture of emergent vegetation and unvegetated standing waters areas. The target distribution of open water to emergent vegetation ratio would be about 30 to 35 percent of each pond area as open standing water with the remaining 65 to 70 percent as dense emergent vegetation.
- The standing water areas would be about 2.5 to 3.0 feet deep to provide sedimentation and water storage to sustain vegetative growth. This water depth is also adequate to ensure transformation of nitrate if required. The outlet structures would be designed so that occasional seasonal adjustments of the water level can be made to ensure that the proper water depths are maintained and wetland vegetation has a sufficient water supply. The outlet structure would be similar to the structure used for the flow-through detention ponds describe in Section 3.1.1.2.
- A forebay could be constructed at the wetland inlet to dissipate the energy of the flowing water and to trap the larger, heavier sediments (sands and gravels) to minimize the amount of sediment accumulation within the vegetated area. Although finer particles would be carried into the wetland, removal of the sands and gravels in a forebay would extend the life of the wetland. Inclusion of a forebay would be considered for constructed wetlands that are not preceded by a flow-through detention pond.
- Water channels passing through wetland areas would be designed to route water in a circuitous path through the wetland to increase its effectiveness.

- The layout of the wetland would be integrated with the natural topography and landscape. The surface area of a storm water wetland is typically 3 to 5 percent of the drainage basin (CWP, undated).

Sediment Resuspension

Resuspension of accumulated sediments from the wetlands, especially during severe storm events, is a primary consideration in assessing the effectiveness of this scenario component. The features that effectively reduce the likelihood for sediment resuspension include:

- Providing a wide inlet channel that uniformly distributes flow across its width,
- Using strategically placed baffles and diversions, and
- Maintaining a high density of plant stems to decrease flow velocity and wave action.

The above features would be utilized to keep the water velocity within the wetland below the threshold force required to cause significant erosion of the sediments. In addition, the root system and its continued growth within the accumulated sediments serve to anchor the sediment in place.

Sediment resuspension from drainage channels is being investigated by the AME Project Team and included as a modeled component using the HEC-6T computer code. The parameters controlling sediment resuspension has been developed based on data compiled from other investigations being performed at Los Alamos (sediment suspension characteristics) and field observations/measurements (erodible depths and sediment activities) to provide reasonable modeling results. Similar techniques were applied to quantify sediment loading from the wetlands and were incorporated into the erosion and hydrology evaluation conducted for Scenario 1 (see Tab 3, Attachment B2). Additional field investigations could be conducted to develop Site-specific sediment loading factors for resuspension as a function of drainage channel characteristics and storm intensity/flow velocity (see Data GAP-020 and GAP-110).

3.1.1.3 Riparian Areas

Riparian areas may be developed in drainage channels where existing topography and water conditions would not be conducive to the development of standing-water wetlands. The riparian areas would be utilized to reduce flow velocity, provide filtering, stabilize the drainage channel, and enhance Preble's mouse habitats.

3.1.1.4 Check Dams

Check dams are typically used to slow water flows within drainages to prevent critical flow leading to extensive channel erosion. Figure A-04 provides the typical details for a check dam, which involves placing and anchoring rock riprap or other appropriate structure across the drainage channel. Check dams would be most effective to reduce sediment load and to stabilize drainage channels in ephemeral streams where the topography or other constraints hinder the construction of larger wetlands.

Based on observation of the South Interceptor Ditch (SID), check dams are considered effective in reducing sediment while providing conditions required to sustain wetlands. Surface water runoff is temporarily detained upgradient of each check dam, which facilitates sedimentation and encourages development of wetland vegetation (willows and cattails). The ponded surface water either evapotranspirates or infiltrates, which decreases the amount of runoff and sediment load flowing into Pond C-2.

3.1.2 Description of Scenario Components

For Scenario 1, runoff would be routed through existing, modified, or constructed ponds/wetlands within each drainage. The specific components included in this bounding scenario for the purpose of evaluation are presented in the following sections by drainage. The general locations of these components are presented in Figure A-01. These locations are subject to modification during the initial conceptual design. For example, the location for the wetlands may need to be modified if pre-construction groundwater level measurements indicate that a shallow groundwater source is not available at the identified locations. The use of existing ponds is also subject to change based on application of the Pond Reconfiguration Strategy to the initial conceptual design.

The location used for each scenario component was based on historical actinide loads, location of existing wetlands, and topography. Wetlands would be located immediately downstream or upstream of a flow-through detention pond to reduce flow velocities during intense storm events to encourage suspended sediment deposition. Under this configuration, the amount of wetlands would be increased by approximately 28 acres to the reported RFETS acreage of 193 acres for existing wetlands. A break down of the existing and enlarged/new wetlands by drainage is provided in Table A-04.

One objective of this bounding scenario is to achieve no net loss of existing wetlands or known Preble's mouse habitats that may be otherwise lost due to Site closure or construction activities. To the extent practicable, enlarged and new wetlands would be designed to maintain the current functionality of existing wetlands and provide terrain and vegetation that would enhance existing Preble's mouse habitats. It is assumed that 30% (or about 8 acres) of the 28 acres of wetlands to be added could be used to increase amount of desirable habitat areas available to the Preble's mouse. A break down of the potential additional Preble's mouse habitat by drainage is listed in Table A-04.

The estimated ET values (see Section 3.1.1.2) and acreage for the new and enlarged wetlands were used to determine the total annual additional water demand for each drainage. The assumed target ratios of cattail-bulrush marsh, willow-cottonwood riparian areas, and wet meadow that would be established in each drainage are listed in Table A-04. The predicted total additional water demand for each drainage to compensate ET losses for the new and enlarged wetlands is included on Table A-04. ET losses for existing wetlands are not included since the estimated amount of water available already accounts for the presence of these wetlands. Considering the estimated water availability for a dry year, ample water (on an annual basis) is expected to be available to support the new and enlarged wetlands in each drainage.

The specific locations chosen for wetlands development is dependent on the availability of water after Site closure to sustain the minimal amount of wetlands and riparian areas that are required to achieve the necessary retention and sedimentation functions. The new wetland areas would be excavated and designed to rely on existing groundwater and surface water sources. Wetland and riparian vegetation surrounding existing ponds would expand or contract in response to the future hydrologic regime and changes in soil moisture conditions.

The amount of runoff from RFETS after closure or under natural flow conditions was previously evaluated (ASI, 1991; DOE, 1991; and RMRS, 1999). The results of these studies were used to estimate an overall average unit rate for natural runoff from the Site. The expected annual unit runoff is estimated to be approximately 2 inches for an average year of precipitation and approximately 1 inch for a dry year (DOE, 1991). The expected average unit runoff value is consistent with historical flow gauging data for areas with minimal anthropogenic influences (interbasin water transfers, WWTP effluent, and impervious surfaces in the IA). However, the historical gauging data indicates that annual unit runoff during dry years could be significantly less than 1 inch across a majority of the Site.

Based on these estimates and the acreage associated with anticipated configuration of the drainage basins after closure (including future operation of McKay and Smart Ditches), the expected amount of runoff for average and dry years at various locations is presented in Table A-04. Although the calculated amount of runoff is based on using a Site-wide average unit runoff, the historical gauging data indicates that runoff from certain portions of the drainages may be significantly higher due to the presence of seeps and significantly lower where seepage is not typically observed.

For example, the average unit runoff for Antelope Springs as measured at GS16 is approximately 6.7 inches. Progressing further down Woman Creek, the average unit runoff decreases to 2.1 inches just upstream of Pond C-1 as measured at GS17 and 1.4 inches at the confluence of Woman Creek and the discharge from Pond C-2 as measured at GS14. The average unit runoff for the combine flow for Woman Creek (GS01) and Mower Ditch (GS02) is 1.9 inches. These values show the variability of water supply within various locations along Woman Creek.

For Walnut Creek, natural water availability is more difficult to assess with higher runoff amounts from IA and WWTP effluent discharge. The annual average unit runoff for North Walnut Creek as measured at SW093 is approximately 9.0 inches based on historical gauging data. Seepage areas are present in North Walnut Creek just west of the IA and likely contribute to a significant portion of this flow. The flow of water from these seeps should not be diminished by Site closure. The annual average unit runoff for flow into South Walnut as measured at GS10 is approximately 6.7 inches. However, all the flow originates from the IA and could be greatly reduced after closure.

It is noted that a more detailed hydrologic and water balance study will be completed by the SWWB Project Team during FY 2002. If wetland components are included in the initial conceptual design, findings from the SWWB will be used to verify the predicted amount of water supply available in each drainage. In addition, site-specific groundwater elevation information could be collected for a minimum of 1 year prior to starting construction to determine the adequacy of the identified locations and to establish individual wetland specifications during detailed design.

3.1.2.1 North Walnut Creek Components

For developing this bounding scenario, the present locations of Ponds A-1, A-2, and A-3 were used with the following modifications to allow passive flow-through and to accommodate the establishment of both emergent wetland and standing water areas.

- The bypasses around Ponds A-1 and A-2 would be removed to allow cascaded flow through these two ponds.
- The outlet structure, emergency spillway, and/or dam embankment would be modified to allow passive flow-through and to reduce its water storage capacity.
- The wetland system would be designed to handle the peak flow from a 100-year, 6-hour storm event.
- Open water within the ponds would be designed for fixed depth of 2 to 3 feet.

For evaluating and predicting the performance of this scenario using WEPP/HEC-6T computer codes, it is assumed that Ponds A-1, A-2, and A-3 are filled to capacity at the start of the storm event and that all runoff would flow out of the pond through the outlet structure and spillway. The sizing information presented in Table A-05 was adopted to define the reconfiguration of these ponds for evaluation.

Pond A-4 would be utilized as large-capacity, flow-through detention pond with a passive outlet structure designed to restrict the discharge flow as specified in Section 3.1.1.1 to achieve the desired settlement. The adequacy of Pond A-4 to provide the required storage volume and settling characteristics would be evaluated during the design phase. The feasibility of modifying this terminal pond would also be considered if the existing configuration is not adequate. The data for Pond A-4 presented in Table A-05 was adopted to evaluate this scenario.

One new wetland (NWC-01) would be added upstream of Pond A-4 to reduce the velocity and disperse the flow during intense storm events, thereby minimizing resuspension of accumulated sediments. The new wetland area would encompass approximately 2.1 acres with a length of 450 feet and width of 200 feet.

3.1.2.2 South Walnut Creek Components

South Walnut Creek is unique in developing and sustaining wetlands. Although the existing B-series ponds current support a vast network of wetlands, much of the wetlands may be dependent on supplemental water sources (including increased runoff from the

IA, water transfers into Pond B-1, WWTP effluent discharge into Pond B-3) for their survival. With the elimination of these supplemental water sources resulting from Site closure, the ability to maintain these existing wetlands is questionable. Constructing new wetlands or reconfiguring existing wetlands in South Walnut Creek may be further hindered by the following conditions:

- Mass wasting into the wetlands due to the steep and unstable side slopes present in the South Walnut Creek drainage.
- Compromising the integrity of the dam embankments for Ponds B-1, B-2, and B-3 if the planned sediment removal activities increase infiltration rates and subsurface flow under the dam embankment.
- Altering of hydrologic characteristics of South Walnut Creek resulting from the installation and operation of East Trenches Plume System.

Based on the above considerations, an alternate method of controlling runoff in South Walnut Creek using check dams was included as a scenario component to determine its potential benefits and consequences. The existing Ponds B-1, B-2, B-3, and B-4 would be breached and replaced with check dams. These check dams would be similar in design to those presently located in the SID and would be designed to locally retain runoff and sediment within the drainage channel. For evaluation of this scenario, check dams with a height of 6 feet at 300-foot intervals would be used between the North Perimeter Road and Pond B-5. Development of wetland vegetation due to locally ponded water behind the check dams would be in equilibrium with available water supply. As such, the water supply at the check dams that are further downstream in the drainage channel may not be adequate to support wetland vegetation.

If the evaluation results indicate that check dams are effective in achieving these objectives, this component would be considered for application in the South Walnut Creek and other drainages during development of the initial conceptual design. Should this scenario component be included as a design component, the height and spacing interval would be refined considering channel configuration and the evaluation results for this bounding scenario.

Pond B-5 would be utilized as large-capacity, flow-through detention pond with a passive outlet structure designed to restrict the discharge flow as specified in Section 3.1.1.1 to achieve the desired settlement. The adequacy of Pond B-5 to provide the required storage volume and settling characteristics would be evaluated during the initial conceptual design. The feasibility of modifying this terminal pond would also be considered if the existing configuration is not adequate. The data for the existing pond presented in Table A-05 was adopted to evaluate this scenario.

The existing wetland on South Walnut Creek located just upstream of the confluence with North Walnut Creek would be enlarged to increase the sediment retention capacities downstream of the flow-through detention pond, especially during peak flows resulting from large storm events. The enlarged wetland area would encompass approximately 1.4 acres with a length of 600 feet and width of 100 feet. The enlargement (designated SWC-01) would be designed to avoid or minimize adverse changes to existing wetlands.

3.1.2.3 Walnut Creek Components

A new wetland / riparian area (designated WAC-01) would be located on Walnut Creek just downstream of the confluence between North and South Walnut Creeks. This new wetland would be designed to decrease the potential to resuspend actinide-bearing sediments that may be presence within Walnut Creek. The new wetland area would encompass approximately 6.4 acres with a length of 1,400 feet and width of 200 feet. Extending the new wetland further downstream towards the east was not included in this scenario because this area is known Preble's mouse habitat.

3.1.2.4 South Interceptor Ditch Components

The flow from the South Interceptor Ditch (SID) and Woman Creek would be combined and controlled via Pond C-2, which would be converted to a flow-through detention pond. Although the SID is not an integral component of this scenario, it would not be removed. However, long-term maintenance of the ditch would not be provided and the ditch would be allowed to fill-in naturally over time.

3.1.2.5 Woman Creek Components

For evaluation of this scenario, Pond C-1 was included, but modified to allow passive flow-through (subject to the findings of the Pond Reconfiguration Strategy). The sizing information presented in Table A-05 was adopted to define the configuration of this pond for evaluation.

Pond C-2 would be utilized as large-capacity, flow-through detention pond to handle the combined runoff from Woman Creek and the SID. A passive outlet structure designed to restrict the discharge flow as specified in Section 3.1.1.1 would be provided to achieve the desired settlement. The adequacy of Pond C-2 to provide the required storage volume and settling characteristics would be evaluated during the initial conceptual design. The feasibility of modifying this terminal pond would also be considered if the existing configuration is not adequate. The data for the existing pond as presented in Table A-05 was adopted to evaluate this scenario.

The existing wetland located just upstream of Pond C-2 would be enlarged to increase the sediment retention capacities and reduce the flow velocity into Pond C-2, especially during peak flows resulting from large storm events. The enlargement (designated WOC-01) would encompass approximately 3.0 acres with a length of 605 feet and width of 200 feet.

A new "off-channel" wetland (designated WOC-02) would be located on Woman Creek just downstream of Pond C-2. This new wetland would be designed to increase the sediment retention capacities within Woman Creek, especially during peak flows resulting from large storm events. The new wetland area would encompass approximately 15.2 acres with a length of 1,100 feet and width of 600 feet.

Excess water flow from Woman Creek would be diverted around Pond C-2 via the existing Woman Creek Diversion Ditch into the new wetland WOC-02. Either the existing Woman Creek Diversion Dam would be modified and/or a new diversion structure would be constructed at the entrance of the Woman Creek Diversion Ditch to direct primary runoff into Pond C-2 with an overflow spillway to allow excessive storm flow to be diverted to WOC-02. In addition, the existing Pond C-2 spillway would be modified and a new spillway constructed to allow the overflow from Pond C-2 to enter into the Woman Creek Diversion Ditch upstream of WOC-02.

Wetland WOC-02 would be excavated to intercept shallow groundwater to provide the required water supply to sustain the wetland vegetation. Water levels measurements as discussed in Section 3.1.1.2 would need to be collected to verify that the shallow groundwater supply is adequate. If the groundwater is determine not to be adequate, then the new Woman Creek diversion structure would be designed to allow base flow into the Woman Creek Diversion Ditch to sustain the wetland. The outlet flow wetland WOC-02 would flow back into Woman Creek downstream of Pond C-2. Riprap would be provided at the confluence between the wetland outlet channel and Woman Creek.

3.1.3 Construction Considerations

This section presents the construction considerations for the various components included in this bounding scenario.

3.1.3.1 General Considerations

The requirements of both Sections 401 (water quality certification) and 404 (wetlands) of the Clean Water Act may need to be considered for constructing the detention basins within the drainages. Construction activities would be conducted in such a manner to avoid impacting existing wetlands, riparian areas, or Preble's mouse habitats. Temporary construction barriers would be used to delineate areas to be avoided by machinery.

The temporary erosion controls used to preclude soil erosion from construction activities may need to fairly extensive and well maintained to minimize disturbance and resuspension of actinide-bearing sediments that my be present in the drainage channels. Construction haul roads would be located to avoid crossing existing drainage channels. Standard construction provisions for dust control would be required.

3.1.3.2 Flow-Through Detention Ponds

Design, planning, and review activities would take about 6 months. The duration for construction would depend on whether the existing ponds can be used and the extent of any required modifications or whether new ponds would need to be constructed.

If the existing Ponds A-4, B-5, and C-2 are suitable and only minor modifications to the outlet structure, conversion of the ponds to flow-through could be completed in one construction season. Modification of the outlet structure would require the pond to be drained and may require some disturbance of existing pond bottom sediments or dam embankment. Temporary diversion of runoff and phasing of the construction activities by terminal pond may be required to facilitate on-going water management activities.

3.1.3.3 Wetlands and Riparian Areas

Final site selection could require at least one year of water level measurements. Design, planning, and review activities would take about 6 months. The duration of construction activities would depend on the final determination of the location and size of the constructed wetlands. Given the identified wetland locations and sizes for this bounding scenario, the wetland would become fully functional (with established vegetation meeting designed performance exceptions) within 2 to 5 years after the initial construction has commenced based on previous project experience of constructing wetlands in the Front Range. The time required to fully establish a wetland is dependent on availability of an adequate and dependable water supply, proper water level adjustment, and avoidance of other adverse events such as damage due to flooding. The performance of the constructed wetlands to remove and retain sediments will generally increase over the initial start-up period as the plant stem density increases. During this interim period, phasing in reconfiguration of the existing ponds and/or maintaining the current batch release mode of operation may be required to maintain compliance with surface water quality standards. As such, establishment of the new and enlarged wetlands may need to be initiated in advance of final Site closure. The general sequence for the construction activities is as follows:

- The wetland sites would be excavated and graded to provide the desired configuration and bottom slopes and the earthen embankments and water control structures would be constructed.
- Plant wetland vegetation.
- Maintain and adjust water level for at least two years after planting to establish vegetative growth.

Additional details for each phase of construction are provided below.

Wetland Site Preparation

Elevations must be accurately established to maintain proper hydraulic configuration and the substrate must be properly prepared. Construction in drainages also requires strict procedures and precautions to prevent damage to ecological resources. Because of these unique considerations, an experienced contractor should be used to prepare the wetland sites.

It is estimated that approximately 96,600 cubic yards of soil would need to be excavated to provide the appropriate basin and depths for the five constructed wetlands. The actual quantities are dependent on depths required to intercept shallow groundwater and application of the Pond Reconfiguration Strategy. Approximately 26,000 cubic yards of the surplus soils could be used to fill/level Pond A-2 to obtain a higher value wetland by creating a shallower pond with more uniform depths. The remaining excess soil could be used for final grading of the IA. The cut and fill values presented above do not include breaching dams B-1, B-2, B-3, and B-4 and reducing the height of Pond A-3. A more refined cut/fill balance would be developed during the initial conceptual design.

Initial Wetland Planting

Seeds, seedlings, entire plants, or parts of plants (rhizomes, rootstocks, tubers, or cuttings) can be used to establish wetland vegetation. Using rhizomes, rootstocks, or tubers is typically used to generate new plants. While many wetland plants produce wind-borne seeds, spread of vegetation by stolons and runners is more common since seeds generally will not sprout under water. The flowing techniques can be used to establish wetland plants.

- The most effective technique is the use of nursery stock as dormant rhizomes, live potted plants, or bare rootstock. On-site nurseries could be established in advance of the initial planting to cultivate the required plants for the project. Row planting should be conducted so that the rows run perpendicular to the direction of flow. The plants in each successive row should be offset to improve coverage and reduce channeling while the vegetation is filling in. Planting individual species in groups or clumps rather than being evenly distributed could provide a more natural appearance and improved plant survival (GPO, undated – Volume 5).
- Sediment and plant material from an existing wetland (known as "wetland mulch") could also be used to accelerate colonization of the constructed wetlands with the seed bank from the original wetland. This method can help to enhance diversity of the new wetland, but may carry forward wanted species or establish a mix of vegetation that is not consistent with the design specifications.
- The least expensive option is to allow the constructed wetland to colonize itself if an ample existing seed source is available in the drainage. One disadvantage to this last technique is that invasive species such as cattails or Phragmites may dominate the wetland and a longer period may be required of its establishment.

Wetland Vegetation Establishment

Maintaining an appropriate water level is the most critical aspect of plant survival during the first year after the initial planting. When the initial planting has been completed, the substrate should be saturated, but not flooded. After new growth has reached approximately 5 inches, the water level can be raised. The water must not overtop the plants for extended periods or the plants could die. Wetland vegetation should be fully established within two or three growing seasons (GPO, undated – Volume 1).

3.1.3.4 Check Dams

Special construction provisions for the check dams are not required. The design, planning, and review activities would be concurrent with other scenario components and be scheduled as part of pond reconfiguration tasks. The check dams could be installed in less than one construction season (1 to 2 months).

3.1.4 Operational and Maintenance Considerations

The flow-through detention ponds, wetlands, and check dams would be designed for unattendant, passive operations. However, periodic inspection and maintenance would be required to ensure that the scenario components are performing correctly. If a storm water pond system evolves into a wetland status, then Section 404 permits of the Clean Water Act may be required to conduct any future maintenance activities.

Long-term monitoring data indicates that removal effectiveness does not decrease as long as loadings are reasonable and the wetland system is well designed, constructed, and maintained (GPO, undated – Volume 1). However, some other long-term monitoring data indicates that deterioration of components over time can significantly decrease the overall performance of a wetland system (CWP, updated – Article 88). While the removal rate for the pond component also declined over time, the reduction was not as significant as the wetland system. When hydrologic changes or sediment loads exceed the natural assimilative capacity of these systems, wetland and riparian areas may become stressed, degraded, or destroyed. Therefore, wetlands and riparian areas should be protected from changes that would degrade their existing functions. Degraded wetland can deliver increased amounts of sediment, nutrients, and other pollutants to the receiving stream if not properly maintained.

The major operational and maintenance activities that would be required for the various components are listed in Table A-06. Some of these items are addressed in further detail below. Operations and maintenance requirements for other remediation systems (groundwater plume systems and ET covers), monitoring environmental media (groundwater, soils, and air), and Site maintenance (roads and other facilities) are not presented.

- Water level management is the key to maintaining wetland vegetation. While wetland plants can tolerate temporary changes in water depth, care should be taken not to exceed the tolerance limits of desired species for extended periods. Large water level fluctuations have been shown to decrease specie diversity (GPO, undated – Volume 5). During the first three years after construction, the water level should be checked and adjusted until it becomes stabilized at optimal levels (GPO, undated – Volume 5).
- As sediment builds-up in the wetland, the self-sustaining vegetative cover would continue to grow on top of the sediment so long as the appropriate soil saturation conditions are maintained. Wetlands that have been constructed for other projects within the Front Range have been able to recover and grow through sediment deposits after being buried by erosion from a severe storm event within one growing season. As such, excavation of accumulated sediments from wetlands would not normally be required. However, if soil saturation cannot be maintained or if the depth to groundwater becomes to great to sustain wetland vegetation, removal of sediments and re-establishment of the wetland vegetation may be required.

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- If the wetlands are used to facilitate reduction of nitrate or other parameter concentrations, additional maintenance (such as plant harvesting) could be required. The permanent pool depth of standing-water areas within the wetlands or flow-through detention ponds that are used as primary areas for nitrate transformation would need to be maintained between to 2.5 and 3.0 feet throughout the year. The water depth would be adjusted by raising or lowering the elevation of the flashboards at the outlet structure, as long as the impoundment has adequate freeboard. As such, excavation of accumulated sediments from deep standing-water areas would not be required or infrequently required.
- Frequent mowing of the embankment encourages grasses to develop a good ground cover with extensive root systems that resist erosion, and prevents shrubs and trees from becoming established. The roots of shrubs and trees that can create channels and cause subsequent leakage through the embankment should be removed.
- Periodic removal of debris, sediment, and vegetative growth (trees) would be required to extend the longevity of the check dams. A 1993 investigation of McKay Ditch by E. Mangeot indicates that all but two of the 26 rock check dams were damaged and eroded during a large storm that occurred in May 1981. The damage was likely caused by the accumulation of vegetation and debris depositing on the upstream face of the dams resulting in clogging and build-up of head that evenly caused the rock riprap to wash out. The riprap may have also been undersized to handle the resulting peak velocity. This investigation suggests that unmaintained check dams may be subject to failure and using check dams to encourage wetland vegetative growth could become a detriment to the structure.

3.1.5 Construction and Operating Cost

This section presents the information used to estimate the cost for constructing and operating the various components included in this bounding scenario. Historical unit costs were adjusted for inflation where appropriate. If the existing terminal ponds (Ponds A-4, B-5, and C-2) can be converted to flow-through detention ponds, the construction cost is estimated to be between $2.3 million and $3.5 million. If new flow-through detention ponds are required, the construction cost is estimated to be between $5.3 million and $8.2 million. The annual O&M cost (without provisions for surface water monitoring at the POCs) is estimated to be $275,000, which includes a 20% allowance for management, record keeping, and reporting. Additional details for the construction and operating cost estimates are provided below.

Flow-Through Detention Ponds

If new flow-through ponds are required, the estimated construction cost is $3.5 million based on using the cost information for wet detention basins presented in Section 3.2.5, the existing pond capacities provided in Table A-05, and inflation rate of 3%. The added cost for fully breaching the existing terminal ponds (Ponds A-4, B-5, and C-2) is estimated to be approximately $1.8 million. The cost for constructing new flow-through detention ponds does not include importing offsite fill material.

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However, it is likely that the existing terminal ponds (Ponds A-4, B-5, and C-2) would be adequate for use as flow-through detention ponds. The outlet structures and emergency spillways of these existing ponds may need to be modified to accommodate passive flow-through operations. Inlet flow spreaders and energy dissapators would also be added to each pond. The outlet structures of Ponds A-4 and B-5 were previously modified to install manual slide gate valves at the inlet of the discharge (within the pond) for passive gravity drainage. The outlet works of Pond C-2 has not been modified and the control valve is located at the outlet of the discharge pipe (downstream of the embankment). As such, a pump is currently used to empty Pond C-2. Actual expenditures to upgrade Ponds A-4 and B-5 was requested, but not provided. In the absence of actual cost data, it is assumed that upgrade cost would be approximately $500,000, which is based on taking 10% of the new construction cost for Ponds A-4 and B-5, and 25% for Pond C-2.

The annual operation and maintenance for the flow-through detention ponds is estimated to be approximately $172,000 based on using 5% of the total constructed value for new detention ponds.

Constructed Wetlands

Construction cost (including field surveying and staking, clearing, grubbing, temporary erosion controls, excavating, grading and planting) for an emergent wetland with a sediment forebay range from $26,000 to $55,000 per acre with permitting, design and contingency costs are estimated at 25 percent of total construction cost (EPA, 1999). Using the above cost information, the constructed cost for the 28.1 acres of constructed wetlands is estimated to be between approximately $0.9 million and $2 million.

Maintenance costs for wetlands is estimated to be approximately $40,000 based on using 2 percent per year of the construction cost provided in literature published by the Center of Watershed Protection (1997).

Check Dams

Construction cost for check dams is estimated to be $275 per cubic yard of placed material based on previous project experience. Using a check dam slope of 2:1 with a height of 6 feet and estimated average width of 40 to 50 feet, it is estimated that installing the 9 check dams (spacing of 300 foot) would cost approximately $360,000.

Maintenance costs for the check dams is estimated to be approximately $18,000 based on using 5 percent per year of the construction cost.

Existing Pond Modifications

The construction cost to modify the existing Ponds A-1, A-2, A-3, and C-1 and fully breaching existing Ponds B-1, B-2, B-3, and B-4 as identified on Table A-05 is estimated to be $625,000. The breaching of the B-series ponds includes removal of the embankment, rough grading of pond sediments, and revegetation. Removal and disposal of pond sediments is not included.

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3.2 Scenario 2 – Detention Basins

This bounding scenario utilizes detention basins to capture and retain all runoff for gravity settlement. Samples of the accumulated storm water would be collected and analyzed. The accumulated water would be batch-discharged into the downstream drainage channel if the analytical results verify that the water is of acceptable quality. The distinguishing characteristics of this bounding scenario that achieve the FDOs include:

- Utilizing large capacity detention basins and administrative controls to provide a high degree of reliability to maintain compliance with surface water quality standards for a wide range of storm events and erosion loads.
- Manual batch release and control of the discharge flow from the detention basins to reduce the potential for downstream flooding and associated channel erosion (including resuspension of actinide-bearing sediments).

The scenario components and information presented in this description are preliminary and would be refined during the design process if detention basins were included as a design component. The components and locations included in this bounding scenario are shown on Figure A-05. These preliminary locations were developed only to allow evaluation of this bounding scenario. Should any scenario component be included as a design component, the preliminary locations (including use of existing ponds/dams) would be further evaluated and refined during the design process.

3.2.1 Design Functions and Considerations

This bounding scenario has the least amount of components consisting only of large capacity detention basins to retain runoff for gravity settlement prior to release. The detention basins would be formed by constructing aboveground earthen embankments across the drainage. Although this bounding scenario is the simplest to describe, it utilizes administrative and operation controls that are more extensive than the other bounding scenarios.

The two types of detention basins regularly used for storm water management are wet and dry ponds. Wet ponds are detention basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Dry detention ponds function similar a wet pond, but would not have a permanent pool. The typical removal effectiveness for these detention basins is presented in Table A-07.

Wet ponds are more effective in removing sediments and nutrients from storm water and, therefore, were used as the design basis for the detention basins. Wet ponds are more effective than dry ponds because the permanent pond:

- Reduces souring of the pond bottom leading to resuspension of sediments,
- Provides conditions to sustain increased biological activity (algal) for nutrient reduction, and

- Increases retention time thus allowing additional sedimentation and nutrient reduction to occur.

A typical design concept for a wet pond type detention basin is provided as Figure A-06. As shown in Table A-07, there is considerable variability in the effectiveness of wet ponds. This variation is likely related to proper design and maintenance. Relevant design criteria presented in Center of Watershed Protection's (CWP) *Stormwater Management Fact Sheet: Wet Pond* (undated), EPA's *Storm Water Technology Fact Sheet: Wet Detention Ponds* (1999d), and the UDFCD's *Urban Storm Drainage Criteria Manual, Volume 3* (1999) are summarized below.

Wet Pond Capacity / Permanent Pond Considerations

The key design factors affecting the removal effectiveness is the length of time that runoff remains in the pond also known as Hydraulic Residence Time (HRT). The amount of removal through both sedimentation and biological uptake processes increase with HRT. Solids settling and eutrophication modeling methods are available to determine a design HRT (Hartigan, 1988).

Studies have shown that more than 90 percent of the removal occurs during the quiescent period (the period between the rainfall events) (MD DEQ, 1986). The retention time and removal effectiveness between storm events increases as a function of the permanent pool volume (V_P) to average storm runoff (V_R) ratio. Small V_P/V_R ratios generally result in poor removal effectiveness. The ratio between the contributing drainage area (A) and the permanent pool surface area (A_S) is another indicator of removal effectiveness. Data from previous studies indicates that an area ratio (A/A_S) less than 100 is typically more effective (MD DEQ, 1986).

EPA recommends that wet ponds be designed with a length to width ratio of at least 2:1 to prevent short-circuiting (1999d). Short-circuiting occurs when runoff entering a detention basin flows directly through the facility from the inlet to the outlet without being detained for the designed period. However, short-circuiting for batch release operations is not a concern because continuous flow through the detention basin would not normally occur during the storm event.

Maintaining a sufficient permanent pool depth is important to prevent the resuspension of trapped sediments. The optimal depth for the permanent pool ranges between 3 and 9 feet for most regions, given a 2-week HRT (Hartigan, 1988). To maintain the permanent pool, adequate base flow is required from either groundwater seeps and/or runoff from the drainage area. In semi-arid regions, detention basins should be designed to accommodate a variable permanent pool level that can have a 3-foot draw down during the dry season (CWP, updated – Article 66). Infiltration from the detention basin into the underlying groundwater needs to be considered to maintain the permanent pool especially during the dry months. Typically, underlying soils with permeabilities of between 10^{-5} and 10^{-6} cm/sec are adequate to maintain a permanent pool (EPA, 1999d).

Runoff would be detained above the permanent pool and batch released when required. The detention basins would be sized to provide storage for the permanent pool, design storm event (100-year, 6-hour), and realistic pre- and post-event storm event flow to accommodate sample collection and analysis without overtopping the basin. The pre-/post-event detention volume is defined as the maximum runoff that occurred from 1993 to 1998 over a 30-day period.[RLS9] The detention basin bottom would be excavated to provide additional capacity for sediment accumulation over a 25-year period.

Maintaining permanent vegetation between the permanent pond and pre-event detention elevations is unlikely due to the fluctuating water level that would regularly occur over this zone. As such, the detention basins would provide low quality wetlands and would not be a favorable habitat for the Preble's mouse.

Forebay

Many wet ponds are designed with a forebay[3/] to settle out coarse sediment particles before they reach the main pool. Although sediment removal from the forebay may be required on a frequent basis (5 to 7 years), the interval between sediment removals from the permanent pool may be extended well beyond the 25-year design capacity. In addition, the forebay would limit frequent sediment clean-outs to a smaller area.

Earthen Embankment

The earthen embankment would be designed per State of Colorado Dam Safety Regulations (see 2 CCR 402-1) to provide wet retention capabilities for long durations. As such, an infiltration collection system would be constructed in and beneath the dam to collect seepage into the embankment. The collection system would be designed to prevent seepage flow through the dam and associated outlet structure that could cause erosion resulting in structural failure of the embankment. Additional freeboard (approximately 5 feet) would be provided to meet State of Colorado regulations contained in 2 CCR 402-1, Rule 5A(5)(b)(X).

To provide a stable and maintainable embankment, the minimum width of the dam crest would be 15 feet and the slopes of the embankment (both upstream and downstream faces) would no steeper than 3H:1V. The embankment would be design with appropriate armoring to withstand the affects of soil erosion and geomorphic activity during low water storage levels and during the maximum storage level. The downstream face of the embankment would be vegetated with native grasses and the upstream face would be lined with riprap designed to withstand wave action.

Inlet Structure

Inlet structures consisting of an energy dissipater and a flow spreader would be provided to minimize disturbance of bottom sediments to prevent re-suspension by maintaining inflow that has a shallow depth and low velocity.

3/ Forebays are a separate deep-water pool (typically about 10% of the volume of the permanent pool) located near the pond inlet.

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Outlet Structure

The accumulated runoff would be normally discharged through an outlet structure consisting of a vertical riser and a discharge pipe that conveys the discharged water through the embankment. A slide gate valve would be provided at the inlet to the discharge pipe (upstream of the dam embankment) to allow manual release of the retained runoff. To increase the life of the outlet, the riser and discharge pipe would be constructed of reinforced concrete rather than corrugated metal pipe.

The riser would be anchored to a concrete foundation to prevent floatation and to provide structural support. Risers are typically located in or adjacent to the embankment to allow access for maintenance. The riser would be designed with a reverse-slope pipe or a weir outlet with a trash rack to present clogging. Reverse-slope pipes are less likely to be clogged by floating debris because they draws water from below the permanent pool surface. The invert elevation where the reverse slope pipe connects to the riser establishes the water elevation of the permanent pool. If orifices are used to control the peak discharge flow, they would be greater than 3 inches in diameter to minimize the potential for clogging.

The discharge pipe would be equipped with an anti-seep collar to prevent formation of an erosion cavity along the length of the discharge pipe that could result in failure of the embankment. Energy dissipation and erosion protection measures would be provided at the discharge pipe outlet to prevent scour and undercutting.

Emergency Spillway

In addition to the outlet structure, a separate emergency spillway would be provided to safely convey flows from abnormal events that exceed the storage capacity of the detention basin. The emergency spillway would be designed per State of Colorado regulations to safely pass the excess overflow without causing erosion of the dam embankment. The invert elevation of the emergency spillway would be set at the water surface elevation at the maximum storage level. The spillway channel would be appropriately stabilized, lined, or armored to prevent scour.

3.2.2 Description of Scenario Components

For developing this bounding scenario, two new detention basins are included as shown in Figure A-05. One detention basin is located on Walnut Creek just downstream of existing Ponds A-4 and B-5 to retain flow from North Walnut Creek, South Walnut Creek, and No Name Gulch. The other detention basin is located on Woman Creek near Pond C-2 to retain the combined flow of the SID and Woman Creek. The specific locations used for the detention basins were based on the following considerations:

- Provide detention of all runoff originating from the IA and other potential sources of actinide-bearing surface soils,
- Minimize the amount of storage necessary to retain the design inflow,

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- Utilize existing topography to reduce the amount of fill required to construct the earthen embankment,
- Avoid areas with active geomorphology including locations susceptible to mass wasting, unstable hillside, groundwater seepage, and high erosion areas.
- Allow construction of the new basin while maintaining current operations, and
- Minimize disruption to known wetlands and Preble's mouse habitats.

The locations for the detention basins are considered preliminary and would be subject to change during the initial conceptual design if detention basins are included as a design component. In addition to inclusive of the two new detention basins, the existing ponds would be beached as a conservative assumption for evaluating the scenario components. The actual fate of the existing ponds would be determined during the initial conceptual design by applying the Pond Reconfiguration Strategy.

New detention basins were included in this bounding scenario because the long-term integrity of the existing dam structures to provide continuous wet pond operations is questionable. The new detention basins would also reduce the long-term stewardship requirements that would be required if all of the existing ponds were included in their current configuration. The adequacy for the existing ponds to fulfill the long-term detention requirements of this bounding scenario would be further evaluated during the initial conceptual design by applying the Pond Reconfiguration Strategy. The existing ponds would be modified in lieu of constructing new detention basins if cost-effective.

3.2.2.1 Walnut Creek Components

Figure A-07 provides a plan view for the Walnut Creek detention basin. This figure shows the general location of the earthen embankment and the maximum area inundated by the retained runoff.

An exceedence of the surface water quality standard occurred at monitoring location GSO3 (Walnut Creek at Indiana Street) in June 1997. An investigation into the cause of this exceedence was conducted and the results of the investigation are documented in the corresponding Source Evaluation Report (DOE, 1998a). This investigation was unable to identify a specific source that caused the exceedence and concluded that the likely cause of the exceedence is the presence of legacy-contaminated sediments due to the historical operations of RFETS. It is postulated that legacy-contaminated sediments are present between the outfalls of the existing terminal ponds (A-4 and B-5) and GS03. Although this exceedence occurred at GS03 and there is a potential for legacy-contaminated sediments to be present in the lower portion of Walnut Creek, the detention basin was not placed closer to Indiana Street for the following reasons:

- Since the 1997 exceedence, water quality at GS03 has been consistently below the surface water quality standards and remediation efforts within the IA should continue to reduce loading and potential for exceedences at this location.
- Locating the detention basin closer to Indiana Street would have significant impacts to known Preble's mouse habitats.Controlling the discharge flow during

batch release should minimize resuspension of actinide-bearing sediments that is located within the drainage channel.The exceedence occurred during low flow when transport of channel sediments should not occur and the sample volume associated with the exceeded was below "Not Sufficient Quantity" requirements.

The identification of a definitive source of the exceedence at GS03 is considered a data gap that would be further assessed by ongoing surface water monitoring. The final location for the Walnut Creek detention basin would be dependent on these future monitoring results, as well as, the conclusions from the Pathway Report under development by the AME Project Team.

The Walnut Creek detention basin would be constructed to store approximately 416 acre-feet of water. Approximately 186 acre-feet[4/] of this total storage would be dedicated to detaining runoff from a 100-year, 6-hour storm event while the remaining 230 acre-feet[5/] of storage would be available to manage and detain normal pre-and post-event runoff and maintaining the permanent pool. The water surface area at the maximum storage level would be approximately 28.4 acres. The final sizing of the detention capacity would be determined during the initial conceptual design should this scenario component be included as a design component.

The bottom of the detention basin would be excavated to provide space for sediment storage. The quantity of material excavated from the detention basin would be approximately 3,350 cubic yards (2 acre-feet), which corresponds to the estimated amount of sediment expected to accumulate over a 25-year period[6/].

The maximum height of the earthen embankment would be approximately 42 feet. Using a dam crest width of 15 feet and a 3H:1V slope for the upstream and downstream faces, the maximum base width of the dam would be approximately 270 feet. The length of the embankment centerline at the dam crest would be approximately 1,170 feet. Based on these dam dimensions, approximately 143,400 cubic yards of fill would be required. Deeper excavation of the basin to provide additional fill material and to lower the embankment height, which would reduce the amount of fill required to construct the embankment, would be assessed during the initial conceptual design to provide a better cut / fill balance.

Inlet structures with energy dissipators would be constructed for each of the three drainages (North Walnut Creek, South Walnut Creek, and No Name Gulch) entering the detention basin as shown in Figure A-07.

4/ Runoff volume from 100-year, 6-hour storm event based on values presented in the 1992 Drainage and Flood Control Master Plan (EG&G, 1992). Runoff volume is conservative because impervious surfaces within the IA will be eliminated after Site closure.

5/ Runoff volume for pre-/post-storm event storage based on values presented in the AME Soil Erosion Report (Kaiser-Hill, 2000a).

6/ Sediment accumulation based on average annual erosion values calculated for the Walnut Creek watershed using WEPP computer code as presented in the AME Soil Erosion Report (Kaiser-Hill, 2000a) multiplied by 25.

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3.2.2.2 Woman Creek Components

Figure A-08 provides a plan view for the Woman Creek detention basin. This figure shows the general location of the earthen embankment and the maximum area inundated by the retained runoff. The Woman Creek detention basin is located to retain runoff, sediment, and actinides associated with sediment originating from the original landfill, SID, the 903 Pad area, and the windblown dispersion area east of the 903 Pad. The dam embankment for existing Pond C-2 would be removed in conjunction with constructing the new detention basin to provide the required storage capacity. The future operation of Mower Ditch and disturbance of Preble's mouse protection areas would need to be considered if the Woman Creek Detention Basin were located further downstream toward Indiana Street.

The Woman Creek detention basin would be constructed to store approximately 283 acre-feet of water. Approximately 156 acre-feet[7/] of this total storage would be dedicated to detaining runoff from a 100-year, 6-hour storm event while the remaining 127 acre-feet[8/] of storage would be available to manage and detain normal pre-and post-event runoff and maintaining the permanent pool. The water surface area at the maximum storage level would be approximately 20.7 acres. The final sizing of the detention capacity would be determined during the initial conceptual design should this scenario component be included as a design component.

The bottom of the detention basin (including the existing portion of Pond C-2) would be excavated to provide space for sediment storage. The quantity of material excavated from the detention basin would be approximately 2,230 cubic yards (1.4 acre-feet), which corresponds to the estimated amount of sediment expected to accumulate over a 25-year period[9/].

The maximum height of the earthen embankment would be approximately 37 feet. Using a dam crest width of 15 feet and a 3H:1V slope for the upstream and downstream faces, the maximum base width of the dam would be approximately 240 feet. The length of the embankment centerline at the dam crest would be approximately 1,820 feet. Based on these dam dimensions, approximately 143,100 cubic yards of fill would be required. Deeper excavation of the basin to provide additional fill material and to lower the embankment height, which would reduce the amount of fill required to construct the embankment, would be assessed during the initial conceptual design to provide a better cut / fill balance.

7/ Runoff volume from 100-year, 6-hour storm event based on values presented in the 1992 Drainage and Flood Control Master Plan (EG&G, 1992). Runoff volume is conservative because impervious surfaces within the IA will be eliminated after Site closure.

8/ Runoff volume for pre-/post-storm event storage based on values presented in the AME Soil Erosion Report (Kaiser-Hill, 2000a).

9/ Sediment accumulation based on average annual erosion values calculated for the Woman Creek and SID watersheds using WEPP computer code as presented in the AME Soil Erosion Report (Kaiser-Hill, 2000a) multiplied by 25.

The Woman Creek diversion dam would be removed and the SID and Woman Creek flows would be combined and routed to a single inlet on the detention basin as shown on Figure A-08. Credit for the fill material associated with Pond C-2 embankment would not be included in a cut/fill balance because Pond C-2 would need to be operated while the new detention basin was constructed. Although the SID would not be physically removed, maintenance to retain this diversion ditch would not be provided and the SID would be allowed to fill-in naturally over time. Similar to the Walnut Creek detention basin, the inlet structures on Woman Creek and the SID would consist of an energy dissipater and a flow spreader to minimize disturbing and resuspending the bottom sediments.

A diversion ditch or swale would be constructed on the north side of the Woman Creek detention basin to capture additional runoff originating from wind dispersion area east of the 903 Pad. The diversion structure would run for approximately 1,100 feet in the northeast direction up the hillside.

3.2.3 Construction Considerations

This section presents the construction considerations for the various components included in this bounding scenario.

3.2.3.1 <u>General Considerations</u>

The requirements of both Sections 401 (water quality certification) and 404 (wetlands) of the Clean Water Act may need to be considered for constructing the detention basins within the drainages. Construction activities would be conducted in such a manner to avoid impacting existing wetlands, riparian areas, or Preble's mouse habitats. Temporary construction barriers would be used to delineate areas to be avoided by machinery.

The temporary erosion controls used to preclude soil erosion from construction activities may need to be fairly extensive and well maintained to minimize disturbance and resuspension of actinide-bearing sediments that my be present in the drainage channels. Construction haul roads would be located to avoid crossing existing drainage channels. Standard construction provisions for dust control would be required.

During construction, operation of the existing terminal ponds (Ponds A-4, B-5, and C-2) would continue. Stream flow would be temporarily diverted around the construction site, which may include pumping of discharged water from the terminal ponds. Each basin would be available for use immediately at the end of the construction period.

3.2.3.2 <u>Detention Basins</u>

The information presented in this section is based on constructing new detention basins. Design, planning, and review activities would take about 10 to 14 months. Both detention basins could be constructed within a period of one construction season (6 to 10 months).

A large amount of fill material may be required to be imported to construct the embankments. Reuse of soils from existing pond embankments could reduce the amount of imported fill material required. However, a phased implementation would be required to ensure that adequate water storage capacity is available during construction for continued and uninterrupted surface water management operations.

3.2.3.3 Diversion Ditch / Swale

Special construction provisions for the drainage diversion are not required. The design, planning, and review activities would be concurrent with the Woman Creek Diversion Dam. The drainage diversion could be installed in less than one month.

3.2.4 Operational and Maintenance Considerations

The detention basins would be designed for attendant operations. The detention basins would be operated in a batch release mode after sampling and verification that the accumulated water meets surface water quality standards. Periodic inspection and maintenance would also be required to ensure that the detention basins are performing correctly. The major operational and maintenance activities that would be required for the various components are listed in Table A-08. Some of these items are addressed in further detail below. Operations and maintenance requirements for other remediation systems (groundwater plume systems and ET covers), monitoring environmental media (groundwater, soils, and air), and Site maintenance (roads and other facilities) are not presented.

- Water level in the basins would be maintained through periodic discharge to insure adequate reserve capacity to accommodate the design storm event.
- Frequent mowing of the embankment encourages grasses to develop a good ground cover with extensive root systems that resist erosion, and prevents shrubs and trees from becoming established. The roots of shrubs and trees that can create channels and cause subsequent leakage through the embankment should be removed.

3.2.5 Construction and Operating Cost

This section presents the information used to estimate the cost for constructing and operating the various components included in this bounding scenario. Historical unit costs were adjusted for inflation where appropriate. The total construction cost is estimated to be between \$9.0 million and \$14.6 million. The annual O&M cost (without provisions for surface water monitoring at the POCs) is estimated to be \$765,000, which includes a 20% allowance for management, record keeping, and reporting. Additional details for the construction and operating cost estimates are provided below.

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Detention Basins

Brown and Schueler (1997) performed a study and determined that the construction cost for wet detention basins can be estimated by the following equation:

$$C = 24.5 * V^{0.705}$$

Where:

C = Construction, design and permitting cost in 1997 dollars.
V = Total volume of detention basin in cubic feet.

The estimated construction costs for the Walnut (416 acre-feet) and Woman (283 acre-feet) are $3.6 million and $2.8 million based on using inflation rate of 3%. The above estimates are based on using local fill material for construction. If fill material would be required to be imported for an offsite borrow area, the construction cost would increase by approximately $5.6 million based on using a delivered unit cost of $20.00 per cubic yard.

The annual cost of routine maintenance for detention basins is typically estimated at about 3 to 5% of the construction cost (Schueler, 1992). Using a factor of 10% to cover operation and maintenance, the annual cost for both detention basins is estimated to be approximately $640,000.

Drainage Swale

Capital cost for a vegetated swale in 1987 dollars is $4.90 to 9.00 per linear foot for a 15-foot wide channel (top width) by 1.5 foot deep and the O&M cost in 1991 dollars is about $0.58 per linear foot (EPA, 1999c). Construction of the 1,100-foot drainage swale is estimated to cost approximately $15,000 (adjusted for inflation) with average annual maintenance cost of $1,000.

Existing Pond Modifications

Except for the removal of Pond C-2, this bounding scenario is independent on the reconfiguration of the existing terminal ponds, which would be determining by the application of the Pond Reconfiguration Strategy during the initial conceptual design. For developing a cost estimate for this bounding scenario, it is assumed that the existing Pond A-4, all B-series pond, and Pond C-2 would be fully breached and that the remaining ponds would be reconfigured to enhance wetlands. The cost for modifying the existing ponds is estimated to be $2.6 million.

3.3 *Scenario 3 – Source Isolation*

This bounding scenario utilizes engineered drainage and erosion controls to diminish contaminant migration into surface water. The scenario components would be applied to individual sectors that are susceptible to migration and have the potential to cause an exceedence of the surface water quality standards. The distinguishing characteristics of this bounding scenario that achieve the FDOs include:

- Using grade reduction and controlled drainage diversion on unstable hillsides and other areas to minimize surface water erosion of actinide-bearing surface soils that could contribute to an exceedence of the surface water quality standards.
- Using positive drainage and ET provisions to minimize infiltration above sectors with subsurface contamination that could migrate and contribute to an exceedence of the surface water quality standards.

The scenario components and information presented in this description are preliminary and would be refined during the design process if any of source isolation components are included as a design component. The components and locations included in this bounding scenario are shown on Figure A-09. These preliminary locations were developed only to allow evaluation of this bounding scenario. Should any scenario component be included as a design component, the preliminary locations would be further evaluated and refined during the design process.

Surface water controls for sediment removal (such as detention ponds) would not be required under this scenario to maintain compliance with surface water quality standards. Although elimination of the existing ponds would be assessed during the initial conceptual design based on application of the Pond Reconfiguration Strategy, the existing ponds are breached under this bounding scenario to fully evaluate the effectiveness of the source isolation controls. The breaching of the existing dams under this bounding scenario does not mean that the existing ponds would be breached if any of the source isolation components were included in the initial conceptual design. The development of this bounding scenario is only intended to represent an extreme of the potential options that could be applied as the final land configuration for RFETS. If the existing ponds were included under this bounding scenario, then Scenario 3 would be similar to Scenarios 1 and 2 and would not be bounding.

The breaching of the existing ponds for Scenario 3 is considered appropriate because the evaluation of the scenarios is not intended to select a winner, but to identify the strengthens and weaknesses of individual scenario components to determine which scenario components could be included in an initial conceptual design. This approach would be used to determine if source isolation controls alone would be adequate to maintain compliance with surface water quality standards at the POCs. If they are not adequate, source isolation components could be combined with water controls to formulate an appropriate initial conceptual design. If source isolation is found to be adequate, then retaining the existing ponds through the application of the Pond Reconfiguration Strategy would serve to enhance the overall performance.

3.3.1 Design Functions and Considerations

Various engineered drainage and erosion controls have been effectively utilized to reduce sediment loading in storm water and to control flooding. The controls include both natural materials (such as rock riprap and vegetative growth) and man-made products (such as turf mats and gabions) to control erosion. Drainage diversion and infiltration controls are standard practices to isolate areas that have a higher potential of surface or subsurface contaminant migration/release (these areas include industrial plants, landfills, mining operations, etc.). Under this bounding scenario, these source isolation controls would be applied as the primary mechanism to maintain compliance with surface water quality standards at RFETS. The specific controls considered under this bounding scenario include:

- Hillside Stabilization,
- Infiltration Controls,
- Drainage Improvements, and
- Revegetation.

This section is not intended to present and describe all possible drainage and erosion controls, but to address and evaluate controls that are representative of the range of available options. Other controls with equivalent performance may be considered and adopted should source isolation techniques be included in the initial conceptual design.

3.3.1.1 <u>Hillside Stabilization</u>

The landscape at RFETS continues to evolve in response to geomorphic processes. The principle geomorphic mechanisms include drainage channel incision, which causes steepening of the hillside running between the drainage channel and the top of the pediment. When the slope of the hillside exceeds the cohesive properties of the soil, hillside movement by soil creep or mass wasting (slumps or landslides) occurs. The slumping typically coincides with the location of a seep where the saturate soils are more prone to failure due to the additional weight of the water and decreased fictional resistance at the water/soil interface. Secondary erosional processes (such as gully formation) can occur at the slump. The resulting failure and subsequent gully formation could increase erosion of exposed surface soils to the drainages, uncover subsurface structures/additional contamination, or cause damage to remediation systems.

The shaping of the pediment at RFETS has been occurring for more than a million years and will continue to occur in the future. The goals of hillside stabilization is not to prevent these geomorphic processes from occurring, but to implement engineering actions within specific sectors to minimize erosion of actinide-bearing soils, stabilize the closure configuration of the IA, and provide long-term protection of remediation systems to maintain compliance with the surface water quality standards at the POCs.

Hillside slumping and sliding occur at RFETS on slopes that are typically steeper than 14 percent at locations where weathered claystone with low shear strength are capped with alluvium (Shroba, 1982). The mechanism for hillside failure and possible solutions were evaluated as part of the *Geotechnical Investigation Report* for the Original Landfill (DOE, 1995). Both colluvium sliding on severely weathered claystone and landsliding within moderately weathered claystone was identified. This geotechnical report indicates that hillside grades would need to be less than 14 percent (7H:1V) and a shallow toe buttress would need to be constructed to alleviate shallow slope failures.

Grade Reduction

For developing this bounding scenario, grade reduction would be accomplished by cutting back the top of the hillside to achieve a stable slope. Although the geotechnical report conducted for the Original Landfill specifies a slope of 14 percent to address slope stability, the development of this scenario is based on a more conservative slope of 11 percent (9H:1V) to further reduce erosion and minimize potential failure due to deep-seated landsliding in the underlying colluvium and weathered claystone.

Adding fill material to the hillside was considered as an alternative to grade reduction, but adding fill is restricted in many sectors for the following reasons:

- Using fill material would be precluded if the space between base of the slope and the drainage channel were not width enough to adequately reduce the grade.
- Placing fill material at the base of the unstable slopes adjacent to the drainages would be precluded if it infringes on Preble's mouse habitats.
- Adding fill material to a hillside would be precluded if the additional weight of the fill material would destabilize the hillside.
- Importing the required fill material from offsite borrow areas could make this option costly to implement.

Toe Buttress and Subsurface Drain

A compacted earthen buttress with a toe drain could be constructed at the toe of the slope to further stabilize the hillside. The actual need for the buttress and toe drain would be subjected to further geotechnical investigation. For developing this bounding scenario, the buttress and toe drain are considered optional scenario components. Due to the extent and nature of construction required, installation of the toe buttress and subsurface drain would be expensive.

To reduce the potential for deep-seated slides that have historically occurred within moderately weathered bedrock, the base of the buttress may need to be keyed into unweathered bedrock to intercept the weak interface layers in the underlying colluvium and weathered claystone. The keying of the buttress would require extensive excavation to remove unstable slide deposits and weathered claystone above the unweathered claystone. Temporary shoring (such as sheet piling) may be required to stabilize the excavation during construction.

A subsurface toe drain would be installed to reduce the build-up of water head that could result in failure of the buttress. The toe drain would also tend to dewater the hillside, thus increasing the resistance forces to slope failure. The toe drain would be installed along the uphill side of the buttress at its intersection with the foundation soils. The drain would be sloped to a collection point for controlled discharge.

Hillside Terracing

Terraces, benches, and ditches are standard engineering practices to reduce erosion of steep and long hillsides. These terracing features are designed to provide an area of low slope or reverse slope to prevent runoff from gaining velocity and erosive forces. The spacing of the terrace features depends on the erodibility of the soils, steepness and length of the slope, and rock outcrops. The terracing features would run perpendicular to the slope and convey the runoff to engineered drainage channels. The channels would convey the runoff down the hillside into the receiving stream. To prevent gully erosion from the concentrated runoff, the channels would be armored. Due to the steepness of the slope (11%), riprap would likely be used as the armoring material.

For developing this bounding scenario, terracing is considered optional and would be considered only if it is determined that grade reduction by itself is not adequate to ensure slope stability and to maintain compliance with surface water quality standards. As such, the erosion and hydrologic modeling evaluation did not include terracing as a scenario component. If terracing were determined to be required, further design details would be developed during the initial conceptual design.

3.3.1.2 Infiltration Controls

Contouring, flow diversion, and ET provisions could be used to control the amount of infiltration into subsurface zones to diminish the possibility of mobilizing and transporting contaminants to surface water that may result in an exceedence. These infiltration controls are suitable to reduce migration of contaminants from the vadose zone and as a means to locally alter groundwater flow. The water balance model being developed by the SWWB Project Team could be applied to assess the benefits of the infiltration controls with respect to reducing migration of any subsurface contaminants.

Contouring

Contouring of the land surface is used to provide positive drainage above sectors with subsurface concerns. The contouring would also be designed to increase the amount of runoff within the sector to minimize the water available to infiltrate into the subsurface zone. A slope of 3 to 5 percent is typically adequate to facilitate overland flow and to reduce the potential for ponding, while minimizing the amount of soil erosion.

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Flow Diversion

The goal of flow diversion is to intercept runoff from upland areas and divert it away from areas with subsurface concerns to reduce the amount of runoff available to infiltrate into the subsurface zone. Earth dikes, swales, or ditches can be used to intercept and convey runoff away from sectors with subsurface concerns. The flow diversion structure could be lined to limit infiltration to the subsurface from the diversion structure and to provide erosion protection. Additional details and design criteria for drainage devices are contained in Chapter 7 of the *Urban Storm Drainage Criteria Manual, Volume 2* (UDFCD, 2001).

The flow diversion structure would also be used to convey the increased runoff from the contoured sector to the receiving stream. The potential impacts of increasing the amount of runoff to the receiving stream resulting from flow diversion would be considered during the initial conceptual design.

ET Provisions

Enhancing evapotranspiration (ET) provisions in conjunction with recontouring and flow diversion is another method to eliminate (or at least reduce) infiltration and recharge from deep percolation. ET provisions would be used over specific sectors to minimize the potential migration of subsurface contaminants to surface water, especially in the IA where removal of impervious surfaces (including buildings and parking lots) would tend to increase infiltration after closure. ET provisions generally involves establishing appropriate vegetation over a suitable soil rooting media to:

- Promote vegetative growth during the growing season for effective evaporation and plant transpiration;
- Provide sufficient water absorption and storage capacity during months when vegetative growth is dormant;
- Provide a weather-resistive, abrasive surface to resist wind and water erosion at RFETS; and
- Control the rate of runoff from precipitation.

The water storage capacity provided by the soil-rooting layer is an important design component to the successful reduction of infiltration especially during heavy precipitation events and the winter months when transpiration rates are negligible. The depth of the soil-rooting layer is thicker than required to revegetate areas strictly for erosion control or aesthetics. For example, to prevent infiltration, the soil-rooting layer may be several feet deep. The material specified for the soil-rooting layer must be suitable for deep rooting by the selected vegetation and have ample characteristics to provide the required water storage capacity. Testing is required to determine if common RFETS "topsoil" could be made suitable (with proper preparation/additives) for this purpose. If the RFETS "topsoil" are determined to be unsuitable, offsite borrow sources have been would be used if shown to be effective. Because the thickness of the soil-rooting layer could be significant, the resultant topography must be considered in designing local drainage and surface water features.

3.3.1.3 Drainage Improvements

Various drainage improvements could be implemented to minimize erosion of actinide-bearing sediments accumulated within drainage channels, improve long-term stability of drainage channels, or reduce long-term stewardship requirements. These improvements include flow diversion, culvert removal, and channel stabilization.

Flow Diversion

The flow diversion components previously presented in Section 3.3.1.2 could also be used to reduce the amount of runon onto areas that are susceptible to erosion of actinide-bearing surface soils. Reducing flow into these would decrease the sediment and actinide loads that could be transported to the drainages.

Storm Water Culvert Removal

Current inventory indicates that there are more than 250 storm water culverts and structures within the IA and BZ. A majority of these structures would be removed to close the IA, while others may be retained for road crossings and stabilization of the drainage channel to reduce erosion. Retaining these structures needs to balanced with long-term stewardship requirements, preservation of ecological resources (habitats and wetlands), and distraction to open space usage of the Site.

For developing this bounding scenario, all culverts (except those associated with crossing of the retained roads) would be removed to evaluate long-term drainage channel stability and maintenance, as well as, their contribution to preventing soil erosion. The locations of the removed culverts would be converted to an open channel that has the same bottom width, channel slope, banks, and surface covering as the adjacent portions of the stream.

Check dams, drop structures, and other control components located within the principal drainage channels and hillsides that are required to maintain compliance with surface water quality standards at the POCs, provide ecological benefits, or stabilize the drainage channel would remain intact and unaltered. These structures would be further evaluated as part of the initial conceptual design to verify that they are consistent with long-term performance objectives for the LCDB Project.

Channel Stabilization

Additional engineering structures and components may be required at locations where culverts are removed or new drainages are constructed to stabilize the channel bottom and banks. The engineered features would be designed to maintain long-term longevity of remediation systems, minimize impacts to ecological resources, use natural materials that blend in with surrounding landscape to support final land use of open space/National Wildlife Refuge, and recycle existing Site materials (such as security boulders) where appropriate. The following stabilization controls could be applied.

- **Vegetation** - The first choice for channel stabilization is to use grass, sod, or riparian vegetation to decrease the erodibility of the channel. If the velocity in the channel would erode the vegetation, then other methods would be required.
- **Linings** – A variety of materials can be used to line the channel. These materials include (but not limited to) rock riprap, concrete, gabions, and turf reinforcement mats. Additional details and design criteria for lining channels are contained in Chapter 7 of the *Urban Storm Drainage Criteria Manual, Volume 2* (UDFCD, 2001). Further details for turf reinforcement mats are provided in EPA's *Storm Water Technology Fact Sheet: Turf Reinforcement Mats* (EPA, 1999b).
- **Check and Drop Structures** – These engineered devices are designed to provide special hydraulic conditions that allow a drop in water surface and/or channel grade to preclude supercritical flow within unprotected portions of the drainage channel. Additional details and design criteria for check and drop structures are contained in Chapter 8 of the *Urban Storm Drainage Criteria Manual, Volume 2* (UDFCD, 2001). Check dams were also described in Section 3.1.1.4.

3.3.1.4 Revegetation

Vegetative covers provide both dust control and a reduction in erosion potential by increasing infiltration, trapping sediment, stabilizing the soil, and dissipating the energy of hard rain. Revegetation would be applied to disturbed and barren areas and to close roads that do not have a beneficial or legitimate use after the Site is closed. The goals of the revegetation efforts is to:

- Minimize the amount of unvegetated soil surface area subjected to water and wind erosion (especially in areas with elevated levels of contamination).
- Provide a vegetative cover that is long-term and self-sustaining,
- Minimize need for artificial or human intervention to ensure long-term survival,
- Allows land usage that is consistent with open spaces,
- Utilize and blend with native plant species to the extent practicable, and
- Avoid the establishment of monocultures.

Permanent vegetation would be carefully selected for survival in a semi-arid climate and consist of native plant communities to ensure long-term survival. The native species would consist of mixed mesic grassland and xeric tallgrass prairie. These vegetation types would include dominant plant species such as blue grama, western wheatgrass, sideoats grama, little bluestem, big bluestem, mountain muhly, and Canada bluegrass.

3.3.2 Description of Scenario Components

If source isolation provisions are included in the initial conceptual design, the scope of the scenario components would be appropriately expanded or contracted based on the hydrologic and erosion modeling results developed for this bounding scenario. It is further recognized that the following sectors may be currently contributing to surface water quality exceedences, but are not specifically addressed under this bounding scenario.

- Historically, GS10 has been the location of the most frequent exceedence of the surface water action levels and largest 30-day moving averages. However, no discernable source for the exceedences at GS10 has been identified (DOE, 1998a). This bounding scenario was developed based on the assumption that the planned D&D and remediation efforts for the IA would be adequate to address these unidentified sources. As such, specific source isolation provisions for sectors associated with GS10 are not included in this bounding scenario.
- The ET covers planned to be installed over the Original and Present Landfills and Solar Evaporation Ponds are assumed to have been previously completed and would be adequate to preclude impacts to surface water. As such, additional source isolation provisions for the ET covers are not included in this bounding scenario.
- This bounding scenario was developed based on the assumption that the existing groundwater plume systems will continue to be operated and would be adequate to preclude any impacts to surface water. As such, additional source isolation provisions for these areas are not included in this bounding scenario.

Based on preliminary assessment of historical monitoring and characterization data, the following source isolation and reconfiguration actions are considered appropriate and have been included under this bounding scenario for evaluation.

- The sector above the IA VOC Plume would be contoured to provide positive drainage; thereby, reducing infiltration and potential migration of subsurface contaminants.
- The grade of the 903 Pad hillside would be reduced to improve slope stability and decrease soil erosion.
- Ditches would be constructed within the IA to provide runoff diversion.
- The drainage channels for portions of North and South Walnut Creeks would be stabilized to provide longevity, reduce long-term stewardship, and enhance ecological resources.
- Disturbed areas and barren zones within sectors that require source isolation controls would be vegetated to reduce erosion.

Some or all of the abovementioned source isolation provisions that are included as a component of Scenario 3 may be incorporated into other on-going Site closure/remediation plans and would, therefore, not be required as part of the LCDB Project. The abovementioned components were included under this bounding scenario to illustrate the source isolation approach for evaluation. Further details for each source isolation component are provided in the following subsections.

3.3.2.1 IA Components

The IA will be extensively regraded and revegetated to accommodate closure of the Site. This section addresses specific source isolation techniques that can be employed within the IA to minimize the potential for surface and subsurface contaminant migration to surface water.

IA VOC Plume Infiltration Controls

Remedial plans for the IA VOC plume have not been finalized. Sufficient characterization and SWWB information is currently not available to assess the nature and extent of the IA VOC plume and the potential affects that infiltration increases may have on this plume (see Data GAP-010). The SWWB information would be used to determine if the infiltration and hydraulic characteristics of the IA VOC plume may be significantly altered with the closure of the IA due to removal of parking lots, roads, and other impervious surfaces. A groundwater plume system may be installed if future characterization and SWWB information indicate the need for such a system.

Alternatively, positive drainage provisions may be included as a component of the final land configuration to counter-act potential increases in the amount infiltration caused by removal of impervious surfaces in the IA. The infiltration controls could consist of land recontouring to provide positive drainage away from the IA VOC plume and diversion of upland drainage. The land surface could be recontoured to provide positive drainage away from the areas situated above the IA VOC plume. The above components may be incorporated into the decision documents for the IA VOC plume as appropriate.

For development of this bounding scenario, using fill material to provide positive drainage was included instead of excavation to avoid any issues with disturbing the underlying plume or other subsurface contamination. It is estimated that approximately 375,000 cubic yards of fill material would be required based on a recontoured slope of 5 percent. The fill material would be minimally compacted to reduce permeability and revegetated as described in Section 3.3.1.4. For developing this bounding scenario, standard topslope vegetation (Xeric Tall Grass Prairie) was used as the vegetative cover. This type of vegetation was used because it is native to the surrounding area and thus would be well suited for long-term survival, would not introduce non-native invasive species, and would avoid the establishment of monocultures. The need to utilize deep-rooted vegetation with greater ET values would be further assessed if modeling results from the SWWB Project Team show that positive drainage, flow diversion and standard vegetation features are not sufficient to limit subsurface migration. Alternatively, a groundwater plume collection and treatment system would be installed if SWWB modeling results indicate that source isolation techniques would not be effective.

IA Drainage Improvements

A diversion ditch located immediately west of the IA VOC plume would be installed to intercept and divert surface water to North Walnut Creek. The purpose of this diversion ditch is to convey upland runoff away from the IA VOC plume to reduce the amount of runoff available to infiltrate into the ground. For developing this bounding scenario, the ditch would not be lined. The need to line the ditch would be further assessed if modeling results from the SWWB Project Team show that the unlined ditch is a significant source of groundwater recharge and would cause to the IA VOC plume to expand.

The IA portions of North and South Walnut Creeks could be retained and improved to provide long-term stability, reduce channel erosion, and enhance ecological resources as described in Section 3.3.2.2. The specific channel routing and stabilization requirements would be developed in further detail as part of the initial conceptual design. All other portions of the IA would be graded to provide natural, overland drainage. Culverts not associated with road crosses would be removed.

3.3.2.2 Walnut Creek Components

For developing this bounding scenario, the erosion and hydrologic modeling was conducted with the A-and B-series ponds removed because source isolation is not dependent on water controls. Modeling this bounding scenario with the ponds eliminated allows the performance of the source isolation components to be conservatively assessed.

Although this bounding scenario does not rely on detention and water control structures, long-term stability of Walnut Creek was considered under this bounding scenario. The specific components and improvements included under this bounding scenario are described below. The need to provide additional channel stabilization would be considered during the initial conceptual design.

North Walnut Creek Drainage Improvements

For developing this bounding scenario, the 72-inch diameter concrete culvert that runs beneath the parking lot adjacent to the former PACS3 would be removed and an open drainage channel would be reestablished. The portion of this culvert that crosses the North Perimeter Road would be retained. Because this portion of North Walnut Creek has been extensively modified and straightened, the drainage channel is subjected to large erosive forces. Returning this portion of North Walnut Creek to a meandering stream is precluded due to the proximity of the North Perimeter Road. As such, check dams or drop structures would be installed to prevent scouring of the new open channel.

Three CMP laterals convey runoff from northern portion of the IA down the hillside directly into the 72-inch diameter concrete culvert. For developing this bounding scenario, the eastern and central laterals would be removed and regraded for overland flow. The western lateral would be removed and converted into an open channel because the current drainage is more established and would be used to facilitate drainage from the Solar Pond ET cover. The open channel would need to be stabilized by concrete lining, riprap, or some other means because its slope would be on the order of 10 percent. The specific details and stabilization requirements would be further assessed during the initial conceptual design.

Removal of the drop structures located on North Walnut Creek to the north of Building 371 was considered, but not included in this bounding scenario. Returning this portion of North Walnut Creek to a meandering stream is precluded due to the proximity of the North Perimeter Road. The existing drop structures were retained because they appear to be in good shape and adequately designed to prevent erosive flows.

South Walnut Creek Drainage Improvements

Unlike Scenario 1, which includes check dams to regulate the flow velocity in South Walnut Creek, no drainage stabilization provisions were included under this bounding scenario. Although this approach is not consistent with the overall channel stabilization goal adopted for this bounding scenario, the modeling results with (Scenario 1) and without (Scenario 3) channel stabilization allows assessment of the performance of channel stabilization as a scenario component. As such, minimal stabilization features have been included for South Walnut Creek under this bounding scenario. The inclusion of channel stabilization as part of the initial conceptual design would be based on the results of the Scenario 1 and 3 model results.

The portions of South Walnut Creek located within the IA would be converted to a open channel with the exception of where is flows under the North Perimeter Road. The adequacy of the twin 30-inch diameter culvert crossing would be further evaluated as part of the initial conceptual design.

Walnut Creek Drainage Improvements

The portion of the Walnut Creek form the confluence of North and South Walnut Creeks to Indiana Street is primarily in an undisturbed, natural condition. As such, no drainage improvements are included for Walnut Creek.

3.3.2.3 Woman Creek Components

For developing this bounding scenario, the erosion and hydrologic modeling was conducted with both C-series ponds removed because source isolation is not dependent on water controls. Modeling this bounding scenario with the ponds eliminated allows the performance of the source isolation components to be conservatively assessed.

Soil erosion from the 903 Pad and adjacent hillside has been identified as a contributor to exceedence of surface water quality standards in the discharge of SID into Pond C-2 as monitored at SW027 (DOE, 1998b and 2001a). The AME Project Team has also extensively investigated the mechanism associated with these exceedences. Source isolation methods to decrease the amount of erosion from the 903 Pad area and associated hillside were considered in developing this bounding scenario. It is recognized that the extent of remedial activities for the 903 Pad have not been finalized and would need to be considered prior to adopting specific source isolation techniques. For developing this bounding scenario, it is assumed that soil below Tier I action levels would remain in place after completion of the 903 Pad remedial actions.

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Grade reduction was included to evaluate source isolation as a plausible approach to maintain compliance with surface water quality standards for Woman Creek by improving the stability of this hillside and reducing the actinide load into the drainages. For developing this scenario, the grade reduction efforts would include:

- Reducing the current grade of the hillside,
- Revegetating disturbed areas to increase resistance to erosion forces.

Grade reduction would be achieved by cutting back the upper portion of the 903 Pad hillside. The current toe of slope adjacent to the SID would be retained. To provide an initial assessment of grade reduction, the boundary of the area that would be disturbed is shown on Figure A-09 and encompasses approximately 140 acres. The disturbed area would not infringe on known Preble's mouse habitats and wetlands.

The slope of the 903 Pad hillside currently ranges from 14 to 18 percent and has experienced slope failure. For developing this scenario, the slope would be reduced to approximately 11 percent. Cutting back the slope would not expose any portion of the known Tier I groundwater plumes as new hillside seeps. If this scenario component is advanced into the initial conceptual design, a geotechnical investigation could be conducted to determine if a toe buttress is required to preclude deep landsliding. Additional soil borings would be performed along the slope and toe of the hillside to obtain the required geotechnical information.

The amount of soil to be excavated is estimated to be approximately 1,550,000 cubic yards. It is recognized that some of the soils to be excavated would contain actinides between Tier I and Tier II action levels and would be subject to soil management requirements and approvals under RFCA. A majority of the excavated soil (approximately 1,000,000 cubic yards) would be used as fill along the eastern end of the 903 Pad hillside if placement of the fill material does not destabilize this portion of the hillside. An additional 375,000 cubic yards of the excavated soils could possibly be used to provide positive drainage over the IA VOC plume (see Section 3.3.2.1). This preliminary cut/fill soil balance would result in an excess amount of soil that is approximately 175,000 cubic yards. A more detailed cut and fill balance would be prepared as part of the initial conceptual design if grade reduction is included as a design component.

Terracing was not included within the bounding scenario, but would be considered if grade reduction alone is determined (based on hydrology and erosion modeling results) not adequate to maintain compliance with surface water quality standards.

903 Pad Diversion Ditch

A diversion ditch would be installed immediately west of the 903 Pad to intercept and divert surface water to South Walnut Creek. Because infiltration is not a concern for the 903 Pad, the drainage ditch would not need to be lined. The purpose of the ditch is to minimize the amount of runoff flowing into the 903 Pad area that could contribute to erosion of actinide-bearing surface soils. Portions of the existing Central Avenue ditch, including the concrete lined channel between SW022 (Central Avenue Diversion Box) and South Walnut Creek and the associated energy dissipation structure would be incorporated as part the diversion ditch.

3.3.3 Construction Considerations

This section presents the construction considerations for the various components included in this bounding scenario.

3.3.3.1 General Considerations

The requirements of both Sections 401 (water quality certification) and 404 (wetlands) of the Clean Water Act may need to be considered for construction within the drainages. Construction activities would be conducted in such a manner to avoid impacting existing wetlands, riparian areas, or Preble's mouse habitats. Temporary construction barriers would be used to delineate areas to be avoided by machinery.

Standard temporary erosion controls (such as silt fencing, hay bales) would be used to minimize soil erosion during construction activities. Construction haul roads would be located to avoid crossing existing drainage channels.

Operation of the existing terminal ponds (Ponds A-4, B-5, and C-2) is expected to continue until revegetation of disturbed areas is fully established and stabilized. After construction was completed, the existing ponds would be reconfigured in accordance with the Pond Reconfiguration Strategy.

3.3.3.2 Grade Reduction

It is estimated that final design (including soils investigation) for this scenario would be completed within 6 to 9 months. The below listed construction activities could be completed in one construction season (approximately 6 to 9 months).

- Topsoil removal and stockpiling.
- Rough regrading.
- Final contouring and scarifying[10/] for temporary stabilization from wind and water erosion.
- Installation of riprap lined channels.
- Topsoil replacement.
- Seeding and mulching.

If terracing and/or a toe buttress with subsurface drains were required, it could be installed concurrent with the above construction activities. Some of the soils from the

10/ Scarifying would be accomplished with a ripping tool parallel to the contours of the slope. The scarification would be two to four inches deep and four to six inches apart.

regrading of the hillside may contain actinides between RFCA Tier I and Tier II action levels and could require addition soil management including analytical testing and administrative approvals. In addition, increased controls to preclude wind dispersal would likely be required. The ability to meet the construction schedule is dependent on the extent of these additional management requirements.

Grade reduction of the 903 Pad hillside, if required, would be performed in a phased manner to (1) confine disturbance to the smallest area possible and (2) vegetate or stabilize the disturbed soils immediately after final grades are attained. This phased approach would limit the surface area of barren soil that would be exposed to water and wind erosion. The grading activities would also be scheduled during the time of year that the erosion potential at the Site is relatively low. The construction activities should be scheduled so that the permanent vegetation could be established by the end of the growing season. It is expected that a mature vegetative cover capable of controlling soil erosion and surviving normal climate conditions could be established within one year after completion of construction.

3.3.3.3 Infiltration Controls

It is estimated that final design (including water balance evaluation) for this scenario would be completed within 6 to 9 months. The below listed construction activities could be completed in one construction season (approximately 4 to 6 months). Construction activities could be conducted concurrent with closing the IA. The regrading and vegetation activities would be similar to the grade reduction of the 903 Pad hillside as described in Section 3.3.3.2.

3.3.3.4 Diversion Ditches

Special construction provisions for the diversion ditches are not required. The design, planning, and review activities for the diversion ditches would be concurrent with the final grading and drainage plans for the IA. The diversion ditches could be installed in less than one month.

3.3.3.5 Drainage Improvements

The design, planning, and review activities for the drainage improvements would be concurrent with the final grading and drainage plans for the IA. The drainage improvements could be completed 4 to 6 months.

3.3.3.6 Revegetation

Topsoil having adequate texture and fertility would be applied to disturbed areas to facilitate vegetative growth. The depth of topsoil used would be adequate to support the root systems of the plant species. Topsoil would be placed in a contemporaneous manner so that revegetation is concurrent with final contouring and scarifying operations. Existing topsoil would be removed prior to disturbance and stockpiled for reuse. If topsoil is required to be imported from off-site locations to offset any deficits, it would be free of noxious weeds/seeds.

After seeding, the area would be mulched. Mulch would be anchored by crimping or with a tackifier or net. Mats, blankets, nets, sod, or geosynthetic materials may be used in highly erodible areas (such as drainage channels or steep slopes) to aid in establishing adequate vegetative cover and to control erosion during the establishment period.

3.3.4 Operational and Maintenance Considerations

Minimal operations and maintenance would be required for the components included in this bounding scenario. The major operational and maintenance activities that would be required for the various components are listed in Table A-09. Some of these items are addressed in further detail below. Operations and maintenance requirements for other remediation systems (groundwater plume systems and ET covers), monitoring environmental media (groundwater, soils, and air), and Site maintenance (roads and other facilities) are not presented.

- Periodic visual inspection for signs of excessive erosion, slope stability, and stressed vegetation within source isolation areas. Inspections could be conducted annually and after significant rainfall events.
- Required corrective actions for continued function of drainage and erosion controls identified by periodic inspections.
- Vegetation management would be performed to maintain healthy growth for the species selected and intended use. The management provisions may regulate grass height, controlling noxious weeds, and seeding in damaged areas. Controlled burning could be used as a management tool for vegetation.

3.3.5 Construction and Operating Cost

This section presents the information used to estimate the cost for constructing and operating the various components included in this bounding scenario. Historical unit costs were adjusted for inflation where appropriate. The construction cost is estimated to be approximately $13.2 million. The annual O&M cost (without provisions for surface water monitoring at the POCs) is estimated to $5,000, which includes a 20% allowance for management, record keeping, and reporting. Additional details for the construction and operating cost estimates are provided below.

<u>Grade Reduction / Recontouring</u>

Under this bounding scenario, an extensive amount of earthwork is required. The grade reduction for the 903 Pad hillside is estimated to cost approximately $7.2 million. The general base capital costs for constructing a vegetative cover average around $13,800/acre for seeding and $29,000/acre for sod (EPA, 1999d). The cost to revegetate the 150 acres of disturbed area is estimated to be $2.1 million.

IA VOC Plume Recontouring

The construction cost for recontouring and revegetating the area above the IA VOC plume is estimated to be approximately $1.3 million. This cost estimate is based on using surplus soil from the 903 Pad hillside grade reduction for fill material.

Drainage Swales

Under this bounding scenario, drainage ditches would be constructed west of the IA VOC plume and west of the 903 Pad. In addition, drainage improvements for North and South Walnut Creek to remove existing culverts would also be converted to open vegetated channels. Capital cost for a vegetated swale in 1987 dollars is $4.90 to 9.00 per linear foot for a 15-foot wide channel (top width) by 1.5 foot deep and the O&M cost in 1991 dollars is about $0.58 per linear foot (EPA, 1999c). Using this cost information, the construction of the drainage ditches and channels is estimated to cost approximately $65,000 (adjusted for inflation) with average annual maintenance cost of $1,200. An additional allowance of $55,000 is included for channel stabilization provisions.

Breaching of Existing Ponds

For development of this bounding scenario, all ponds are assumed breached. The cost to fully breach and revegetate the existing ponds is estimated to be approximately $2.5 million. Removal and disposal of pond sediments is not included.

4.0 SCENARIO EVALUATION

The three bounding scenarios were evaluated against each other to assess the relative strengths, weaknesses, effectiveness and limitations of individual scenario components and to identify specific areas / drainages where an individual component may be well suited. Each scenario was assessed over a wide range of evaluation criteria in order to consider each component's strengths and weaknesses from various perspectives.

The evaluation criteria are not weighted to develop an overall score for each bounding scenario or to select one "winner" for development as an initial conceptual design. Instead, the objective of the scenario evaluation process was to develop evaluation results and other information to highlight differences between the various scenario components and to identify which scenario components could be utilized within specific drainages for inclusion in an initial conceptual design. The evaluation results were also used to further assess data gaps and to develop a path forward to resolve significant data gaps.

The evaluation results for the bounding scenarios are presented in Table A-10. The left hand column of this table lists the criteria that were evaluated. The center columns provide the evaluation result for each bounding scenario with respect to negative and positive qualities or performance of the scenario components as they relate to the evaluation criterion and each other. The right hand column provides the rationale for the evaluation results assigned to each bounding scenario. The rationale also addresses the relative strengths and weaknesses of each bounding scenario and discusses the applicability of individual scenario components within specific drainages.

Section 4.1 provides additional information describing how the evaluation criteria were developed. Section 4.2 presents the protocols used to evaluate the bounding scenarios. The evaluation results presented in Table A-10 are summarized in Section 4.3.

4.1 Evaluation Criteria

The FDOs were used as the starting point for developing the evaluation criteria. Table A-11 provides a cross-reference between the FDOs and the evaluation criteria. A reference to the source FDO is also provided at the end of each evaluation criterion listed in Table A-10 where appropriate. Additional performance measurements were added as evaluation criteria to supplement the FDOs. Relevant project DQOs (see Tab 2, Appendix A) were considered in developing the supplemental performance measurements. These supplemental criteria do not have a corresponding FDO reference listed on Table A-10.

Each criterion statement was developed in a manner that would allow assessment of the scenario's ability, reliability, extent, and confidence in achieving the FDO or performance measure. As such, the text of the evaluation criteria may not be the same as the originating FDO. Some FDOs were not included as evaluation criteria because these FDOs stipulate procedural or design actions that cannot be relatively assessed at this time. These FDOs are deferred and would be addressed during the development of the initial conceptual design. Other FDOs were divided into several evaluation criteria to allow a more detailed assessment of each scenario's attributes and characteristics covered by the FDO. Various FDOs were combined into a single evaluation criterion to avoid duplication and to avoid over- or under-emphasizing any particular scenario, attribute, or characteristic.

The evaluation criteria were grouped into the seven categories listed below to aid in the management and presentation of the evaluation results. Although some evaluation criterion could have been included in several different categories, each criterion was assigned to the most appropriate category to avoid duplication.

A. Erosion and Hydrology

B. Groundwater and Subsurface Considerations

C. Geomorphology and Long-Term Performance

D. Ecological Resources

E. Land and Water Use

F. Construction Considerations

G. Operations and Long-Term Stewardship

4.2 Evaluation Protocols

The protocols listed in Table A-12 were followed in evaluating the three bounding scenarios with respect to each other. Instead of assigning numeric values, each bounding scenario was qualitatively assigned an evaluation result of either "**–**", "**0**", or "**+**" to indicate its negative or positive qualities or performance relative to the evaluation criterion and to the other bounding scenarios. Where available, the evaluation results and relative comparisons were based on preliminary quantitative values (such as quantities of soil required and amount of acreage disturbed) based on preliminary estimates. Existing conditions or the anticipated conditions at completion of active remediation were factored into the evaluation results only to quantify the expected level of changes if the scenario was implemented.

The bounding scenarios were evaluated relative to each other. For example, if Scenario 1 was considered to be superior and Scenario 3 was significantly better than Scenario 2, then the results assigned to Scenarios 1, 2, and 3 would be "**+**", "**–**", and "**0**", respectively. If all the scenarios were considered equal with respect to the evaluation criterion, each scenario received a result of "**0**".

Where appropriate, a "**–**" or "**+**" result was assigned to the bounding scenario to reflect its overall positive or negative quality / performance with respect to the evaluation criterion. For example, if Scenario 1 was considered to negatively impact the Site with respect the evaluation criterion and the other two scenarios were considered equal, then the results assigned to Scenarios 1, 2, and 3 would be "**–**","**0**", and "**0**", respectively.

The evaluation results for each evaluation criterion are provided in Table A-10. The rationale and supporting information considered in assigning individual results is also provided in Table A-10. The rationale column highlights the areas where a particular scenario performed strongly or exhibited weaknesses compared to the other scenarios. The rationale also identifies variations in scenario performance at different site locations or drainages. For example, applicability of a certain component that would be a good choice for one drainage/sector or a weak choice for another was highlighted in the rationale column. The rationales were used to identify components for inclusion in an initial conceptual design.

4.3 Summary of Evaluation Results

This section summarizes the evaluation results presented in Table A-10 for each bounding scenario by each of the seven major evaluation criteria groups. The purpose of this section is to contrast the performance of each bounding scenario in meeting the stated objectives in specific areas. Additional documentation regarding of performance of the bounding scenarios is provided in Tab 2, Appendix G.2 (Geomorphic Evaluation) and Tab 3, Attachments B.2 (Erosion and Hydrology Evaluation).

It is noted that certain bounding scenarios may be negatively skewed due to the configuration of components included in the bounding scenario for evaluation. For example, Scenario 3 is negatively skewed with respect to ecological criteria solely because the scenario includes the breaching of the existing ponds as a bounding condition for evaluation of the erosional aspects of this scenario without surface water controls. It is recognized that application of the Pond Reconfiguration Strategy to the initial conceptual design may not be representative of the evaluation results developed for each of the bounding scenarios.

As previously stated, the evaluation results are not scored and there is no intention to select an overall winner. The objective of the evaluation process is to identify the relative differences in a meaningful way that can be used to identify specific components for an initial conceptual design. As such, individual scenario components from could still be included in an initial conceptual design to strengthen the overall performance of the final land configuration.

4.3.1 Erosion and Hydrology Criteria

The criteria under this group address the performance and reliability of the scenario components to maintain compliance with surface water standards at POCs under normal and realistic extreme conditions, and to control flooding. The effectiveness of each bounding scenario to maintain compliance with actinide surface water quality standards was evaluated using WEPP and HEC-6T computer codes. The results from this evaluation effort are presented in Tab 3, Attachment B.2.

The results indicate that the predicted actinide load at the terminal POCs (GS01 and GS03) for each bounding scenario is (on the average) lower than the predicted actinide loads at these two locations for conditions at the completion of active remediation (Scenario 0). However, the average actinide concentrations at the terminal POCs for all the bounding scenarios are predicted to be greater than 0.15 pCi/L over the design storm event (100-year, 6-hour). Although sediment and actinide loads are decreased, they are offset by a decrease in runoff emanating from the closure of the IA. As a result, a corresponding reduction in actinide concentration is not predicted. The WEPP and HEC-6T erosion and hydrologic evaluation may be further refined during the initial conceptual design to reflect the combined scenario component and to provide data over a wider range of conditions.

When compared to the other scenarios, the administrative control provided by batch release operation of detention basins (Scenario 2) provides the highest overall confidence and reliability to maintain compliance with the surface water quality standards at the POCs over a wide range of operating conditions. The detention basins perform better during and following severe storm events and following other abnormal conditions that might increase sediment loads (fires, drought, etc.). The detention basins are also most effective in controlling downstream flooding during and following storm events.

The source isolation components (Scenario 3) generally out performed Scenario 1 with respect to the predicted reduction in erosion and actinide load, especially in Woman Creek. The poor performance of Scenario 1 in Woman Creek appears to be extensive flushing of sediments from the off-channel wetland (WOC-02). This scenario did not perform as well as Scenario 2 with respect to actinide load, but achieved a lower predicted actinide concentration at GS01 (Walnut Creek) than predicted for Scenario 2. The removal of the ponds and associated sediments, which was included as a modeled component for Scenario 3, appears to be responsible for a significant reduction of the predicted actinide load at GS01 and GS03. Source isolation provides this least control features should actinide-bearing sediments enter into the drainage channels.

Passive operation of the flow-through detention ponds and wetlands (Scenario 1) would be less reliable than the detention basins due to a lack of administrative controls. The reliability of Scenario 1 also diminishes with increasing severity of storm events and abnormal conditions that increase sediment loads. The effectiveness of the wetlands would be subject to seasonal variations; however, the performance of the flow-through ponds would be expected to be relatively constant. Resuspension of sediments during large storm events would likely occur. The flow-through detention ponds and wetlands would desynchronize flood flows from different drainages. The desynchronization coupled with the retention capacity and controlled outlets of the flow-through detention ponds would tend to reduce the peak flow during the storm event and allow retained water to be dissipated over a longer period.

4.3.2 Groundwater and Subsurface Considerations Criteria

The criteria under this group address the ability of the scenario components to prevent migration of subsurface contaminants to surface water and to provide secondary controls should subsurface contaminants from known or unidentified sources enter into surface water.

The wetland vegetation and biological activity associated with Scenario 1 provides documented secondary capabilities to reduce certain nutrient, petroleum hydrocarbon, and metal concentrations.

The detention basins with batch release controls (Scenario 2) provide secondary administrative controls to allow additional management of accumulated runoff prior to offsite discharge if required. Detention basins that are operated with a permanent pool (wet pond) also provide secondary removal of certain contaminants (especially denitrification), but are less effective than flow-through detention ponds / wetlands.

The IA drainage diversions included in Scenario 3 could be installed to limit further expansion/migration of known groundwater plumes, but could not address unknown groundwater contaminants. Source isolation components do not provide any secondary reduction of contaminants that reach surface waters.

4.3.3 Geomorphology and Long-Term Performance Criteria

The criteria under this group address the longevity of the scenario components and their ability to resist long term geomorphic changes due to seismic activity, climatic changes, erosion, and mass wasting. Mass wasting of unstable hillsides along the drainages is the most significant geomorphic process that is evolving the landscape at the Site and has the potential to impact the integrity and performance of the scenario components. Changes in the climate over the next thousand years could significantly affect erosion rates due to changes in the amount of precipitation and the severity of precipitation events. Accurate predictions of potential climate changes over the next 1,000 years, however, are not available. In the absence of long-term climate predictions, the evaluation of the bounding scenarios was based on current climate conditions. The probability of a significant seismic event at the RFETS is low and all the scenario components can be designed to withstand the design basis seismic event.

Source isolation (Scenario 3) performs consistently better than other scenario components because the source isolation components directly address hillside instabilities and erosion where they are most likely to effect surface water quality.

The detention basins (Scenario 2) require continued maintenance to insure long-term performance and integrity. Although the detention basins could be located in areas that are less susceptible to direct impact from mass wasting, the earthen embankments are the most susceptible scenario component to catastrophic failure. Increase sediment loads and erosion could increase the long-term maintenance requirements.

The flow-through detention ponds and wetlands (Scenario 1) are most susceptible to mass wasting because they are located within the drainages at the base of the hillsides. The construction of wetlands within the drainages may also steepen the hillsides, which could increase the likelihood for mass wasting. Significant mass wasting and increases in sediment loads could significantly impair the long-term performance of the flow-though detention ponds and wetlands.

4.3.4 Ecological Resources Criteria

The criteria under this group address the ability of the scenario components to minimize impacts to ecological resources including endangered species, sensitive habitats, and wetlands. The ecological resources criteria are considered secondary objectives to maintaining compliance with surface water quality standards at POCs. However, inclusion of these secondary objectives to balance the needs of ecological resources against to requirements to maintain surface water quality is necessary to determine the acceptability of the final land configuration by regulatory agencies and stakeholders. Regardless of the scenario components chosen for the initial conceptual design, careful siting of the components should be exercised to minimize impacts and, where appropriate, enhance existing ecological resources. In addition, retaining the existing ponds (even if they are not required to maintain compliance with surface water quality standards) for wetlands preservation would be considered during the development of the initial conceptual design through the application of the Pond Reconfiguration Strategy.

Flow-through detention ponds and wetlands (Scenario 1) perform significantly better than the other scenarios against these criteria because these scenario components enhance the extent and value of existing wetlands and riparian areas, wildlife diversity, and habitat favored by the Preble's mouse.

Detention basins (Scenario 2) were sited in areas to minimize potential impact on existing wetlands and sensitive habitat, however, there is a measurable impact on these ecological resources. Detention basins would not enhance existing wetland functions or values, and would not likely enhance Preble's mouse habitats.

The evaluation results indicate that source isolation (Scenario 3) has the lowest performance with respect to maintaining and enhancing existing ecological resources. These negative impacts are due to breaching the existing ponds to evaluate the only performance of the source isolation controls to maintain compliance with surface water quality standards. The source isolation scenario components themselves do not negatively impact existing ecological resources. These negative results are not intended to deter the use of source isolation components, but are intended to be considered during the application of the Pond Reconfiguration Strategy during the initial conceptual design to determine the fate of the existing ponds. However, the source isolation scenario components do not enhance ecological resources.

4.3.5 Land and Water Use Criteria

The criteria under this group address the ability of the scenario components to accommodate the future use of the Site as open space and to reduce the impacts to off-site water management operations. In general, all three bounding scenario are about equal against this diverse set of criteria.

Source isolation components (Scenario 3) would not place any flow restrictions on surface water leaving the Site. However, unabated runoff from RFETS could exceed the capacity of existing downstream diversion structures (Broomfield Diversion Ditch) during severe storm events. Surface recontouring and erosion control features could be blended with natural topography to minimize visual distractions. Scenario components do not present any obvious man made structures or aesthetic concerns. However, open-space access restrictions to specific sectors may be needed to limit erosion.

Wetlands (Scenario 1) could reduce the quantity of water leaving the Site, which could require consultation and mitigation / augmentation to address any water depletion to the South Platte River. However, wetlands would be accessible as open space and could have a strong aesthetic appeal to visitors by providing increased diversity of wildlife.

The batch release operation of the detention basins (Scenario 2) would limit downstream water use to periods of batch discharge. Some water depletion to the South Platte River would be expected due to evaporation of water from the permanent pool. Consultation and mitigation / augmentation may be required to address any water depletion. The detention ponds would the most visible scenario component and may be considered an aesthetic distraction by the public. However, their performance is less sensitive to possible future land use changes. The detention basins would impose some limited access restrictions.

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4.3.6 Construction Considerations Criteria

The criteria under this group address the potential ecological and environmental impacts that may occur during construction. This criteria group also addresses construction costs and schedule.

Scenario 1 has a significant amount of construction in and around sensitive habitats and wetlands. This will require greater precautions during construction in order to prevent and minimize temporary or permanent damage to these areas. The construction or modification of wetlands would take longer to become fully effective after construction. This scenario is the least costly to implement and would require minimal reconfiguration, especially if the existing terminal ponds (Pond A-4, B-5, and C-2) are suitable for long-term operation as flow-through detention ponds.

The fundamental design principals associated with the detention basins (Scenario 2) are more understood and proven than the wetland or source isolation components. Detention basins would not be located in areas that would significantly impact ecological resources or cause erosion of actinide-bearing soils to surface water. The detention basins are more expensive to construct.

Scenario 3 has the least amount of construction in ecologically sensitive areas; however, it requires more construction activity in areas where actinide-bearing soils may be present. As a result, this scenario requires implementation of more extensive controls during construction to minimize fugitive dust and erosion to surface water. Depending on the extent of source isolation controls required to maintain compliance with surface water quality standards, construction cost could be high. However, source isolation components would have the lowest long-term operating costs.

4.3.7 Operations and Long-Term Stewardship

The criteria under this group address the long-term operational requirements and stewardship responsibilities imposed by each of the scenario components. Stewardship responsibilities include periodic maintenance, monitoring, physical controls, institutional controls and information management and assessment.

Stewardship responsibilities associated with the source isolation component (Scenario 3) would operate without operator intervention and would require the least amount of periodic maintenance and inspection. If continuous surface water sampling and monitoring were required, it would be subjected to largest range of flows.

The stewardship requirements for flow-through detention ponds and wetlands (Scenario 1) are less than Scenario 2, but greater than Scenario 3. Wetlands could require a higher level of monitoring until the wetlands were fully established. Maintenance requirements may be the greatest for wetlands because it relies on the most number and more complex scenario components. Sustaining the wetlands is contingent on a dependable water supply. As such, water availability after Site closure may limit the location and extent that wetlands can be utilized. When wetlands are well established, they are resistant to erosion and can self-repair damage resulting from serve storm events.

The detention basins (Scenario 2) have the greatest operational flexibility but they also have the greatest stewardship requirements, labor requirements, and operations and maintenance cost. The operational requirements for batch-release detention basins are well understood based on the existing ponds. However, periodic removal and management of sediments would be required to maintain detention capacity. Sample collection and flow monitoring would be very dependable because of the extensive control and management of runoff flows.

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TABLES

Table A-01
Summary of Process Steps to Develop Initial Conceptual Design

Activities to Develop initial conceptual design	Location of Activity Results
Define Objectives and Design Basis for LCDB Project	
Review Site information and project requirements to develop the Design Basis for the final land configuration at RFETS.	Performed during work plan development and documented in Tab 2, Appendix B.
Develop Potential Options for Land Configuration	
Develop a list of potential options for land configuration that could be implemented individually or in combination with each other to achieve project objectives.	Performed during work plan development and documented in Section 4 and Table 2 of the Draft LCDB Project Work Plan (see Tab 1).
Develop Bounding Scenarios	
Utilize list of potential land configuration options to develop three bounding scenarios that depict a spectrum of approaches to meet the reconfiguration goals and FDOs established for the project.	Development of the three bounding scenarios is presented in Section 2. Detailed descriptions for each bounding scenario are presented in Section 3
Evaluate Bounding Scenarios	
Evaluate each bounding scenario to identify the strengths and weaknesses of the various scenario components against various criterions.	The evaluation protocols and results are presented in Section 4.
Identify Scenario Components for Initial Conceptual Design	
Identify the most suitable scenario components by geographical area or drainage for inclusion and further development as the initial conceptual design.	The components and rationale for inclusion in an initial conceptual design are presented in Tab 3, Attachment C.

Table A-02
Summary of Scenario Components

Scenario Component	Scenario 1 Wetlands	Scenario 2 Retention	Scenario 3 Source Isolation
Common Components (Anticipated Conditions at Completion of Active Remediation)			
Enhance North Walnut Creek tributary drainage between Buildings 371 and 771 up to Building 130.	X	X	X
Enhance South Walnut Creek between North Perimeter Road and Building 750.	X	X	X
Grade IA to match 1994 aerial topography to provide overland flow.	X	X	X
Install ET covers over the Original Landfill, Present Landfill, and Solar Evaporation Ponds. Relocate existing flagstone steps used to passively treat the Present Landfill Seep.	X	X	X
Continue operation of existing three groundwater treatment systems. [A/]	X	X	X
Revegetate disturbed areas and closed roads.	X	X	X
Scenario Specific Components			
Flow-through detention pond / wetlands in North Walnut Creek.	X	---	---
Flow-through detention pond in South Walnut Creek.	X	---	---
Check dams in South Walnut Creek. [B/]	X	---	---
Flow-through detention pond / wetlands in Woman Creek / SID.	X	---	---
Terminal detention basin in Walnut Creek.	---	X	---
Terminal detention basin in Woman Creek.	---	X	---
903 Pad hillside diversion ditch north and east of Pond C-2.	---	X	---
Grade reduction and stabilization of the 903 Pad hillside.	---	---	X
IA VOC plume infiltration controls (contour for positive drainage, diversion ditch west side of IA VOC Plume, and ET provisions). [B/]	---	---	X
Diversion ditch west of 903 Pad. [B/]	---	---	X
Culvert removal and drainage channel stabilization for IA. [B/]	---	---	X

A/ East Trenches Plume System, Mound Area Plume System, and Solar Ponds Plume System.

B/ Could be applied to all bounding scenarios. For evaluation purposes, component was including under only one of the bounding scenarios. Inclusion of scenario component as part of an initial conceptual design is based on the individual evaluation results.

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Table A-03
Typical Removal Effectiveness by Wetland Design

Constituent	Shallow Marsh	Extended Detention 1/	Pond/Wetland System	Submerged Gravel 1/
Total Suspended Solids	83 ± 51%	69%	71 ± 35%	83%
Nitrogen, Total	26 ± 49%	56%	19 ± 29%	19%
Phosphorus, Total	43 ± 40%	39%	56 ± 35%	83%
Metals	36 to 85%	-80 to 63%	0 to 57%	21 to 83%

1/ Removal rates based on fewer than five data points.

Source: Winer, 2000.

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Table A-04
Estimated Wetland Acreage, Water Requirements and Water Availability

Drainage	Amount of Wetlands (acres)			Estimated Increase in Preble's Mouse Habitat (acres)	Percentage of Target Wetland Vegetation			Estimated Additional Water Required (acre-feet per year)	Estimated Post-Closure Drainage Basin Size (acres)	Estimated Water Available for Average and Dry Years (acre-feet)
	Existing	Enlargement and New	Total		Cattail-Bulrush Marsh	Willow-Cottonwood Riparian Area	Wet Meadow			
North Walnut Creek at Pond A-4 Discharge (GS11)	13.4	2.1 (NWC-01)	15.5	**0.6**	70%	30%	0%	8.5	390	65 / 33
South Walnut Creek at Pond B-5 Discharge (GS08)	6.5	1.4 (SWC-01)	7.9	0.4	20%	80%	0%	5.4	339	57 / 28
Walnut Creek between terminal ponds and Indiana Street (includes No Name Gulch)	18.7	6.4 (WAC-01)	25.1	1.9	50%	40%	10%	24	705	117 / 59
Subtotal Walnut Creek (GS03)	**38.6**	**9.9**	**48.5**	**2.9**				**38**	**1,434**	**239 /120**
South Interceptor Ditch at Pond C-2 Discharge (GS31)	3.1	--	3.1	---	---	---	---	---	191	32 / 16
Woman Creek at Indiana Street excluding SID	53.4	3.0 (WOC-01)	71.6	5.5	20%	80%	0%	12	1,777	296 / 148
		15.2 (WOC-02)			40%	50%	10%	57		
Subtotal Woman Creek (GS01)	**56.5**	**18.2**	**74.7**	**5.5**				**69**	**1,968**	**328 / 164**
Total LCDB Project Area	**95.1**	**28.1**	**123.2**	**9.4**				**107**	**3,402**	**567 / 284**

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Table A-05
Pond Reconfiguration Data for Scenario 1

Pond	Current Data at Spillway Crest			Reconfiguration Data for Permanent Pool Level		
	Surface Area (acres)	Volume (acre-feet)	Water Depth Average/Maximum (feet)	Surface Area (acres)	Volume (acre-feet)	Water Depth Average/Maximum (feet)
A-1	1.09	4.3	3.9 / ≈ 6	0.77	1.4	1.8 / ≈ 4 [1/]
A-2	3.31	28.0	8.5 / ≈ 20	3.31	11.9	3.6 / ≈ 4 [2/]
A-3	4.55	38.1	8.4 / ≈ 17	0.96	2.2	2.3 / ≈ 4 [3/]
A-4	8.65	98.6	11 / ≈ 27	8.65	98.6	11 / ≈ 27
B-1	0.94	3.5	3.7 / ≈ 7	Breach Dam Embankment		
B-2	1.17	6.63	5.7 / ≈ 10	Breach Dam Embankment		
B-3	0.54	1.72	3.2 / ≈ 5	Breach Dam Embankment		
B-4	0.39	0.55	1.4 / ≈ 3	Breach Dam Embankment		
B-5	6.02	73.7	12 / ≈ 30	6.02	73.7	12 / ≈ 30
C-1	1.54	5.28	3.4 / ≈ 6	1.01	2.7	2.7 / ≈ 3 [4/]
C-2	8.90	70.0	7.9 / ≈ 38	8.90	70.0	7.9 / ≈ 38
Landfill Pond	2.80	23.1	8.3 / ≈ 23	Breach Dam Embankment		

Source: Merrick, 1992

1/ Reconfiguration based on cutting down existing spillway by 3 feet to an approximate elevation of 5826 feet. No outlet structure would be provided; all runoff would flow through the spillway.

2/ Reconfiguration based on filling of pond to raise the bottom elevation to approximately 5816 feet. Amount of fill material required is estimated to be 26,000 cubic yards. Existing spillway would be retained at approximate elevation 5820 feet. No outlet structure would be provided; all runoff would flow through the spillway.

3/ Reconfiguration based on decreasing the height of the existing dam embankment so that spillway elevation would be at approximate elevation 5780 feet. No outlet structure would be provided; all runoff would flow through the spillway.

4/ Reconfiguration based on retaining existing outlet works and spillway at approximate elevations 5823 and 5826, respectively.

Table A-06
Potential Operation and Maintenance Activities for Scenario 1

Operational / Maintenance Activity	Frequency
Water quality sampling and flow monitoring at POCs.	Continuous
Inspect for damage and erosion after severe storms or abnormal events (droughts, prairie fires, etc.). Repair undercut or eroded areas at inlets/outlets, embankments, and check dams. Repair other components to maintain compliance with surface water standards.	As Needed
Inspect wetlands and riparian areas for non-native and invasive vegetation and remove where possible. Inspect inlet/outlet structures and check dams for proper operation and blockages. Clean and remove sediment and debris from inlet/outlet structures and check dams. Inspect for channel formation and short-circuiting. Inspect for wildlife management and mosquito control. Mow embankment side slopes. Adjust flashboards to maintain the appropriate water supply and/or depth within wetlands to prevent vegetation stresses and airborne dispersion of accumulated sediments.	Quarterly
Inspect embankment, inlet/outlet structures, emergency spillway, and check dams for deterioration, erosion, and damage. Remove unwanted vegetation and displace burrowing animals from embankment. Remove debris from emergency spillway. Inspect wetland vegetation for signs of stress. Harvest wetland plants "choked out" by sediment build-up and perform supplemental plantings if required. Monitor sediment level in wetlands, permanent pools, and forebays.	Annual
Remove accumulated sediments form forebays and dispose in an appropriate manner.	Every 2 to 7 years
Remove sediment from wetlands when plants are "choked" with sediment or the wetland becomes eutrophic. Dispose in an appropriate manner. Remove sediment from detention ponds when pool volume is significantly reduced. Dispose in an appropriate manner.	Every 20 to 50 years

Table A-07
Typical Removal Effectiveness by Detention Basin Design 1/

Constituent	Wet Pond	Dry Pond
Total Suspended Solids	80 ± 27%	61 ± 32%
Nitrogen, Total	33 ± 20%	31 ± 16%
Phosphorus, Total	51 ± 21%	20 ± 13%
Metals	29 to 73%	29 to 54%

1/ Values reported as average ± one standard deviation.
Source: Winer, 2000.

Table A-08
Potential Operation and Maintenance Activities for Scenario 2

Operational / Maintenance Activity	Frequency
Water quality sampling and flow monitoring at POCs (Indiana Street). Water level measurements in detention basins and embankment water level monitoring.	Continuous
Inspect for damage and erosion after severe storms or abnormal events (droughts, prairie fires, etc.). Repair undercut or eroded areas at inlets/outlets and embankments. Repair other components to maintain compliance with surface water standards.	As Needed
Inspect inlet and outlet structures for proper operation and blockages. Clean and remove sediment and debris from inlet and outlet structures. Water quality sampling and flow monitoring at terminal pond POCs.	Each Batch Discharge
Mow embankment side slopes.	Quarterly
Inspect embankment, inlet/outlet structures, and emergency spillway for deterioration, erosion, and damage. Remove unwanted vegetation and displace burrowing animals from embankment. Remove debris from emergency spillway. Test safety devices and structures. Monitor sediment level in permanent pools and forebays.	Annual
Remove accumulated sediments form forebays and dispose in an appropriate manner.	Every 2 to 7 years
Remove sediment from detention basin when permanent pool volume is significantly reduced or when the pond becomes eutrophic. Dispose in an appropriate manner.	Every 20 to 50 years

Table A-09
Potential Operation and Maintenance Activities for Scenario 3

Operational / Maintenance Activity	Frequency
Water quality sampling and flow monitoring at POCs (Indiana Street).	Continuous
Inspect for damage and erosion after severe storms or abnormal events (droughts, prairie fires, etc.). Repair eroded areas and revegetate to maintain compliance with surface water standards. Repair other components to maintain compliance with surface water standards. Implement vegetation management provisions.	As Needed
Inspect source isolation areas, drainages, and channel stabilization devices.	Annual

Table A-10
Evaluation Criteria and Results

	A. Erosion and Hydrology Considerations Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
1	Reliability and performance of the scenario to prevent erosion of actinide-bearing surface soils that would result in exceedence of the surface water quality standards at the POCs or limit the quality of the surface water to support any use classification. **(FDO GEN-01)** **(FDO SW-01)**	0	+	0	Scenario 1 – This scenario is less reliable than Scenario 2. The performance of this scenario tends to decrease with the severity of the storm (runoff, peak flow, and sediment load). Existing monitoring data indicates that exceedences can occur even at low TSS concentrations that may not be achievable under this scenario for all storm events. Actinide-bearing sediments could also be resuspended from the wetlands and drainage channels during large storm events. Resuspension of sediments has been identified as a possible contributor to historical exceedences. Performance of would also expected to be seasonal with lower effectiveness during the winter and early spring when the vegetation is dominant. The effectiveness would tend to increase during dry seasons of the summer because the vegetation would be more active and larger percentage of water passing through the wetlands would be absorbed. Scenario 2 – This scenario provides a high degree of control and confidence in achieving surface water quality standards by controlling release of runoff from the Site based on by pre-discharge sample results. The performance of this scenario is independent of storm intensity. Existing method of water retention followed by batch release has historically been effective in meeting surface water quality standards at the POCs. However, the 30-day moving average was previously exceeded at GS03 and GS08 during pond discharge. The average actinide concentrations at GS01 and GS03 are predicted to be greater than 0.15 pCi/L over the design storm event (100-year, 6-hour). Scenario 3 – This scenario includes measures to reduce erosion in areas that could impact surface water quality. This scenario reduces the amount of erosion and predicted actinide loading at the terminal POCs, previous soil erosion evaluation performed by the AME Project Team using WEPP and HEC-6T indicates that source isolation alone may not be adequate to ensure compliance with surface water quality standards at the POCs. Because sedimentation components and water discharge controls are not provided, this scenario is considered less reliable than Scenarios 1 and 2. Scenario 3 is more effective for Woman Creek than Walnut Creek due to grade reduction provisions.

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	A. Erosion and Hydrology Considerations Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
2	Capability of the scenario to operate and perform (comply with surface water standards) <u>during</u> a severe storm event (greater than the design storm of 100-year, 6-hour intensity). **(FDO GEN-04)**	0	+	0	Scenario 1 - A severe storm event would generate additional surface water flow and sediment loading. With increased flow and sediment load coupled with higher potential for resuspension of sediments from the wetlands and drainage channels, the performance of this scenario could result in actinide loading that may exceed surface water quality standards. Scenario 2 – Runoff in excess of the design capacity of the detention basins (includes pre-event capacity as well as runoff from a 100-year, 6-hour storm event) would overflow via the emergency spillway during a severe storm event. During overflow conditions, the shorten settling time could result in actinide loading that may exceed surface water quality standards during the storm event. However, the sediments in the retained runoff would settle prior to discharge. Therefore, the sediment load would be significantly reduced. Scenario 3 – A severe storm event would generate additional erosion resulting in additional surface water flow and sediment loading. Although the operation of this scenario is insignificantly impacted, the increased storm flow and sediment load coupled with higher potential for resuspension of sediments from the drainage channels increase the probably of exceeding the surface water quality standards. Severe storm events would have a greater impact in South Walnut Creek where fewer drainage and erosion controls would be applied.
3	Capability of the scenario to withstand damage to its design components <u>during</u> a severe storm event (greater than the design storm of 100-year, 6-hour intensity) and their ability to continue to operate and perform (comply with surface water standards) <u>following</u> a severe storm event. **(FDO GEN-04)**	0	+	–	Scenario 1 – Wetlands can withstand severe storm events very well. Although there could be some individual plant damage, it is likely that the wetland would recover after some time and continue to perform the sediment retention function. Scenario 2 – Each detention basin would be equipped with an emergency spillway to safely handle overflows without damaging the dam structure. Repairs are not expected to be required. After discharge of accumulated water from the severe storm event, the future performance of the detention basins would not be impaired. Scenario 3 – Severe storm events may result in localized erosion that would require repair to ensure the continued performance of drainage diversion ditches and erosion controls.

	A. Erosion and Hydrology Considerations Evaluation Criteria	Evaluation Results			Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
		Scenario 1	Scenario 2	Scenario 3	
4	Capability of the scenario to prevent downstream flooding from a 100-year, 6-hour storm event.	0	+	–	The evaluation of this criterion includes consideration of impacts to downstream water diversion and control structures including Broomfield Diversion Ditch and Woman Creek Reservoir. The Broomfield Diversion Ditch was constructed to preclude runoff from RFETS to flow into the Great Western Reservoir. This ditch has an estimated capacity of 40 cfs. The Woman Creek Reservoir, which has a capacity to retain runoff from a 100-year storm event, was constructed to preclude runoff from Woman Creek to enter into Standley Lake. However, credit for the flood control functions provided by Woman Creek Reservoir cannot be relied on because this reservoir is not controlled by DOE and is outside the bounds of the POCs. Flow from Mower ditch is also currently diverted into Woman Creek Reservoir. Scenario 1 – The flow-through detention ponds and wetlands would desynchronize flood flows from different drainages. The desynchronization coupled with the retention capacity and outlets of the flow-through detention ponds would tend to reduce the peak flow during the storm event and allow retained water to be dissipated over a longer period. However, the capacity of the Broomfield Diversion Ditch may be exceeded if the detention and outlet structures are not properly designed or fail. Under normal operating conditions, it is unlikely that the capacity of the Woman Creek Reservoir would be exceeded. Scenario 2 – Under normal operating conditions, the detention basins would prevent downstream flooding. During batch discharge, the flow rate would be regulated to preclude flooding and exceeding the capacity of the Broomfield Diversion Ditch. Uncontrolled overflow would only occur during severe storm events; however, the peak flow would be reduced. Scenario 3 – This scenario does not include any provisions to prevent downstream flooding. The capacity of the Broomfield Diversion Ditch would likely be exceeded. Although, exceeding the capacity of the Woman Creek Reservoir is unlikely if accumulated water were removed on a regular basis, the potential for flooding is higher than Scenario 1 because no retention components are included in this scenario.

	A. Erosion and Hydrology Considerations Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
5	Confidence in the ability of the scenario to consistently meet surface water quality standards over a wide variety of conditions that could increase the potential for soil erosion. For example, soil disturbance, prairie fires, drought, or other changes that remove vegetative cover.	–	0	–	Scenario 1 – Increase soil erosion would tax the ability of the scenario to consistently meet surface water quality standards. If wetland plants suffer damage due to drought or fire, the effectiveness of the scenario would decrease and could result in actinide loading that may exceed surface water quality standards. This situation is aggravated by the potential resuspension (even during a minor storm event) of any actinide-bearing sediments that accumulate within the wetlands if the plants are severely damaged. The confidence in the ability of this scenario to consistently perform in South Walnut Creek is lower than North Walnut and Woman Creeks due to the anticipated lack of an adequate and consistent base flow (especially with the elimination of imported water) and the historically larger actinide load at GS10. Scenario 2 – Longer settling times may be required prior to discharge to accommodate increases in the amount of soil erosion. If increased erosion persists, accumulated sediment may need to be removed more frequently. Additional maintenance and repair of dam embankments may be required under increased erosion conditions to prevent long-term deterioration of the embankment. However, the performance of the detention basins to preclude exceedences would not be affected. Scenario 3 – Increase erosion rates would degrade the ability of the scenario to consistently maintain surface water quality standards. This scenario is anticipated to provide a more consistent performance in Woman Creek because of the grade reduction and drainage controls employed for the 903 Pad hillside.

	B. Groundwater and Subsurface Considerations Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
1	Reliability and performance of the scenario to prevent migration of potential contaminants from groundwater that could cause an exceedence of the surface water quality standards at the POCs or limit the quality of the surface water to support any use classification. **(FDO GEN-01)** **(FDO SW-01)**	+	+	0	For all scenarios, the existing groundwater remediation systems (i.e., groundwater plume collection and treatment systems) are the primary measure to prevent migration of groundwater to surface water. Groundwater contaminants include VOCs, nitrate, and uranium. At completion of active remediation, nitrates from the Solar Ponds Plume are assumed to be below the water quality standard of 10 mg/L based on current decreasing trend of nitrate concentrations. Historical exceedence of VOC and uranium surface water quality standards at the POCs has not been identified as a concern. For developing the bounding scenarios, it was assumed that a groundwater plume system would not be installed for the IA VOC plume because the historical monitoring data indicates that this plume is not currently migrating. However, factors that could influence groundwater flow (increased infiltration with removal of impervious surfaces, elimination of underground utilities, and cessation of imported water) would be altered during the closure of the IA. Scenario 1 – Constructed wetlands are regularly used to provide reduction of nutrients, metals, and petroleum hydrocarbons in addition to reducing sediment loads. If other contaminants migrate into the surface water, wetlands could aid in their removal. Scenario 2 – If pre-discharge sampling indicates a problem, additional water management or treatment could be initiated. If the detention basins were operated with permanent pools (wet ponds), reduction of nutrients (especially denitrification) would also likely occur. Scenario 3 –This scenario includes drainage controls to minimize infiltration over the IA VOC plume to minimize the potential expansion / migration of the plume. [Subject to verification by the SWWB.]
2	Extent that the scenario enhances the performance or reliability of existing remediation systems (groundwater plume systems and ET covers) in preventing surface water exceedences via leaching of subsurface soil **(FDO SUB-01)** or groundwater transport **(FDO GW-01)**.	0	0	+	Scenario 1 – Provisions to enhance existing remediation systems are not included. Scenario 2 – Provisions to enhance existing remediation systems are not included. Scenario 3 – Includes drainage provisions designed to minimize infiltration that could result in expansion of the IA VOC plume. [Subject to verification by the SWWB.]

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	B. Groundwater and Subsurface Considerations Evaluation Criteria	**Evaluation Results**			**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
		Scenario 1	**Scenario 2**	**Scenario 3**	
3	Extent that the scenario prevents or eliminates subsurface pathways/conduits (e.g., footing drains, outfalls, UG utilities, or process line corridors) that could convey residual contamination to surface water. **(FDO SUB-02)**	**0**	**0**	**0**	These features (subsurface pathways and conduits) mainly reside within the IA. All three scenarios include removal, plugging, or other means to eliminate subsurface pathways and conduits as part of D&D/ER activities to close the IA. As such, each scenario is considered equal in eliminating subsurface pathways that could convey residual contamination to surface water. The adequacy and need to eliminate specific subsurface pathways and conduits is subject to verification by the SWWB. The elimination of subsurface pathways/conduits could have a more significant benefit on South Walnut Creek where a higher percentage of the base flow to this drainage may be from IA sources and imported water.

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	C. Geomorphology and Long-Term Performance Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
1	Extent of consequences in the event of catastrophic failure of scenario components resulting in an immediate endangerment of life or property.	0	0	+	Scenario 1 – Catastrophic failure of a flow-through retention basin would likely have fewer consequences than Scenario 2. Released waters would not likely cause significant flooding or exceed the capacity of downstream water diversion components. However, sediment resuspension may occur. Scenario 2 – The current terminal dams are designated as Hazard Classification III (Loss of life or offsite property damage is not expected) under State of Colorado Dam Safety Regulations (see 2 CCR 402-1). The current classification would also be appropriate for the new detention basins. Although catastrophic failure of the detention basins would not cause an immediate endangerment of life or property, failure could result in localized flooding and release of retained sediments. Floodwater would be retained in Woman Creek Reservoir, but the capacity of the Broomfield Diversion Ditch would likely be exceeded and would flow into the Great Western Reservoir. Scenario 3 – This scenario does not consist of any components that would result in an immediate endangerment of life or property in the event of catastrophic failure.
2	Long-term ability of the scenario to withstand probable seismic events. **(FDO SEIS-01)**	+	0	+	The probability of a seismic event at RFETS is considered low. Historical records indicate that should a seismic event occur, the maximum force would be magnitude 7 on the Richter scale. All LCDB structures would be designed to withstand this force without failure. The evaluation results are based on the sensitivity of specific scenario to seismic events. Scenario 1 – Due the smaller size of embankments and water storage volume, this scenario would be less sensitive to a seismic event than Scenario 2. Scenario 2 – Due to the larger size of embankments and water storage volume of the detention basins, this scenario would be more sensitive to a seismic event. Seismic design criteria would not be required per State of Colorado regulations based on size and hazard classification assigned to the detention basins. No inferred faults are located in the immediate vicinity of the Walnut Creek detention basin. An insignificant inferred fault is located just to the northwest of the Woman Creek detention basin. Scenario 3 – This scenario contains components that are the least sensitive to a seismic event. Differential movement of the positive drainage features for the IA VOC plume would not likely to result in significant damage.

	C. Geomorphology and Long-Term Performance Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
3	Long-term effectiveness, durability, and permanence of the scenario in the event of significant long-term (1,000 years) climatic changes.	0	+	+	The LCDB Project Team conducted a literature review of long-term predictions to assess climate changes at RFETS. It is concluded that long-term climate changes cannot be predicted on a site-specific basis with any confidence. In the absence of long-term predictions, it is assumed that current climate will remain unchanged over the next 1,000 years. As such, the long-term effectiveness, durability, and permanence of each scenario are based on considering current climate conditions. Scenario 1 – With adequate maintenance and water supply, the effectiveness, durability, and permanence of the scenario would be expected to remain unchanged. Scenario 2 – The effectiveness, durability, and permanence of the scenario is not dependent on climate changes. Scenario 3 – This scenario includes provisions to increase the stability of the Site.
4	Extent that scenario provides long-term stability of Site to prevent significant erosion and mass wasting in areas containing actinide-bearing soils that could result in exceedence of surface water quality standards at the POCs.	0	0	+	Scenario 1 – This scenario includes installing check dams within South Walnut Creek, which would serve to stabilize the drainage channel by reducing flow velocity. However, excavation for wetland construction may locally increase instability of adjacent slopes in North and South Walnut Creeks if the adjacent slopes are made steeper. South Walnut Creek is considered more unstable than North Walnut Creek. Increased instability would not be a concern in Woman Creek where the constructed wetlands are not adjacent to significant slopes. Scenario 2 – This scenario does not include any specific provisions to enhance long-term stability of the Site. However, the performance of this scenario is the least reliant on long-term stability to minimize erosion. The detention basins are located in areas where slope stability (especially with increased water table associated with the detention basins) should not be a concern. Scenario 3 – This scenario includes reducing the grade of the 903 Pad hillside and providing specific drainage controls to enhance the long-term stability of the Site.

	C. Geomorphology and Long-Term Performance Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
5	Long-term ability of the scenario to prevent or mitigate exposure of currently confined subsurface soils or groundwater plumes that could cause an exceedence of surface water quality standards at the POCs.	0	0	+	Scenario 1 – This scenario does not include any direct controls to prevent exposure of currently confined subsurface soils or groundwater plumes. Wetlands would continue to perform sediment removal functions regardless of actinide source (surface soils or newly exposed subsurface soils). Wetlands would also assist in the removal of other contaminants that may enter surface water via migration of groundwater plumes. Scenario 2 – This scenario does not include any direct controls to prevent exposure of currently confined subsurface soils or groundwater plumes. The detention basins would continue to perform sediment removal functions regardless of actinide source (surface soils or newly exposed subsurface soils). Should exceedences due to migration of groundwater plumes become a problem, the detention basins provide adequate flexibility for adding components. Scenario 3 – This scenario includes measures (grade reduction and drainage controls) to enhance Site stability to prevent exposure of currently confined subsurface soils. This scenario also includes provisions to minimize the potential expansion / migration of the IA VOC plume. [Subject to verification by the SWWB.]
6	Long-term ability of the scenario to prevent mass wasting, slumping, or other conditions that could negatively impact remediation systems or drainage / erosion controls. **(FDO GEN-02)**	–	0	+	The long-term stability of the ET Covers will be addressed during their design under a separate project. None of the scenarios would be expected to negatively impact the stability of the ET Covers or other existing / planned remediation systems. The evaluation results presented below address the long-term stability of individual scenario components. Scenario 1 – This scenario includes excavating the hillsides in order to accommodate new and enlarged wetlands. Increases in slope coupled with potential saturation of soil from water retained in the wetlands could increase the potential for slumping. Any mass wasting in the drainages could negatively impact the wetlands by increasing sediment loads. Scenario 2 – Local increase in water table associated with detention basins may increase potential for slumping, but there are no high-risk areas adjacent to the dam embankments. Increased erosion due to mass wasting would not affect the performance of the detention basins, but could result in increased maintenance to remove accumulated sediments. Scenario 3 – This scenario includes provisions to increase the stability of the Site, thus lower the potential for negative impacts to existing / planned remediation systems or drainage / erosion controls.

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	D. Ecological Resources Evaluation Criteria	**Evaluation Results: Scenario 1**	**Evaluation Results: Scenario 2**	**Evaluation Results: Scenario 3**	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
1	Ability of the scenario to minimize disturbance to designated Preble's mouse protection areas. **(FDO T/E-01, T/E-03, and T/E-04)** Ability of the scenario to maintain self-sustainable habitat conditions associated with designated Preble's mouse protection areas. **(FDO T/E-02, T/E-03, and T/E-04)** Extent that the scenario establishes additional or new self-sustainable habitat conditions associated with designated Preble's mouse protection areas. **(FDO T/E-02, T/E-03, and T/E-04)**	**+**	**0**	**–**	Preble's mouse habitat is primarily composed of a combination of wetland riparian areas. The protection areas also include adjacent parcels of upland habitat that may be used by the Preble's mouse. Scenario 1 – New and enlarged wetlands and riparian areas constructed under this scenario would be designed to encourage terrain and vegetation considered favored by the Preble's mouse. It is assumed that 30% (or 9.4 acres) of the total new and enlarged wetland area (28 acres) would be used to increase amount of desirable habitat areas available to the Preble's mouse. Approximately 60% of the expanded habitat would be located in Woman Creek. The gains for each drainage basin are presented in Table A-04. No impacts are expected on downstream habitat. Scenario 2 – The Walnut and Woman Creek detention basins would result in a maximum loss of existing Preble's mouse habitat of 0.5 and 2.0 acres, respectively. This scenario does not include development of features that would offset expected loss of available Preble's mouse habitat. However, potential Preble's mouse habitat may naturally develop along the fringes and headwaters of the detention basin depending on standing water characteristics. No impacts are expected on downstream habitat. Scenario 3 – This scenario would not produce additional potential Preble's mouse habitat. The existing habitats could be substantially reduced if the existing ponds were beached. No impacts are expected on downstream habitat.
2	Ability of the scenario to minimize disturbance to jurisdictional wetlands. **(FDO WET-01)**	**+**	**0**	**–**	Scenario 1 – Would involve some alterations of jurisdictional wetlands and could result in the net gain of approximately 28 acres of larger new or enlarged wetlands. The gains for each drainage basin are presented in Table A-04. If there is inadequate water to support wetlands under this scenario, the amount of downstream wetlands that could be developed may be restricted. Scenario 2 – The Walnut and Woman Creek detention basins would result in the permanent loss of 0.5 and 2.0 acres (maximum) of wetlands, respectively. No impacts are expected on downstream wetlands. Scenario 3 – The existing ponds support approximately 24 acres of wetlands. If the existing ponds were beached, these wetlands would likely be lost. No impact is expected on downstream wetlands. Provisions to minimize infiltration over the IA VOC plume, could have a negative effect to downgradient wetlands that are sustained by groundwater seeps.

	D. Ecological Resources Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
3	Ability of the scenario to prevent net loss of any existing major functions and values for jurisdictional wetlands. **(FDO WET-03)**	+	0	–	Scenario 1 – This scenario could provide a significant long-term net gain of additional functions and values associated with adding approximately 28 acres of wetlands. The largest gains in functional capabilities would occur in North Walnut and Woman Creeks. Scenario 2 – Some wetland functions and values would be replaced by retention of water in the detention basins, although in different form than present conditions. These functions and values include establishment of wildlife habitat depending on impoundment area and standing water characteristics, sediment retention, water quality transformation, and erosion control. Scenario 3 – This scenario incurs a greater loss of existing major functions and values for wetlands than the other scenarios if the existing ponds were breached.
4	Ability of the scenario to minimize disturbance to protected and special-interest plant communities present in the project area. These communities include wetlands, riparian woodlands, xeric tall grass prairie, and tall upland shrub lands. **(FDO VEG-04)**	+	0	–	Scenario 1 – This scenario could temporarily affect some wetlands and possibly riparian areas in North and South Walnut Creeks and in Woman Creek during construction. After implementing the scenario, a net gain of approximately 28 acres of special-interest communities would be established. Scenario 2 – The detention basins would result in permanent net loss of wetland and riparian areas in Walnut Creek and Woman Creek of 0.5 and 2.0 acres (maximum), respectively. Scenario 3 – If the existing ponds were breached, the disturbance to protected and special interest plant communities (including wetlands and riparian vegetation) is expected to include approximately 24 acres.
5	Extent that the scenario maintains hydrology suitable for maintaining existing and new wetlands that would remain after closure. So that these wetlands do not require artificial or human intervention to ensure long-term survival. **(FDO WET-02)**	+	0	–	Scenario 1 – This scenario includes installation of check dams and drainage components that would allow wetlands to naturally shrink or expand in response to available surface and groundwater conditions. Human intervention would not be required. Scenario 2 – The detention basins would not likely provide hydrologic conditions that would be suitable for unattended wetland maintenance. Designing the detention basins to provide slow seepage of accumulated runoff would be an important feature to sustain seasonal or permanent wetlands and riparian areas along the existing stream channel and could provide potential habitat for the Preble's mouse down gradient of the detention basin. This feature would be more significant in Woman Creek, which accounts for 80% of the expected downstream wetland losses due to installation of the detention basins. Scenario 3 – Hydraulic components to provide for the unattended maintenance of wetland or riparian areas are not included in this scenario.

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	D. Ecological Resources Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
6	Ability of the scenario to minimize disturbance to wildlife habitats, especially identified sensitive habitats (i.e., breeding sites and preferred foraging areas). **(FDO WILD-01 and WILD-02)**	+	0	–	Scenario 1 – Some temporary construction disturbances would occur in North and South Walnut Creeks and in Woman Creek. Long-term disturbances would be relatively minor and probably less extensive than current conditions. Scenario 2 – Basin construction and inundation of retained water are likely to cause relatively more displacement than Scenario 1. Potential and existing Preble's mouse habitat and songbird riparian areas would be affected. Scenario 3 – If the existing ponds were breached, waterfowl breeding sites could be adversely impacted.
7	Ability of scenario to maintain self-sustaining target plant community conditions to ensure long-term survival without human intervention. **(FDO VEG-01 and VEG-05)**	–	0	0	Scenario 1 – This scenario consists of larger amount of wetland plant communities that are dependent on having a reliable water source to ensure long-term survival. The availability and quantity of the future water supply conditions at RFETS after closure are currently being assessed by the SWWB Project Team and are not fully understood at the present. As such, this scenario could have a higher reliance on human intervention to ensure that an adequate and reliable water supply is available to ensure long-term survival. Scenario 2 – Because this scenario does not rely on plant communities that require dependable water supply to ensure long-term survival, the plant communities would likely be self-sustaining without human intervention. Scenario 3 – Same as Scenario 2.

	E. Land and Water Use Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
1	Ability of the scenario to incorporate open-space land use values. **(FDO USE-01 and VEG-01)**	+	0	0	All scenarios would include access restrictions to ET covers and groundwater remediation systems. Scenario 1 – Additional restrictions to open-space access and values would not be included under this scenario. Wetlands and riparian habitats would be accessible as open space. Scenario 2 – Limited access restrictions may be required to certain portions of the detention basins (inlet and outlet works) and to preclude recreational use (swimming and fishing) of impounded water. Scenario 3 – Open space land use values over most of the Site would be compatible with this scenario because minimum control components are presence. However, trails and other uses that could increase erosion within areas susceptible to erosion of actinide-bearing soil (IA and 903 Pad) could be restricted if the overall performance of scenario is based on minimizing erosion from these areas.
2	Extent that the scenario minimizes the inclusion of aesthetic distractions such as water catch basins, culverts and barriers. When such structures are required, they should be designed to minimize aesthetic distraction by blending the structure with the existing landscape to the extent practical. **(FDO GEN-05)**	0	–	0	This evaluation is based on consideration the several visible man made structures (ET Covers) will remain following the end of active remediation regardless of the scenario. Scenario 1 – This scenario utilizes natural processes and components that should not be readily discernable as man-made structures. This scenario would create a low aesthetic distraction. Scenario 2 – The Walnut and Woman Creek detention basins would be visible from Indiana Street as well as from locations on-site. Excavation of the basins below current grade and flattening embankment slopes could lower the overall basin profile to reduce their visibility. Specifically, the embankment running to the north of the Woman Creek basin can be blended with the existing landscape. However, these provisions would add to the cost to construct the basins. Scenario 3 – The visual impact of this scenario is considered similar to Scenario 1. Recontouring of the 903 Pad hillside could be accomplished to blend with the natural topography to minimize any aesthetic distractions. Engineered drainages would be more visible, but could be designed to limit lines of sight and blend with the natural surroundings.
3	Ability of the scenario to avoid conflicts with known cultural resources present in the LCDB project area.	0	0	0	There are no known cultural resources present in the LCDB project area. As such, none of the scenarios would cause any interferences or conflicts.

	E. Land and Water Use Evaluation Criteria	Evaluation Results			Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
		Scenario 1	Scenario 2	Scenario 3	
4	Ability of the scenario to reduce the impact of off-site water management operations (use of surface water after it leaves the site). Potential for water depletions to the South Platte River. **(FDO T/E-04)**	–	0	+	It is noted that offsite water management is currently restricted by the Woman Creek Reservoir and the Broomfield Diversion Ditch. Scenario 1 – Surface water would leave the Site whenever the flow is in excess of scenario needs (wetland evapotranspiration and retention capacity). Expansion of wetlands would reduce the overall quantity of surface water that would naturally leave the Site. Offsite flow is not likely during dryer months. The estimated additional water required to sustain the new and enlarged wetlands is estimated to be approximately 107 acre-feet per year (see Table A-04). If all the existing wetlands are retained, the net additional depletion to the South Platte River is estimated to be 107 acre-feet per year. As such, offsite water management operations (including depletions to the South Platte River) could be negatively impacted. Scenario 2 – Offsite water uses would not be restricted since accumulated surface water would be discharged after testing confirms the acceptability of the water quality. The quantity of water discharged may be reduced due to evaporation and infiltration from the detention basins. The evaporative losses from Walnut and Woman Creek Detention Basins are estimated to be approximately 24 and 17 acre-feet per year. These evaporative losses are based on assuming the average water surface area would be 25% of the maximum water surface water and using an average annual pan evaporation rate of 40 inches per year. As such, the overall amount of water depletion to the South Platte is estimated to be approximately 41 acre-feet per year. Elimination of existing ponds and wetlands could offset the amount of water depletion. Offsite water management would be restricted to period of batch discharge. Scenario 3 – Source isolation places no flow restrictions on surface water leaving the Site. As such, this scenario imposes the least amount of restrictions for offsite water management. However, unrestricted storm runoff flow from Walnut Creek could exceed the capacity (40 cfs) of the Broomfield Diversion Ditch. With the elimination of the existing ponds, no water depletions to the South Platte River would be expected.

	E. Land and Water Use Evaluation Criteria	Evaluation Results			Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
		Scenario 1	Scenario 2	Scenario 3	
5	Ability of the scenario to provide continued operation of third party, on-site, water supply ditches (McKay, Kinnear, Smart, and Upper Church Ditches).	0	0	0	For the purpose of this evaluation criterion, it is assumed that Kinnear and Upper Church Ditches would not be used in the future. It is also noted that Mower Ditch is no longer used for water supply. Scenario 1 – This scenario includes wetland components located on Woman Creek. No interference with the operation of the McKay and Smart Ditches would be anticipated. These components could interfere with the operation of Kinnear Ditch if used in the future. Scenario 2 – This scenario includes a detention basin located on Woman Creek. No interference with the operation of the McKay and Smart Ditches would be anticipated. The Woman Creek Detention Basin would interfere with the operation of Kinnear Ditch if used in the future. Scenario 3 – This scenario would not effect operation of third party, on-site, water supply ditches.
6	Extent that the scenario impacts existing easements and mineral rights.	0	+	–	For all scenarios, restrictions on easement and mineral right holders would be required to maintain the integrity of the ET Covers and to preclude encroachment into groundwater plumes. Scenario 1 – Execution of existing easements and mineral rights would be restricted to preclude increase runoff and sediment loads that would interfere with the performance of the scenario components. Specific drainage and erosion controls may need to be imposed on easement and mineral right holders. Scenario 2 – Execution of existing easements and mineral rights would be less restrictive than Scenario 1 because the performance of the detention basins are less sensitive to land surface configuration changes. Alteration of watersheds that would allow runoff from areas susceptible to erosion of actinide-bearing soils to bypass a detention basin would need to be restricted. Scenario 3 – This scenario would required the greatest amount of restrictions to preclude distribution of any surface or subsurface soils that could result in exceedence of the surface water quality standards.

	F. Construction Considerations Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
1	Extent that the scenario minimizes cost for construction. **(FDO GEN-03)**	**0**	**–**	**–**	Scenario 1 – If the existing terminal ponds (Ponds A-4, B-5, and C-2) can be converted to flow-through detention ponds, the construction cost is estimated to be between \$2.3 million and \$3.5 million. If new flow-through detention ponds are required, the construction cost is estimated to be between \$5.3 million and \$8.2 million. Scenario 2 – The total construction cost for new detention basins is estimated to be between \$9.0 million and \$14.6 million. Scenario 3 – The construction cost is estimated to be approximately \$13.2 million.
2	Ability of the scenario to preclude interference with previous remedial actions during construction. **(FDO GEN-02)**	**0**	**0**	**–**	Scenario 1 – Based on the location of constructed components, this scenario should preclude interference with previous remedial actions. Scenario 2 – Based on the location of constructed components, this scenario should preclude interference with previous remedial actions. Scenario 3 – Grade reduction of the 903 Pad hillside would include areas that would be remediated as part of the 903 Pad action. Although no longer operational, the grade reduction could also alter the 881 Hillside French Drain. Integration to prevent degradation or impact to these remedial actions would be required.

	F. Construction Considerations Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
3	Length of time required to design, construct, and start-up the scenario.	–	0	0	The final design, construction, and start-up of all three scenarios assumes that components are constructed sequentially, first one drainage and then the other. This phase construction would extent the schedule, but allows mobilization of a smaller construction force, improves construction oversight, and limits impacts due to construction activities. Additionally, lessons learned in one drainage can be incorporated into the subsequent construction of components in the other drainage. The estimates for final design are based on obtaining advance approval of decision documents. Scenario 1 – Design and construction of the wetlands and flow-through detention ponds would be accomplished in 24 months (two construction seasons). This includes an initial 6-month period to complete the final design (does not include the 12 to 24 month period to obtain water level measurement to assess site suitability) followed by construction of the Walnut Creek components. The Woman Creek components would be constructed the following year. In Colorado's Front Range settings, 2 to 5 years are typically required before wetlands become fully established to achieve peak performance for sediment removal and water quality transformation functions. Scenario 2 – Design and construction of the detention basins would be accomplished in 24 months (two construction seasons). This includes an initial 10 to 14-month period to complete final design (including time for approval by the State Engineer) followed by construction of the Walnut Creek basin. The Woman Creek basin would be constructed the following year. Upon completion of physical construction, the detention basins would be immediately available for operation. Scenario 3 – Design and construction of the recontouring/regarding components would be accomplished in approximately 18 months. This includes an initial 6 to 9-month period to complete the final design (including soils investigation). Component construction would be completed in phases to minimize the amount of area disturbed at any given time. Upon completion of physical construction, it would take approximately one season for vegetation to become fully established.
4	Ability of the scenario to minimize ecological disturbance during construction.	+	0	–	Scenario 1 – Temporary Preble's mouse habitat disturbance during construction of new wetlands would occur in the North Walnut, South Walnut, and Woman Creeks. Scenario 2 – Limited impact on ecological resources during construction. Approximately 20 acres of established vegetation would be temporarily disturbed during construction. Scenario 3 – Construction would have minimal impact on Preble's mouse, but would reduce available wetlands by approximately 24 acres to support other ecological resources. More than 140 acres of established vegetation would be temporarily disturbed during construction.

	F. Construction Considerations Evaluation Criteria	Evaluation Results: Scenario 1	Scenario 2	Scenario 3	Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
5	Ability of the scenario to control erosion of actinide-bearing soils, thus preventing exceedences of surface water standards during construction.	0	+	–	Scenario 1 – The wetland and flow control components constructed in this scenario would require the disturbance of sediments in existing ponds and drainage channels. Additional runoff and erosion controls may be required in North and South Walnut Creeks during construction to prevent or mitigate resuspension of actinide-bearing sediments from these construction areas. Based on historical monitoring results at GS10 and the planned removal of sediments from Ponds B-1, B-2, and B-3, the need for erosion controls during construction is more important for South Walnut Creek. Controls would not likely be necessary for Woman Creek due to the current segregation provided by the SID. Scenario 2 – The components of this scenario are constructed in areas where the actinide concentrations are negligible and are therefore erosion is not a significant concern beyond normal construction controls and considerations. Scenario 3 – Implementation of this scenario would require significant earth moving and construction activities in areas where actinide-bearing soils are presence. This would require extensive runoff and erosion controls during construction. If the existing ponds were breached, sediment management and controls to minimize resuspension during and after construction activities would be required.
6	Extent that the fundamental principles involved in the design and construction of the scenario are well understood and proven such that there is a high level of confidence that the scenario can be successfully implemented.	0	+	0	Scenario 1 – The construction of new and enlarged wetlands is a mature technology. However, the confidence to accurately predict the settling performance of this scenario is significantly less than Scenario 2, especially for large or severe storm events. The availability of surface water is not fully known (see Data GAP-0101) and could significantly impact wetland performance. Scenario 2 – Use of detention basins for sediment removal is a mature technology and poses no significant technical challenges for implementation. Retention and batch release has been historically successful at RFETS. Scenario 3 – Utilization of source isolation is less proven than the other scenarios to maintain compliance with surface water quality standards at the POCs. The confidence to accurately predict soil erosion and actinide migration of this scenario is significantly less than Scenario 2.

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	F. Construction Considerations Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
7	Extent that the scenario can be constructed as designed without delay or cost increase.	0	0	0	Scenario 1 – The construction methods associated with wetlands and flow control devices are standard and well proven. Delays or cost increases are not expected. Scenario 2 – The construction of an earthen detention basin utilizes standard, well-proven construction methods. Delays or cost increases are not expected. Scenario 3 – Earth moving for regrading and recontouring to promote positive drainage utilizes standard, well-proven construction methods. Delays or cost increases are not expected.
8	Extent that the scenario minimizes the release of airborne particulate matter during construction, especially particulates that may contain actinides.	0	0	–	Scenario 1 – Between 60,000 and 310,000 cubic yards of soil and sediment may be moved during construction. Actinide-bearing sediments from existing ponds and drainage channels would need to be managed to construct new and enlarged wetlands. Scenario 2 – Between 390,000 and 580,000 cubic yards of soil and sediment may be moved during construction. Actinide-bearing sediments from existing ponds and drainage channels would need to be managed to construct the detention basins. However, the amount sediment removed from the drainage channels would be less than Scenario 1. Approximately 286,500 cubic yards of the earthen fill would be used to construct the dam embankments. A majority of this fill material would likely be imported from offsite borrow sources and would not contain actinides above background. The detention basins are located in areas with little or no actinide-bearing soils / sediments that would be subject to disturbance. Scenario 3 – Between 1,550,000 and 2,000,000 cubic yards of soil and sediment may be moved during construction. The grade reduction of the 903 Pad hillside would involve a large amount of soil that could potentially contain actinides. If the existing ponds were breached, approximately 335,000 cubic yards of soils and sediments from existing embankments and drainage channels may need to be managed. Some of these soils and sediments may contain actinides. As such, this scenario has a higher potential of airborne particulates containing actinides than the other scenarios.

	G. Operations and Long-Term Stewardship Evaluation Criteria	Evaluation Results			Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
		Scenario 1	Scenario 2	Scenario 3	
1	Extent that the scenario minimizes need for long-term operations and provides unattended, passive operations. **(FDO GEN-03)**	**0**	**–**	**0**	Scenario 1 – Operation of the wetlands are passive. Some manual control of the flow through devices would be necessary to adjust levels through initial establishment and seasonal changes. Scenario 2 – Operation of the detention basins would require continuous monitoring for basin level and periodic sampling prior to batch releases. Discharge operations would be performed manually. Excavation of sediment from the basins would require significant activities every 10 to 25 years. Scenario 3 – All scenario components are passive and require minimal long-term operations.
2	Extent that the scenario provides operational flexibility.	**0**	**+**	**–**	Scenario 1 – Standing water wetlands and flow-through detention ponds would be designed to allow adjustment of retained water depth. Wetlands would provide operational flexibility in their ability to aid in the reduction of nitrates and biodegradation of VOCs. Scenario 2 – Detention basins would allow a wide range of operational modes to be accommodated. Discharge of accumulated water could be controlled to correspond to suitable conditions or could be terminated when required. The detention basins could be converted to flow-through operation in the future is response to monitoring results. Permanent pools in the detention basins would provide denitrification capabilities. Components to allow treatment of retained water could be added should the need arise. Scenario 3 – This scenario does not provide any operational flexibility.
3	Extent that the scenario minimizes impacts to operation of remediation systems. **(FDO GEN-02)**	**0**	**0**	**0**	None of the scenarios would impact existing or planned remediation systems (groundwater plume systems and ET covers).

	G. Operations and Long-Term Stewardship Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
4	Extent to which the scenario minimizes long-term stewardship for **periodic maintenance and inspection** to ensure adequate performance of land configuration components including physical and institutional controls. **(FDO GEN-03)**	**0**	**0**	**+**	Scenario 1 – Maintenance of the wetlands and flow through components would require a minimal amount of activity (replanting and infrequent sediment removal). The level of effort would be high initially until wetland plants are well established. After 2 to 5 years, maintenance activities would be significantly reduced with the self-sustainability of the wetlands. Long-term maintenance (if required) would only be necessary after large storm events. Excavating accumulated sediments or raising the outlet elevation may be periodically required to maintain adequate capacity of flow-through detention ponds for flow control and deep-water wetlands for nitrate reduction. Scenario 2 – Based on current requirements, the detention basins would be subjected to a detailed annual safety inspection. The inspection would include assessing the structural integrity of the dam embankment and testing outlet operation. Repairs and maintenance would be completed as required based on inspection findings. Regular maintenance would include removing trees, burrowing animals, etc. Accumulated sediment would be excavated from the basins every 10 to 25 years. Scenario 3 – Maintenance activities would include minor repairs to drainages and hillsides following large storm events. The extent of these activities would be less than the other scenarios.

	G. Operations and Long-Term Stewardship Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
5	Extent to which the scenario minimizes long-term stewardship for **periodic monitoring** to ensure adequate performance of land configuration components including physical and institutional controls. **(FDO GEN-03)** Ease with which the scenario allows for surface water monitoring to evaluate performance and compliance. **(FDO SW-02)**	0	+	–	Scenario 1 – Because flow at the POCs could occur throughout the year, continuous sampling and monitoring would be performed to assess wetland performance and compliance with surface water quality standards. Monitoring could be more extensive during the initial start-up period and would be reduced once the wetlands are fully established and demonstrate a consistent level of performance. Frequent inspection and maintenance would be required to ensure that monitoring and sample collection equipment is functional at all times. Flow-through detention ponds would regulate flow fluctuations at the monitoring locations; as such, measurements would be more reliable than Scenario 3. Scenario 2 – Water levels in the detention basins and other safety parameters (water level in piezometers) would be continuously monitored. On-line instruments that display and alarm remotely could be used to minimize operational personnel. Pre-discharge sampling would be conducted to ensure water quality. Surface water monitoring would only be required during batch discharge thus reducing the number of samples required to be collected. Because discharges would be regulated, flow measurement and sample collection would be very reliable. Pre-discharge inspection of monitoring equipment would only be required prior to batch discharges. The level of accumulated sediment in the basins would be measured annually. Scenario 3 – Because flow at the POCs could occur throughout the year, continuous sampling and monitoring would be performed to assess compliance with surface water quality standards. Monitoring could be more extensive during the initial start-up period and would be reduced once the scenario components had demonstrated a consistent level of performance. Frequent inspection and maintenance would be required to ensure that monitoring and sample collection equipment is functional at all times. Flow at the POCs would not be regulated; as such, flow measurement and sampling equipment would need to handle large flow variability and therefore could provide less reliable results.

	G. Operations and Long-Term Stewardship Evaluation Criteria	Evaluation Results			Rationale for Evaluation Results (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
		Scenario 1	Scenario 2	Scenario 3	
6	Extent to which the scenario relies on **physical controls** (i.e. containment structures, and access barriers) that required long-term stewardship to protect human health and the environment.	0	–	+	All three scenarios require physical controls for the ET Covers and groundwater plume systems. Scenarios were evaluated based on their reliance of other physical controls to maintain compliance with surface water quality standards. It is noted that reliance on physical controls is more desirable than institutional or administrative controls. Scenario 1 – This scenario relies on physical controls (wetlands and ponds) to provide passive sediment removal. However, these controls have the benefit of being passive devices. Scenario 2 – This scenario relies on physical controls to detain water prior to discharge that are more extensive than the other scenarios. These controls also require operator intervention to function properly. Scenario 3 – The scenario relies of the least amount of physical controls (drainage diversion structures) and would function without operator intervention.
7	Extent to which the scenario relies on **institutional / administrative controls** (i.e. easements, deed restrictions, etc.) that required long-term stewardship to protect human health and the environment.	0	+	–	Regardless of the scenario, institutional/administrative controls would be required. The scenarios were evaluated based on the degree to which continued functioning of these controls are required to ensure compliance with surface water quality standards. Scenario 1 – The performance of this scenario relies on institutional controls to restrict or control activities (such as gravel mining) that may increase erosion and runoff upstream of the wetlands and flow-through detention ponds. This scenario requires minimal administrative controls. Scenario 2 – This scenario has the least reliance on institutional controls. Increase sediment loads due to mining activities would have a lower impact on long-term performance than the other scenarios. This scenario does rely on long-term administrative control to provide properly management of accumulated water for discharge. Scenario 3 – This scenario has the most reliance on institutional controls to restrict or control activities and access to areas that may increase erosion rates of actinide-bearing soils. This scenario requires minimal administrative controls.

	G. Operations and Long-Term Stewardship Evaluation Criteria	**Evaluation Results** Scenario 1	Scenario 2	Scenario 3	**Rationale for Evaluation Results** (Scenario 1 – Flow-Through Detention Ponds/Wetlands, Scenario 2 – Batch Release Detention Basins, Scenario 3 – Source Isolation / Drainage and Erosion Controls)
8	Extent to which the scenario minimizes long-term stewardship for **information management / periodic assessment** to evaluate and document site information, scenario performance, or need for system enhancement.	–	+	0	Scenario 1 – This scenario presents the most complex operational scheme of the three bounding scenarios and would require more extensive information management activities. Information management would be required understand the performance of the entire system, influence of changing environmental conditions (dry versus wet conditions), predict response to future events, and evaluate the need for enhancements. More frequent monitoring results would need to be generated, evaluated, and managed. Scenario 2 – Information management for this scenario would include pre-discharge sampling, discharge monitoring, and annual safety inspections. Because of the limited number of batch discharges, this bounding scenario is expected to generate the least amount of information. Scenario 3 – Information management for this scenario would include continuous monitoring of flow and water quality sampling at the POCs. A high level of assessment would also be required during the initial operations to ensure proper functioning of the scenario components.
9	Extent that the scenario minimizes life-cycle cost for long-term stewardship, operation, and maintenance. **(FDO GEN-03)**	0	–	+	The below operational cost estimates only cover the components specifically included in each bounding scenario. The operational costs do not include surface water monitoring for the scenario components. O&M costs associated with maintaining other remediation systems (ET covers and groundwater plume systems) and other Site infrastructure (remaining roads and other structures) are also not included. Scenario 1 – The annual O&M cost is estimated to be $275,000. Scenario 2 – The annual O&M cost is estimated to be $765,000. Scenario 3 – The annual O&M cost is estimated to $5,000.

Table A-11
FDO and Evaluation Criterion Cross-Reference

FDO Identifier	Evaluation Criterion Identifiers
GEN-01	A.1 and B.1
GEN-02	C.6, F.2, G.3, and G.4
GEN-03	F.1, G.1, G.5, and G.9
GEN-04	A,2 and A,3
GEN-05	E,2
GEN-06	Deferred to CDR
GW-01	B.2
SEIS-01	C.2
SUB-01	B.2
SUB-02	B.3
SW-01	A.1 and B.1
SW-02	G.5
SW-03	Deferred to CDR
T/E-01	D.1
T/E-02	D.1
T/E-03	D.1
T/E-04	D.1 and deferred to CDR
USE-01	E.1
VEG-01	D.7 and E.1
VEG-02	Deferred to CDR
VEG-03	Deferred to CDR
VEG-04	D.4
VEG-05	D.7
VEG-06	Deferred to CDR
WET-01	D.2
WET-02	D.5
WET-03	D.3 and deferred to CDR
WILD-01	D.6
WILD-02	D.6 and deferred to CDR

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Table A-12
Evaluation Protocol

General Protocols:

- Evaluation criteria are based on FDOs and additional performance measures (based on project DQOs) to supplement the FDOs.
- The reliable and confidence of the scenario to satisfy the FDOs was evaluated.
- Evaluation criteria are not included for FDOs that cannot be applied on an individual scenario basis. These non-discriminatory FDOs will be assessed during the design phase.
- The bounding scenarios were evaluated relative to each other; not against existing conditions, anticipated conditions at completion of active remediation, or any other "Base Case". However, existing conditions or anticipated conditions at completion of active remediation were used to quantify the expected level of changes if the scenario were to be implemented.

Evaluate Results Column:

- For each evaluation criterion, a "–", "**0**", or "**+**" result was assigned to each bounding scenario.
- A "**0**" indicates that the scenario is predicted to provide an average quality or performance against that evaluation criterion when compared to the other scenarios.
- A "**+**" indicates that the scenario is predicted to be significantly better or has more positive qualities or performance relative to the other scenarios.
- A "–" indicates that the scenario is predicted to be significantly weaker or has more negative qualities or performance relative to the other scenarios.
- If there is no significant difference between the scenarios, all scenarios received a "**0**". Assigning "**+**" or "–" to each scenario was avoided.
- The evaluation results ("–" or "**+**")were assigned to the bounding scenarios to reflect its overall positive or negative quality / performance with respect to the evaluation criterion.

Rationale for Evaluation Column:

- The reasons why each scenario received a "–", "**0**", or "**+**" are provided.
- Although the evaluation result applies to the entire scenario, comments on the suitability and performance of individual scenario components to specific areas or drainages were included in the rationale column.
- The rationale comments were used to identify components for inclusion in an initial conceptual design.
- Quantitative values are included in the rationale column where they are available. (Examples of quantification include cubic yards of excavation, acres of impact, and months for construction.)

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FIGURES

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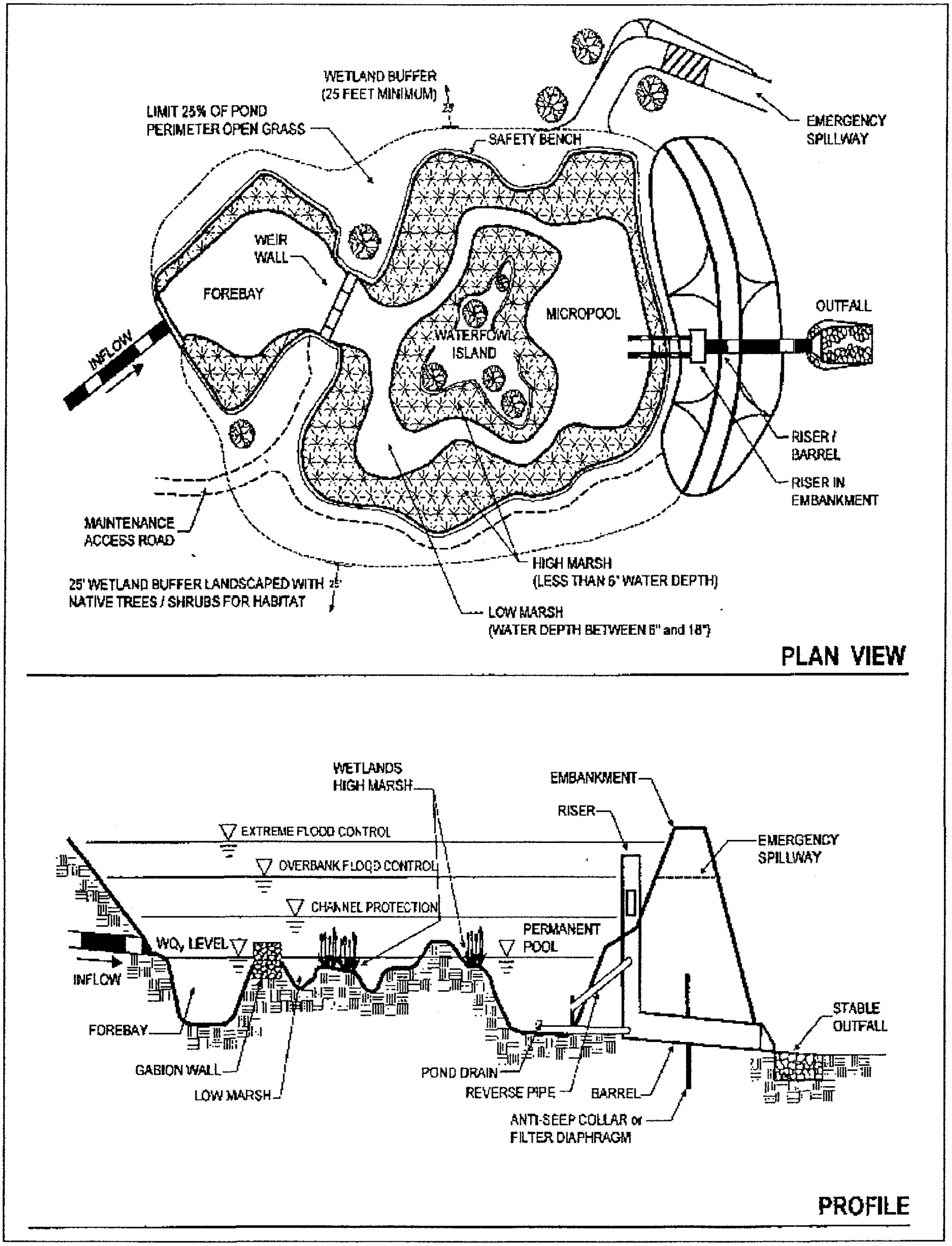
Figure A-02
Pond/Wetland Design Concept



For illustrative purposes only.

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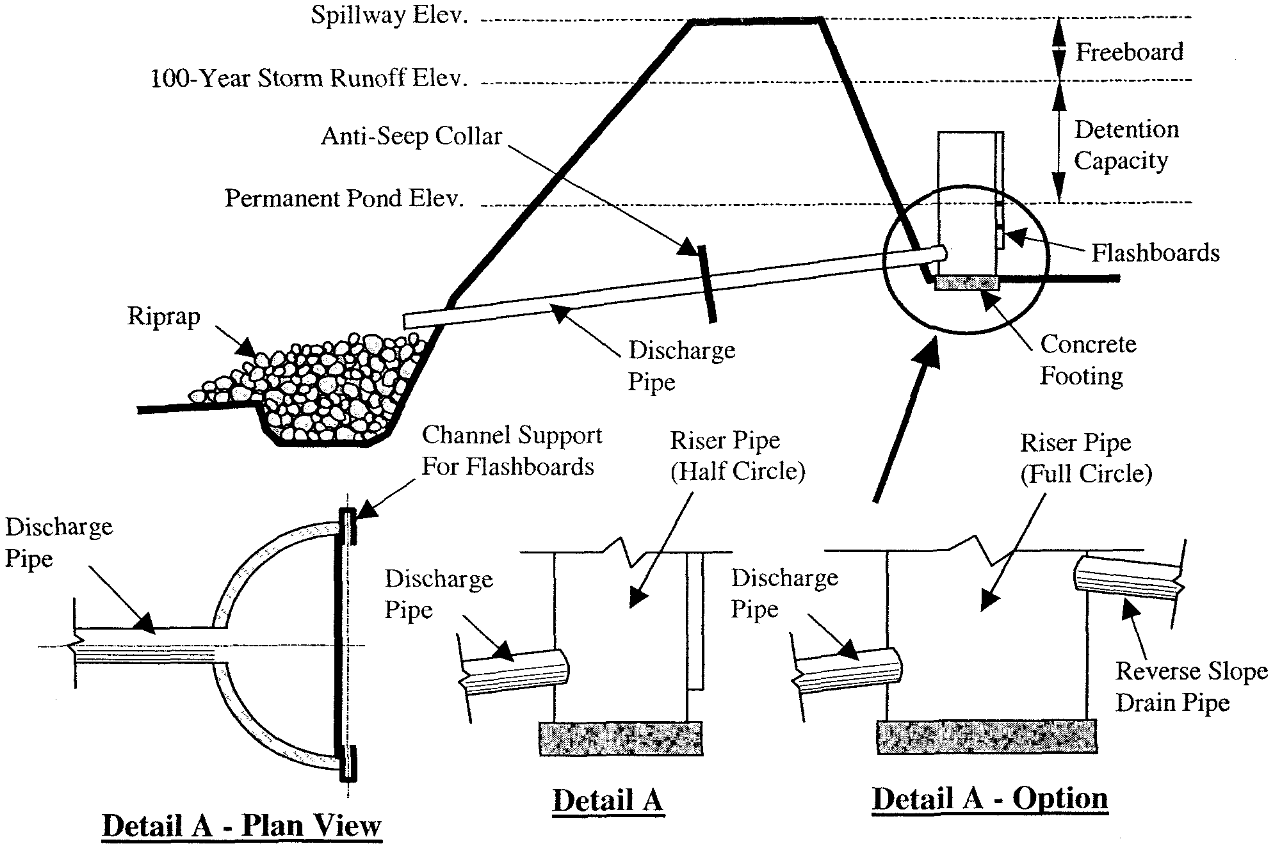
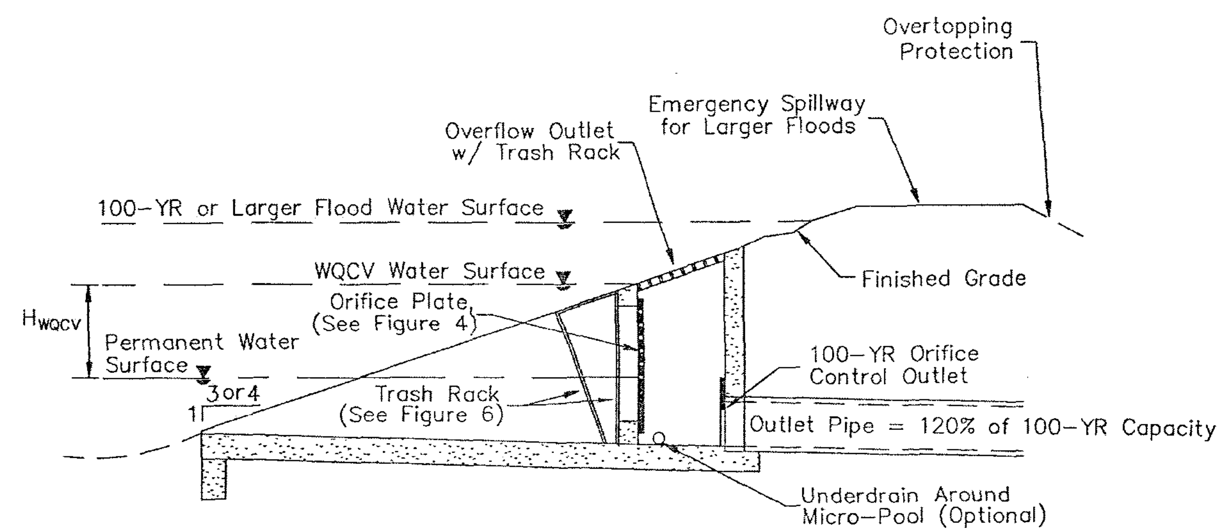
Figure A-03
Typical Water Control Structure Detail

Soils Conservation Service Outlet Structure



Urban Drainage and Flood Control District Outlet Structure



Drop Box Outlet Option

Figure A-04
Typical Check Dam Detail

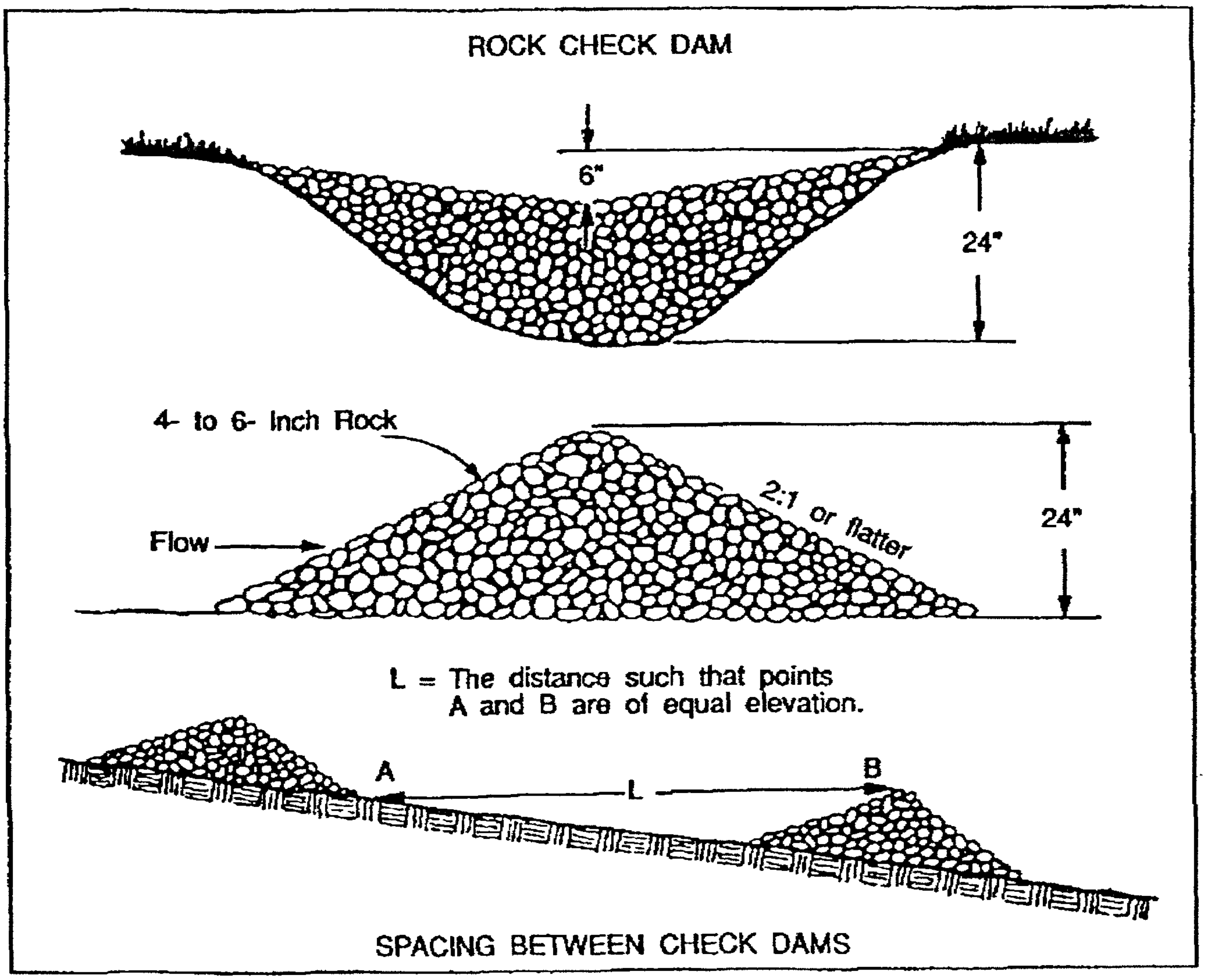


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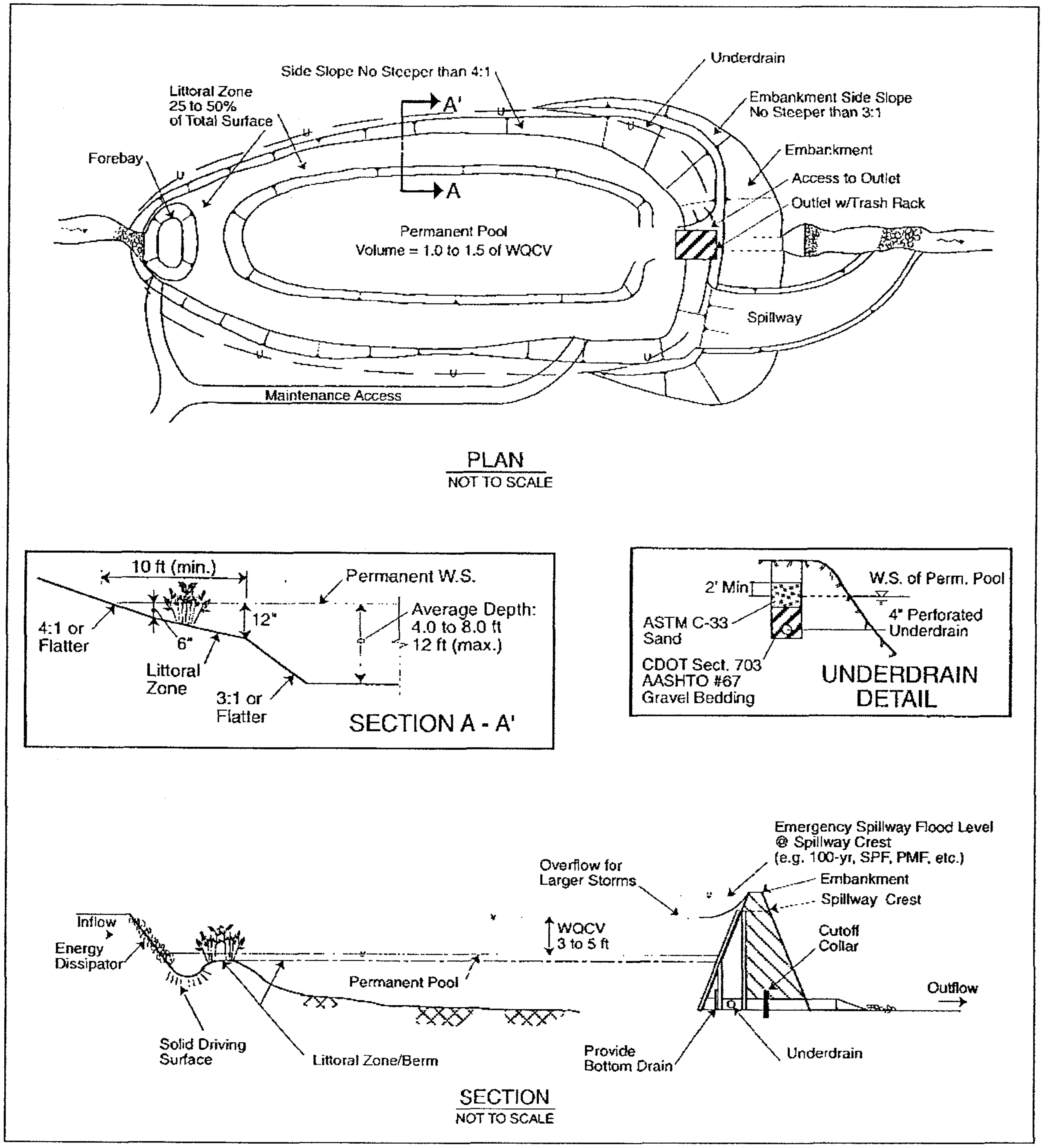
Figure A-06
Wet Pond Detention Basin Design Concept



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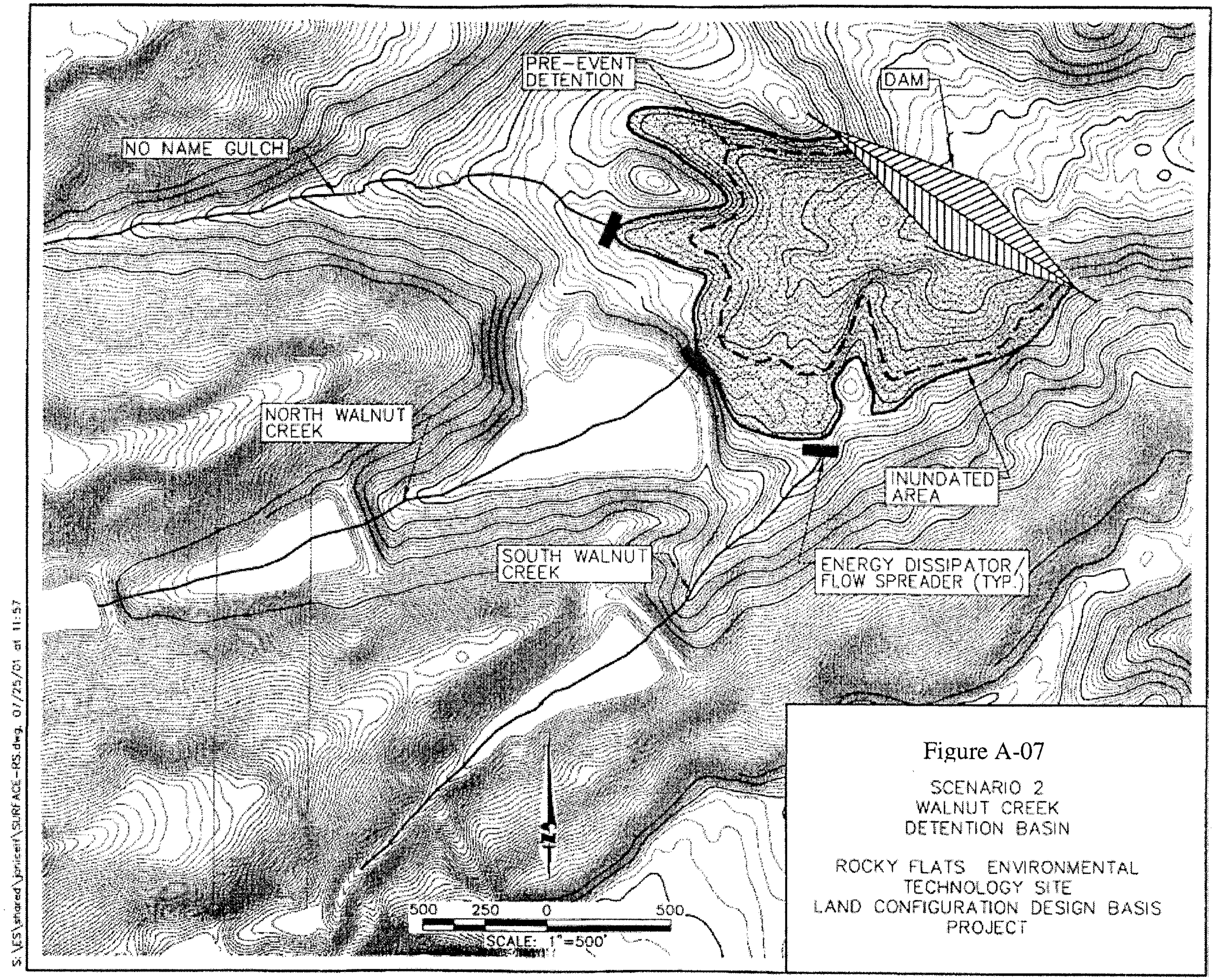

Figure A-07

SCENARIO 2
WALNUT CREEK
DETENTION BASIN

ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE
LAND CONFIGURATION DESIGN BASIS
PROJECT

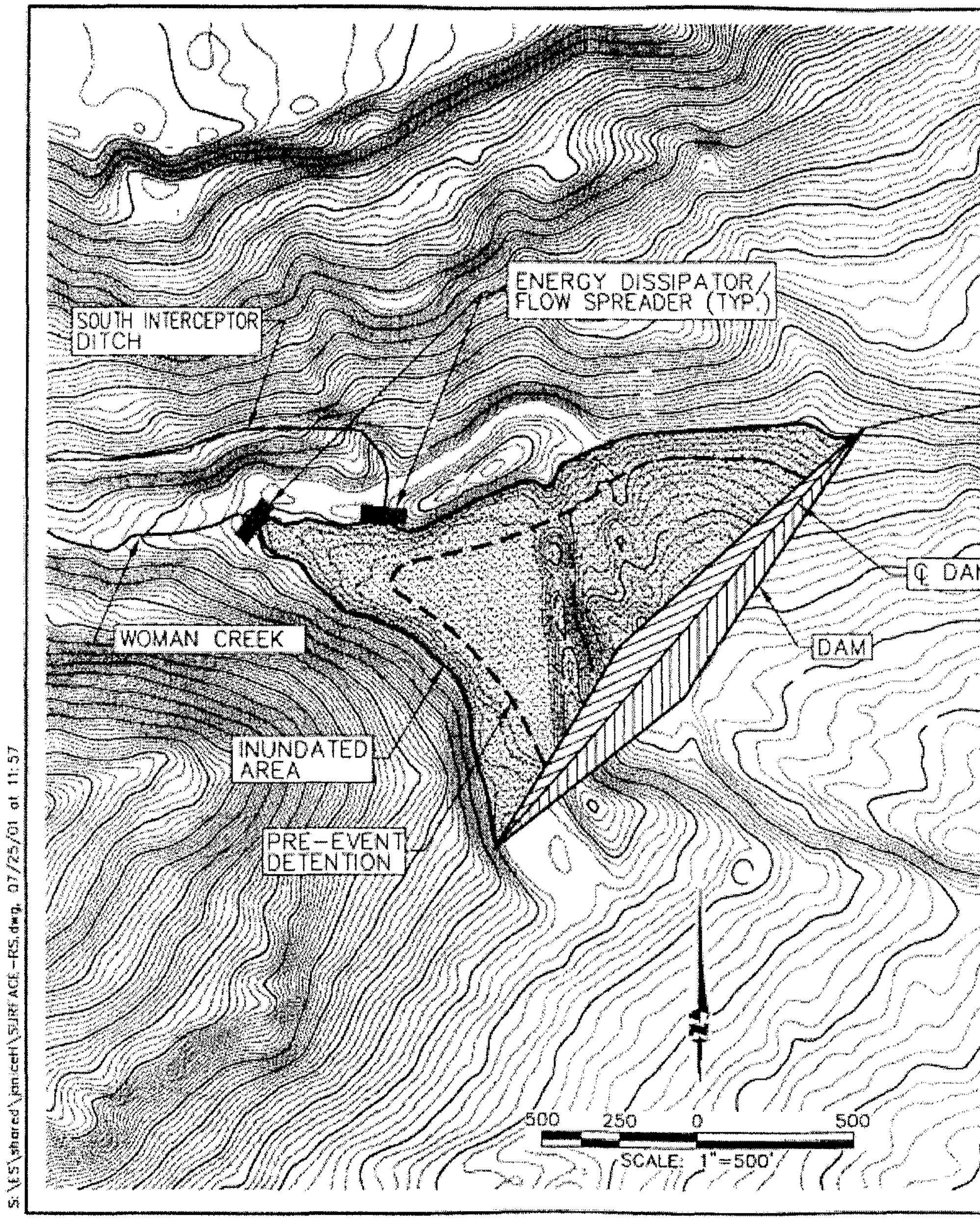

Figure A-08
SCENARIO 2
WOMAN CREEK
DETENTION BASIN

ROCKY FLATS ENVIRONMENTAL
TECHNOLOGY SITE
LAND CONFIGURATION DESIGN BASIS
PROJECT

TAB 3
ATTACHMENT B.1

WORK PLAN FOR EROSION AND HYDROLOGIC EVALUATION
LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This attachment (Appendix F) has been revised since its last issuance dated July 2001 to incorporate responses to Regulatory Agency Comment 56 (see Tab 1).

The dates provided in Figure F-01 have not been updated and may not be reflective of the current or future LCDB Project schedule.

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1.0 INTRODUCTION

An erosion and hydrologic evaluation will be conducted to quantify the sediment loading and hydrology at the completion of active remediation and to assess the ability of each bounding scenario to meet the functional design objectives (FDOs). The evaluation will be integrated and conducted with assistance from the AME Project Team. The following steps will be conducted to perform the evaluation.

- Acquire input data developed by the AME Project Team.
- Run the Water Erosion Prediction Project (WEPP) computer code to develop an evaluation tool for the LCDB Project and validate against the AME Project Team results for existing Site conditions.
- Evaluate the anticipated conditions at completion of active remediation that incorporates the IA and changes to the BZ including ET covers for the original landfill, present landfill, and solar ponds. The WEPP input files and output results for the anticipated conditions at completion of active remediation will be provided to the AME Project Team for additional evaluation (to the extent allowed by project schedules) including conversion of sediment concentrations to actinide concentrations.
- Appropriately modify the WEPP input files to be representative of the conditions associated with each bounding scenario. The WEPP input files and output results for each bounding scenario will be provided to the AME Project Team for additional evaluation (to the extent allowed by project schedules) including conversion of sediment concentrations to actinide concentrations.
- Incorporate the WEPP computer code results and analyses performed by the AME Project Team in the evaluation of the bounding scenarios to identify the appropriate components for inclusion in the initial conceptual design.
- Determine the storm-event integrity of the initial conceptual design for land configuration (especially the Walnut and Woman Creek drainages) to safely handle a 100-year design storm event. The hydrologic evaluation will be used to assess the feasibility to convert the ponds to flow-through systems, to define the water surface elevations, estimate the magnitude and location of possible problem areas, and identify the bounding for controlling water depths and velocities.
- For the initial conceptual design, additional erosion and hydrological evaluations may be conducted to demonstrate compliance with surface water quality standards at the Points of Compliance (POCs). This additional evaluation may include refinement of the WEPP input files to properly reflect the initial conceptual design and may include prediction of sediment loading or actinide concentrations associated with other storm events and conditions.

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2.0 EROSION AND HYDROLOGIC EVALUATION APPROACH

The procedures for conducting the erosion and hydrologic evaluation are consistent with the methods developed by the AME Project Team. The approach is described in the following sections.

2.1 Estimation of Rainfall Runoff and Sediment Erosion

The WEPP computer code, Version 99.52 (USDA, 1999), will be used to estimate the runoff and overland soil erosion. Other methods that that were considered to estimate rainfall runoff and sediment erosion include:

- The Universal Soil Loss Equation (USLE) (Wischmeier, 1978),
- The Modified Universal Soil Loss Equation (MUSLE) (Williams, 1977), and
- The Revised Unified Soil Loss Equation (RUSLE) (Toy, 1998).

The WEPP computer code was determined to be the best method to perform the tasks needed for the LCDB Project because:

- The WEPP computer code was previously used by the AME Project Team. Use of other methods would not provide a consistent approach or direct comparison of results.
- The WEPP computer code has been extensively used, tested, and validated.
- The WEPP computer code is designed to estimate runoff and erosion from a watershed for specific and historical storm events.
- The WEPP computer code allows soil erosion to be spatially predicted.
- The WEPP computer code predicts the particle size distribution of the sediment delivered to the drainage channel, which is needed to predict actinide transport.

2.2 Input Data for the WEPP Computer Code

In general, the input data for the WEPP computer code used for the LCDB Project will be consistent with data assembled and used by the AME Project Team. However, the WEPP computer code will be expanded to include the IA because historical gaging and monitoring data used by the AME Project Team is not applicable to predict future IA conditions for the LCDB Project. The IA will be divided into approximately 30 additional sub-watersheds and the WEPP input data for these IA watersheds will be developed based on comparable information derived from adjacent sub-basins to reflect the anticipated conditions at completion of active remediation. The IA sub-watersheds will be oriented so that runoff and soil loading can be predicted at key locations (i.e., points of compliance, confluence of two drainages, etc.).

The AME Project Team previously subdivided the BZ into approximately 150 sub-watersheds. These sub-watersheds will be retained for the LCDB Project to minimize the number of revisions to WEPP input data and to take advantage of the calibration efforts already performed by the AME Project Team. To the extent required, minor adjustments to the BZ watersheds will be made to reflect anticipated conditions at completion of active remediation, incorporate updated information, and be consistent with the LCDB Project scenarios.

Reasonable and appropriate design factors that reflect the actual topography, soil conditions, vegetation, and other anticipated physical conditions of the drainage basins at the completion of active remediation and for each bounding scenario will be identified and selected for input into the WEPP computer code. The design factors include:

- **Climatic factors** such as design rainfall data to include storm depth, duration, and distribution data for the 100-year, 6-hour storm event.
- **Soil factors** such as soil texture, initial saturation, initial erodibility, rill erodibility, critical shear, effective vertical hydraulic conductivity, the number of soil layers, and the depth, sand percentage, clay percentage, organic matter percentage, CEC, and rock percentage in each layer.
- **Vegetation factors** such as the type of vegetation, plant growth parameters (i.e., canopy height versus time and canopy cover versus time), days since last harvest, and initial interrill cover.
- **Slope factors** such as slope shape, steepness, length, and profile width.

Key assumptions, criteria, and other information being developed by other RFETS Project Teams (e.g., AME and SWWB projects) will be considered and incorporated as appropriate. The possible effects of irrigation canals and ditches will be considered. Assumptions regarding interception of runoff and overflow from these canals and ditches will be consistent with the assumptions previously developed and utilized by the AME Project Team and the assumptions for the anticipated conditions to be present after Site closure (see Data Gap-210).

The LCDB Project Team will evaluate the reasonableness of the WEPP input information and will identify significant potential inconsistencies in approaches and assumptions. However, the LCDB Project Team will not validate, verify, or assess the quality of the information utilized and provided by the other RFETS Project Teams. That is to say, the LCDB Project Team will not peer review documents generated by other RFETS Project Teams since such peer reviews are being performed by others.

2.3 *WEPP Computer Code Results*

After the input data files are created, the WEPP computer code will be used to estimate the runoff, soil loss, and deposition in each sub-watershed for the specified storm event. For the purpose of the LCDB Project, evaluation will be based on the 100-year, 6-hour storm event since this storm event represents a realistic worse case condition based on previous erosion and hydrologic results generated by the AME Project Team.

3.0 VALIDATION SCENARIO

The validation scenario consists of running the WEPP computer code using the BZ watersheds and associated input files developed by the AME Project Team for evaluating the existing conditions at the Site. Consistent with the AME approach, the sub-basins for the IA will not be included for the validation scenario. The validation scenario will only be run for the 100-year, 6-hour storm event.

The LCDB Project WEPP results will be compared to the previous WEPP results generated by the AME Project Team to verify that errors due to data transfer / entry or computer performance have not occurred. Any discrepancies between the WEPP results will be explained or resolved with the AME Project Team prior to proceeding with evaluation of the bounding scenarios. Because the input data developed by the AME Project Team was previously calibrated by comparing the WEPP results to historical monitoring data, a separate calibration run will not be performed for the LCDB Project. Although the validation scenario will use input files that are based on current Site conditions, the results will ensure consistency between the LCDB and AME Projects.

4.0 EVALUATION OF BOUNDING SCENARIOS

Figure F-01 provides a flow chart of the information to be exchanged between the LCDB and AME Project Teams. The anticipated conditions at the completion of active remediation will be evaluated to aid in developing the bounding scenarios. The bounding scenarios will be evaluated against each other to determine the most appropriate scenario components that will be included in the initial conceptual design.

The WEPP input files and output results developed for the anticipated conditions at completion of active remediation and each bounding scenario will be provided to the AME Project Team for additional evaluation including conversion of sediment concentrations to actinide concentrations. Any results, findings, conclusions, or recommendations generated by the AME Project Team will be considered by the LCDB Project Team as they become available. The results of the combined LCDB and AME Project Team erosion and hydrological evaluations will be used as one of the criteria in the scenario evaluation process.

4.1 Anticipated Conditions After Active Remediation

The anticipated conditions at completion of active remediation as described in Section 2.0 of Appendix B will be evaluated to assist in developing the bounding scenarios. Different configurations for the operation of the existing ponds / dams may be evaluated to assess the need for onsite ponds to meet surface water quality standards. The existing dams may be assumed to be breached so that no runoff detention is provided, which represents the worse case conditions (uncontrolled flow) and may provide a more suitable baseline for developing the bounding scenarios. Otherwise, the existing ponds will be evaluation as if the ponds are full per the previous soil erosion evaluation conducted by the AME Project Team.

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The BZ input data used for the validation scenario will be appropriately modified to reflect the anticipated conditions at the completion of active remediation. In addition, the sub-basins and associated input data developed for the IA will be included.

The anticipated conditions at completion of active remediation will be evaluated for the 100-year, 6-hour storm event. The output results will be used to develop the bounding scenarios and serve as the benchmark for the scenario evaluation process.

4.2 Bounding Scenarios for Final Land Configuration

Several bounding scenarios for the final land configuration will be developed and evaluated to identify the most appropriate components that will be included in the initial conceptual design. One of the scenario evaluation criteria is the performance of the scenario with respect to erosion and hydrology in achieving the surface water quality standards at the POCs. The WEPP input data will be appropriately modified to represent the site configuration, topography, vegetation, and other conditions defined for each bounding scenario. The WEPP computer code will be run for each bounding scenario to predict the sediment loading to the drainage channels resulting from the 100-year, 6-hour storm event. The WEPP output results will be used to predict the performance of each bounding scenario.

4.3 Transfer of WEPP Input Data and Results to the AME Project Team

The WEPP input data, results, and other information will be provided to the AME Project Team for the anticipated conditions at completion of active remediation and each bounding scenario. The input data and output results will be developed to allow the AME Project Team to input the information into the Sediment in Stream Network, Version 6 (HEC-6T) computer code to predict sediment transport and resulting actinide concentrations at various locations within in the streams. The specific input data, results, and other information that will be provided to the AME Project Team will include:

Input Data

- Electronic WEPP input files (soil type, vegetation type, and slope transects) developed for the IA.
- GIS coverages and attributes for all of the IA input data including hillslope boundaries, overland flow element (OFE) boundaries, soil type, vegetation type, and slope transects.
- List of any changes made to the WEPP input files and GIS data for the BZ.

Output Results

- Electronic WEPP output files including the overland flow element event output file (*.OFO).
- Output files will contain the peak runoff, volume of runoff, peak erosion rate, and volume of erosion.

Other Information

- Identification of significant changes to drainage channels and other major land configuration modifications that need to be accounted for by the AME Project Team in the HEC-6T computer code.

4.4 AME Project Team Review

The WEPP input data and output results for the anticipated conditions at completion of active remediation and each bounding scenario will be provided to the AME Project Team for review. This review may include using the HEC-6T computer code and other modeling tools previously developed by the AME Project Team to predict average sediment loading and average actinide concentrations at various locations within the drainage channel for the 100-year, 6-hour storm event.

The kriged actinide concentration maps developed for existing conditions may also be modified to reflect anticipated conditions at completion of active remediation. If revisions to the actinide concentration maps cannot be developed within the time frame allotted for review and evaluation of the bounding scenarios, existing concentration maps will be used as the basis to evaluate the performance of each bounding scenario.

4.5 Transfer of AME Project Team Findings

Findings, conclusions, and recommendations developed by the AME Project Team for the anticipated conditions at completion of active remediation and the other bounding scenarios will be provided to the LCDB Project Team for consideration. The findings will include a summary of any HEC-6T computer code results in the form of spreadsheets (*.xls) that contain graphs or tabularized data depicting the average sediment yield and average actinide concentrations versus drainage channel location for the 100-year, 6-hour storm event. Hydrographs, peak flow, and total flow may also be provided for key locations within the drainage channel to provide basic sizing requirements for each bounding scenario.

In addition to any HEC-6T results, the AME Project Team will provide any comments and recommendations regarding predicted performance, feasibility, and implementation of the bounding scenarios for consideration by the LCDB Project Team.

4.6 Evaluation of the Bounding Scenarios

The WEPP results and any input from the AME Project Team will be used to evaluate the performance of each bounding scenario based on their predicted erosion and hydrologic performance in achieving surface water quality standards at the POCs for the 100-year, 6-hour storm event. If input on the bounding scenarios is not received from the AME Project Team within the allotted time period for scenario evaluation, the evaluation will be based on sediment loading results attained from the WEPP computer code. Estimates for sediment removal and flow detention characteristics using various design configurations may also be conducted to assess the performance of any retention and detention ponds included as a component of a bounding scenario.

5.0 INITIAL CONCEPTUAL DESIGN

An initial conceptual design will be developed to incorporate and expand the scenario components included for each drainage / sector. Additional erosion and hydrological evaluation may be performed during the initial conceptual design phase to provide sizing of components and evaluate the storm-event integrity of the components included in the initial conceptual design. If required, the WEPP input files will be updated to reflect any refinements and modifications that are made as development of the initial conceptual design progresses.

The effects on runoff, erosion, and actinide concentrations resulting from future climate, vegetation, wildlife, and topography changes will be qualitatively assessed. The need for specific engineered structures to accommodate realistic future changes will be assessed and recommendations for any long-term site maintenance will be provided.

The LCDB Project Team, in conjunction with the AME Project Team, will evaluate the initial conceptual design for compliance with the surface water quality standards at the POCs. This demonstration of compliance may include consideration of different storm events and input conditions, as well as consideration of the sampling and analytical methods that would be used to demonstrate compliance and frequency / probability that an exceedence may occur. Any additional WEPP input files and output results will be provided to the AME Project Team for review and verification as described in Sections 4.3 and 4.4. The results, and conclusions of the AME Project Team will be provided to the LCDB Project Team for consideration as described in Section 4.5.

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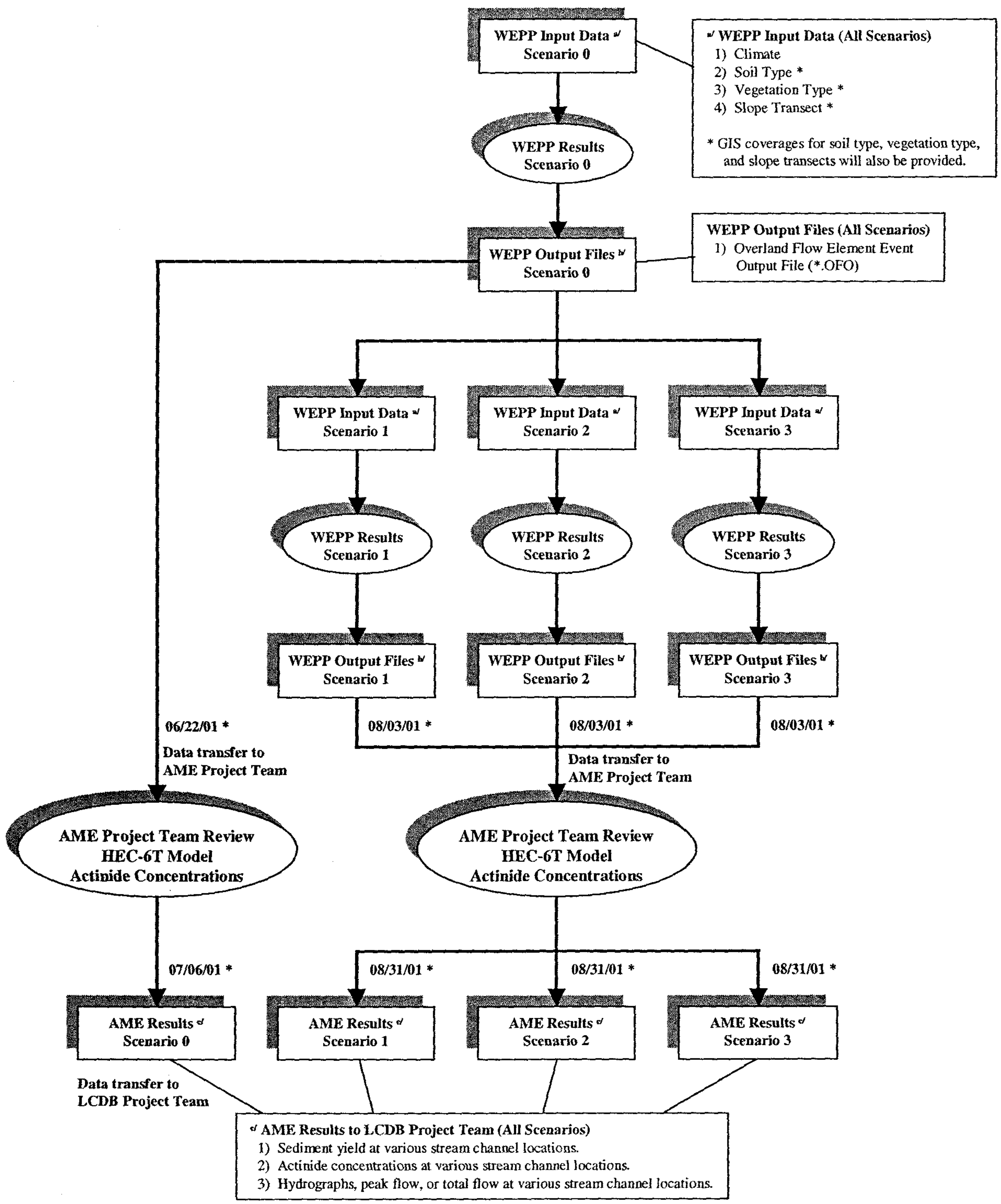
Figure F-01
Interface Diagram: AME Evaluation of LCDB Scenarios



* Note: Identified dates represent late finish dates. Output files and results will be provided as they become available.

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TAB 3
ATTACHMENT B.2

EROSION AND HYDROLOGIC EVALUATION RESULTS FOR BOUNDING SCENARIOS

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EROSION AND HYDROLOGIC EVALUATION RESULTS FOR BOUNDING SCENARIOS

TABLE OF CONTENTS

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1.0 INTRODUCTION

An erosion and hydrologic evaluation was completed to comparatively evaluate the performance of the anticipated conditions at the completion of active remediation (Scenario 0) and the three bounding scenarios (Scenarios 1, 2, and 3). The bounding scenarios represent unique approaches for various configurations that could be used to maintain compliance with the surface water quality standards at the Points of Compliance (POCs) after Site closure. This attachment does not include evaluation of the initial conceptual design (ICD) description (see Tab 3, Attachment C) or the drainage stabilization and topography for the Industrial Area (IA) as presented in the Grading and Drainage Concept (see Tab 3, Attachment E). The three bounding scenarios developed for the Land Configuration Design Basis (LCDB) Project were also compared to existing conditions based on the calibrated erosion and hydrologic results previously developed by the Actinide Migration Evaluation (AME) Project Team. Descriptions of the evaluated conditions are summarized below:

- Existing conditions is based on historical surface water monitoring data and current hydrologic features which includes a fully developed (including buildings and impervious pavement) Industrial Area (IA) and the existing configuration of the ponds. A more detailed description of the existing conditions and the calibrated erosion and hydrologic results developed by the AME Project Team is presented in *Report on Soil Erosion and Surface Water Sediment Transport Modeling for the Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site* (Kaiser-Hill, 2000a).
- The anticipated conditions at the completion of active remediation (Scenario 0) is described in the Design Basis (see Tab 2, Appendix B) and generally consists of:
  - Regrading portions of the SID drainage to promote sheet flow,
  - Revegetating the IA,
  - Installing evapotranspiration (ET) covers over the Solar Ponds, Original Landfill, and Present Landfill, and
  - Retaining existing configuration of drainage routing and pond controls.
- Scenario 1 uses passive flow-through ponds and wetland components as described in Section 3.1 of Tab 3, Attachment A. The components associated with this bounding scenario include:
  - Cascade flow through Ponds A-1, A-2, and A-3 in North Walnut Creek with Pond A-4 being utilized as a large-capacity, passive flow-through, storm water detention pond and the construction of a new wetland upstream of Pond A-4.
  - Replacement of Ponds B-1, B-2, B-3, and B-4 with rock check dams in South Walnut Creek with Pond B-5 being utilized as a large-capacity, passive flow-through, storm water detention pond and enlargement of the existing wetlands located just upstream of the confluence with North Walnut Creek.
  - Construction of a new wetland on Walnut Creek located just downstream of the confluence between North and South Walnut Creeks.

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  - Modifying the Woman Creek Diversion Dam to route the combined SID and Woman Creek flow into Pond C-2, which would be utilized as a large-capacity, passive flow-through, storm water detention pond. A new off-channel wetland would be constructed within the Woman Creek Diversion Ditch to handle excess storm flows.

- Scenario 2 uses two large-capacity[1/] detention basins for passive settling prior to periodic batch release as described in Section 3.2 of Tab 3, Attachment A. The components associated with this bounding scenario include:
  - Walnut Creek Detention Basin is located upstream of McKay Ditch and is designed to retain the combined flow from North Walnut Creek, South Walnut Creek, and No Name Gulch.
  - Woman Creek Detention Basin is located upstream of Mower Ditch and is designed to retain the combined flow from the SID and Woman Creek. A diversion ditch/swale that extends from the Woman Creek Detention Basin along the base of the 903 Pad hillside is included to capture additional runoff associated with the wind dispersal area located to the east of the 903 Pad.[2/]
- Scenario 3 uses engineered drainage and erosion controls as described in Section 3.3 of Tab 3, Attachment A to isolate prevent sources of actinide-bearing soils from entering into the surface water. The components associated with this bounding scenario include:
  - Regrading of Building 881 and 903 Pad hillsides to stabilize this hillside and to decrease soil erosion.
  - Providing positive drainage away from the IA VOC plume to minimize infiltration and potential migration of subsurface contaminants.
  - Stabilizing portions of North and South Walnut Creeks that are located within the IA to increase the longevity of these drainage channels, decrease headward erosion into the IA pediment, and reduce long-term stewardship requirements.
  - Revegetating disturbed areas and barren zones to reduce erosion.
  - Breaching existing ponds as an extreme condition since this scenario does not rely on surface water controls.

The evaluation of Scenario 0 and the three bounding scenarios (Scenarios 1, 2, and 3) was a joint effort between the LCDB and AME Project Teams as presented in Tab 3, Attachment B.1. The AME calibrated Water Erosion Prediction Project (WEPP) computer files were modified by the LCDB Project Team to be representative of the conditions associated with Scenario 0 and each of the bounding scenarios. The WEPP

1/ Each detention basin is designed to retain the combined volume of pre-event runoff and a 100-year, 6-hour storm event. The pre-event runoff is the maximum 30-day volume based on the historical gaging data recorded between 1993 and 1998.

2/ Although the diversion ditch/swale that extends from the Woman Creek Detention Basin along the base of the 903 Pad hillside is not specifically identified in the AME report, this component does not impact the calculations performed by the AME Project Team. The data used to calculate the actinide load and concentrations for Scenario 2 are based on the runoff and erosion that originates downstream of the detention basins and corresponding diversion ditch/swale that was correctly modified.

input and output files were provided to the AME Project Team for review, quality control, and conversion to surface water actinide concentrations using the Sedimentation in Stream Network, Version 6 (HEC-6T) sediment transport computer code and Microsoft Excel ™ based actinide transport models (ATMs) previously developed by the AME Project Team. The HEC-6T routing and ATM actinide soil concentration input data was then modified by the AME Project Team to be representative of the conditions associated with Scenario 0 and each of the three bounding scenarios.

The erosion and hydrologic evaluation was limited to the design storm event (6-hour, 100-year). Although the results are for a single severe storm event and are accurate to one order of magnitude for actinide loads and concentrations (KH/RMRS, 2000), they provide a basis to compare the relative performance of various bounding scenario components and to identify individual drainages where a specific component may be well suited. However, the results cannot be directly compared to surface water quality standards, which are based a 30-day moving average of flow-weighted composite sample results. In addition, the estimated peak flow and runoff volumes are not appropriate for the hydraulic design of drainage control structures.

The evaluation report prepared by the AME Project Team is presented in Appendix 1 to this Attachment. These results were incorporated into the comparative evaluation of the bounding scenarios presented in Tab 3, Attachment A. The reminder of this Attachment is devoted to summarizing the erosion and hydrologic results and their potential implications on the development of a final land configuration for the Site.

2.0 SUMMARY OF EROSION AND HYDROLOGIC RESULTS

A summary of the erosion and hydrologic results is presented in Appendix 1 as Table 2. The predicted actinide load (in pCi) is based on total load for the entire storm event. The predicted actinide concentration (in pCi/L) is the storm event mean, which is calculated by dividing the actinide load by the total volume of storm event runoff. Actinide loads and concentrations were predicted with and without channel erosion, which accounts for streambed sediment scour and re-suspension. The actual actinide concentrations are expected to be within one order of magnitude of the two predicted values. The following general observations are based on comparing the predicted results for post-remediation (Scenario 0) against existing conditions (see Appendix 1, Table 2).

- The storm event runoff at the Walnut Creek and SID gaging stations is predicted to decrease (20 to 85 percent). The predicted decrease in runoff is attributed to elimination of the IA impervious surfaces.
- Although the runoff is predicted to decrease, the storm event sediment load (with drainage channel erosion) at the Walnut Creek gaging stations is predicted to increase (3 to 50 percent). The predicted increase in sediment load is attributed to the predicted increase in the availability of erodible soils from eliminating impervious surfaces within the IA.[3/]

3/ Direct comparison of the predicted sediment loads may not be appropriate because the IA sediment load for existing conditions is based on extrapolated monitoring results and the predicted sediment load for Scenario 0 was derived from computer codes.

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- The sediment load for the SID is predicted to decrease (15 percent), which is consistent with the predicted reduction in runoff.
- Although remedial actions should lower the sources of actinides, the models indicate that the actinide load at the Walnut Creek and SID gaging stations (except for SW093) is predicted to increase (30 to 930 percent). The predicted increase in the actinide load for GS10 (930 percent) does not seem consistent with corresponding predicted increase in sediment load of only 50 percent. This large variation may be due to using historical monitoring results to estimate the actinide load for existing conditions versus using the WEPP/HEC-6T computer codes to predict the actinide load of Scenario 0.
- The actinide load at SW093 is predicted to decrease (6 to 60 percent). This predicted decrease appears to contradict the predicted increase in actinide load at GS10. However, it is recognized that a larger portion of the flow at SW093 is from non-IA sources. The background contribution to the predicted plutonium load at SW093 is estimated to be approximately 15 percent[4/].
- The predicted decrease in runoff volume combined with predicted increase in actinide loads indicates that the average actinide concentration will increase (220 to 425 percent) at GS03 (Walnut Creek at Indiana Street) for the severe storm event (100-year, 6-hour).
- Runoff volume, sediment load, actinide load, and actinide concentrations at GS01 (Woman Creek at Indiana Street) are expected to be unaffected, as long as the SID flow remains segregated from Woman Creek.

Based on the above observations, direct comparison of the predicted results for existing conditions and Scenario 0 may be inappropriate. Furthermore, the comparisons of the absolute performance of the post-closure scenarios and conclusions based on these results may be limited. As such, the predicted results for each bounding scenario (Scenarios 1, 2, and 3) was relatively compared to Scenario 0 to provide an indication of their relative overall performance and to identify individual drainages where specific components may be well suited for developing the final land configuration. The following bullets summarize the general observations regarding the relative performance of each bounding scenario.

- The Scenario 2 detention basins are predicted to provide the greatest reduction in actinide load (47 and 97 percent). However, overland erosion and channel scouring downstream of the basins may continue to be a potential source of actinides at GS01 and GS03.
  - Although the predicted actinide load for Woman Creek at GS01 is reduced, the actinide concentrations increase. This increase is attributed to diverting and retaining the "clean" Woman Creek runoff volume that currently flows to GS01.

4/ Background contribution was calculated by multiplying the predicted sediment load for SW093 (34,601 kg) by the background concentration for plutonium of 0.038 pCi/g. Background concentration for plutonium is from *Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program* (EG&G, 1995).

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- The reduction in actinide load is predicted to be more effective for Walnut Creek at GS03 than Woman Creek. However, the plutonium concentration at GS03 averaged over the storm event is predicted to between 0.29 and 0.37 pCi/L (within one order of magnitude).

- The Scenario 1 wetland and flow-through components are predicted to decrease (48 percent) the actinide load in Walnut Creek at GS03. The check dams are predicted to reduce (65 percent) the actinide load in South Walnut Creek at GS08.

- The Scenario 1 off-channel wetland system used in Woman Creek is predicted to be ineffective and allow flushing of accumulated sediments from the off-channel wetland (WOC-02). The actinide load is predicted to increase (400 percent). Possible causes for this large increase include:
  - The base slope of the off-channel wetland is 2 percent, which may be too steep and, therefore, subject to significant flushing. If wetlands are included as a sediment control component in the final land configuration, it is recommended that they be designed with a flat base or have other provisions to minimize flushing.
  - Entrainment of suspended solids from the SID drainage due to the combined storm water flow of Woman Creek. The SID sediments are currently allowed to settle out in Pond C-2.
  - Increased channel scour due to increased flow from the recombined SID and Woman Creek drainages.

- The results for Scenario 3 indicate that the 903 Pad hillside slope reduction decreases sediment load, runoff volume, and actinide concentration (30 percent). Homogenization of the actinide surface soil concentrations due to the regrading activities is predicted to be more significant than the physical slope reduction in reducing the actinide surface-water concentrations. Although the actinide load from the SID at SW027 is predicted to decrease (40 percent), the actinide load in Woman Creek at GS01 is predicted to increase (150 percent). Possible causes for this increase include:
  - Entrainment of suspended solids from the SID drainage due to the combined storm water flow of Woman Creek. The SID sediments are currently allowed to settle out in Pond C-2.
  - Increased channel scour due to increased flow from the recombined the SID and Woman Creek drainages.

- Under Scenario 3, all of the existing A- and B-series ponds were modeled as being breached to provide an extreme condition for evaluating this bounding scenario. Actual breaching of the existing ponds would be based on application of the Pond Reconfiguration Strategy. The sediment load is predicted to increase at GS03 (17 percent) and GS08 (58 percent). However, the actinide loads at these two locations are predicted to decrease by more than 50 percent. The reason for the reduction in actinide load with an increase in sediment load is not immediately apparent, but may be due to removing contaminated pond sediments that could be resuspended during the storm event.

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3.0 MODEL RESULT IMPLICATIONS

The predicted average actinide concentrations and loads (with and without channel erosion) are presented in Table 2 of Appendix 1. These predicted concentrations are for a single storm event and, therefore, should not be directly compared to the surface water quality standards, which are based on a 30-day moving average of flow-weighted composite sample results. However, the predicted actinide load from this single storm event is comparable to the calculated loads[5/] that have contributed to historical exceedences.

Although the runoff from the design storm event (100-year, 6-hour) is significantly higher than historically experienced, it is probable that a predicted actinide load for the single storm event would result in an exceedence of the surface water quality standards. Based on this assumption, the modeling results indicate that none of the bounding scenarios individually assures compliance with the surface water quality standards at the terminal POCs for Walnut (GS03) and Woman (GS01) Creeks. However, individual scenario components show some improvement in water quality and could be combined together in an initial conceptual design to optimize the overall performance. As such, the following implications and corresponding actions for continued development and implementation of a final land configuration for the Site were identified. These implications and actions were grouped into three main categories: 1) RFCA modifications, 2) design revisions, and 3) erosion and hydrologic evaluation refinements.

1. **RFCA Modifications**

   The surface water protection requirements, numeric standards, monitoring locations, and sampling provisions are specified in Attachment 5 to RFCA and its corresponding required Integrated Monitoring Plan (IMP). These provisions and the current IMP are geared towards monitoring surface water compliance during the remediation phase based on the existing pond configuration and surface water management mode of operation. The feasibility of modifying one or more of the following RFCA or IMP requirements to facilitate the final land configuration could be considered.

   - Increase the averaging period from 30 days to a longer duration that is more representative of actual flow conditions and the drinking water pathway risk. RFCA Attachment 5 states, "Compliance will be measured using a 30-day moving average for those contaminants for which this is appropriate. When necessary to protect a particular use, acute and chronic levels will be measured differently as described in the current Integrated Monitoring Plan." Adopting a different averaging period could be pursued through modification and approval of the IMP.
   - Modify the method to collect composite samples at the POCs to provide at least 2 or 3 sample results over each 30-day period of flow. The averaging of multiple sample results avoids having a false positive in the event of

5/ Calculated actinide loads are based on multiplying recorded flow data by composite sample results.

collecting a long-duration (greater than 30 days) composite sample whose result is greater than 0.15 pCi/L due to normal laboratory/statistical variability. The IMP could be revised to specify a maximum duration for sample collection (includes only days with recordable flow). Given the variability of flow, this sampling approach may require multiple automatic samplers at each POC set at different sampling rates to ensure that an adequate sample volume is collected. Alternatively, replicate samples could be collected for averaging. This modified sampling approach would increase monitoring cost, but could reduce the number of exceedences and subsequent generation of Source Evaluation Reports.

- Identify specific storm events/abnormal conditions that compliance with the surface water quality standards would be waived. The Colorado Surface Water Quality Regulations appear to acknowledge that certain water quality standards cannot be maintained during abnormal flow conditions. For example, 5 CCR 1002-31, Section 31.7(1)(b) states that, "A numeric standard may be exceeded due to temporary natural conditions such as unusual precipitation patterns, spring runoff or drought." The inclusion of waivers for abnormal flow conditions could be pursued through the modification and approval of the IMP. The identification of an abnormal threshold storm event could be based on the probability (frequency) of exceedence based on a specified storm return period using risk-based management principles.
- Raise the actinide surface water quality standard based on actual health/ecological risks. Submitting a petition to the Water Quality Control Commission to revise the site-specific water quality standards (5 CCR 1002-38) in order to revise Attachment 5 of RFCA would likely be required to pursue this option.

2. **Design Revisions**

The ICD description presented in Tab 3, Attachment C is based on consideration of reasonable bounding scenario components and the Design Basis as presented in Tab 2, Appendix B. More stringent design approach/components could be adopted to provide a higher degree of confidence in maintaining compliance with the surface water quality standards at the POCs using the current erosion/hydrologic evaluation approach and assumptions in conjunction with the surface water monitoring program. Some of the design revisions and alternate components that could be considered include:

- Revising the design basis for the final land configuration to adopt a less severe storm event.
- Constructing large capacity basins at Indiana for total retention of runoff (zero discharge). Engineered evaporation enhancements may be required to reasonably restrict the basin size to ensure retention of peak design flows. Alternatively, infrequent batch discharge may be required. This approach was previously discarded as a bounding scenario due to its cost and extensive disturbance of Preble's mouse protection areas.

- Lower the average actinide surface soil concentration through tilling (homogenization), removal, or covering. Although these options could be implemented during active remediation, they were previously discarded as a bounding scenario due to their cost and extensive ecological disturbance.
- Adopting more stringent erosion controls in the IA. The need for additional controls is dependent on confirming that the predicted increase in actinide load is due to increasing the amount of erodible area due to closing the IA as stated in Appendix 1. The additional erosion controls could include, but not limited to, reducing/eliminating runoff, expanding ET covers, or armoring/paving portions of the IA. The additional erosion control provisions developed for the G&D Concept (see Tab 3, Attachment E) that were not included in the bounding scenarios could be further evaluated by the AME Project Team to quantify their performance.
- Constructing a pipeline to convey discharge water from the detention ponds and other water control features directly to the terminal POCs at Indiana Street to minimize resuspension of legacy contaminated sediments that may be present in the lower portions of the drainage channels.

Implementing a more stringent configuration does not guarantee that compliance with the surface water quality standards will be maintained. Furthermore, the above configurations could impact more ecological resources and may be more expensive than the bounding scenario components. Because these configurations do not achieve a balance between their implementation, NEPA objectives, and final land use of RFETS as a National Wildlife Refuge, they are not considered realistic. Such imbalances are contrary to maintaining compliance with surface water standards that were adopted, in part, to protect these ecological resources.

3. Erosion and Hydrologic Evaluation Refinements

The predicted results from the erosion and hydrologic evaluation are accurate to one order of magnitude for actinide loads and concentrations. The following actions could be taken to further refine the erosion and hydrologic evaluation approach and assumptions to assess various bounding scenario components and surface water quality.

- The modeling results for the post-remediation bounding scenarios (Scenarios 0, 1, 2, and 3) tend to be higher than the results obtained from the calibrated model for existing conditions (Kaiser-Hill, 2000a). These predicted results seem to be counter to the expected results considering the remedial actions that will be implemented. The following actions may be appropriate to refine the post-remediation modeling results.
  - Review assumptions used to extrapolate historical data to predict actinide loads from the IA for a large storm event based on existing conditions.
  - Verify that post-remediation actinide loads and concentrations for the IA are consistent with previously calibrated data from areas with similar characteristics.

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- Quantify the contribution of background surface soil concentrations to predicted actinide loads since background concentrations will play a more important role as remediation progresses in maintaining compliance with the surface water quality standards. Previous AME modeling results indicate that actinide concentrations well below Tier I action levels may contribute to exceedences, especially for large storm events (Kaiser-Hill, 2000a).
- Modeling and extrapolating smaller storm events may be used to develop a continuous climate record to further evaluate compliance of large single storm events with the 30-day moving average surface water quality standard (see Data GAP-020).

The abovementioned model refinements may not sufficiently improve the confidence of the modeling results as a tool to assess surface water quality. As stated in Appendix 1, the accuracy of the model results is reported to be within one order of magnitude for the actinide loads and concentrations. Historical monitoring results indicate that exceedences can occur under a variety of flow conditions, even low flow when sediment transport under modeled conditions would be expected to be minimal[6/]. As such, using modeling results does not provide sufficient confidence to demonstrate compliance with the surface water quality standards. However, the model results can be one of the tools used to comparatively evaluate changes in surface water quality based on different scenarios. The evaluation results would be used to guide the development of the final land configuration.

4.0 PATH FORWARD

One course of action for continued development of the final land configuration is to:

- Utilize the erosion and hydrologic evaluation results to refine the ICD description presented in Tab 3, Attachment C.
- Conduct further erosion and hydrologic evaluation of the ICD description and IA G&D Concept (Tab 3, Attachment E) to provide an indication of performance improvements. Include homogenization of surface soil surfaces where grading and revegetation will occur based on the IA G&D Concept.
- Revise the IMP to adopt a longer averaging period and to ensure that multiple sample results are available for averaging.
- Continue to develop design information through the resolution of high priority data gaps (see Tab 2, Appendix C).

6/ The low flow exceedence that occurred at GS03 in June 1997 would not be expected based on the model data and predictions.

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5.0 REFERENCES

The following documents were used to develop this attachment.

EG&G, 1995. *Geochemical Characterization of Background Surface Soils: Background Soils Characterization Program.* EG&G Rocky Flats, Inc., Rocky Flats Environmental Technology Site, Golden, CO, May.

Kaiser-Hill, 2000a. *Report on Soil Erosion and Surface Water Sediment Transport Modeling for the Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site (00-RF01823).* Kaiser-Hill Company, LLC. Rocky Flats Environmental Technology Site, Golden, CO. August.

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TAB 3, ATTACHMENT B.2
APPENDIX 1

HYDROLOGIC EVALUATION OF THE LAND CONFIGURATION DESIGN BASIS PROJECT SCENARIOS FOR THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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HYDROLOGIC EVALUATION OF THE LAND CONFIGURATION DESIGN BASIS PROJECT SCENARIOS FOR THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

January 2002

Rocky Flats Environmental Technology Site
Golden, Colorado 80402

KAISER HILL COMPANY, LLC

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Executive Summary

The Land Configuration Design Basis Project (LCDB) project was initiated to provide the design basis to develop the final Rocky Flats Environmental Technology Site (Site) topography and closure configuration of:

- Streams
- Ponds
- Roads, and
- Other post-closure components

consistent with Site closure, remediation, and final land use objectives. The principal objective for the final land configuration is compliance with the surface-water quality standards identified in the Rocky Flats Clean-up Agreement (RFCA) at the points of evaluation (POEs) and points of compliance (POCs) for the actinides plutonium-239,240 (Pu) and americium-241 (Am). Uranium transport is not addressed in this report. The actinides are associated with soil and sediment particles due to their extremely low solubility. Therefore, mobility of the actinides in overland runoff and streams can be estimated using mathematical erosion and sediment transport models developed by the Site Actinide Migration Evaluation (AME) (KH / RMRS, 2000). An erosion and hydrologic evaluation was conducted, and is reported herein, to quantitatively compare the sediment loading and associated surface-water concentrations of the actinides.

Four bounding LCDB scenarios were modeled to evaluate the broad spectrum of potential Site configuration alternatives summarized in Table Ex-1. The scenarios present different land surface grading and drainage patterns for the Site Industrial Area (IA) and South Interceptor Ditch (SID) watershed. The scenarios also use different hydraulic structures to facilitate settling of sediment-bound actinides in detention ponds, wetlands, and behind energy dissipation structures (e.g. rip rap placed in the stream channels). All of the scenarios use evapotranspiration (ET) covers as reclamation techniques for the Solar Evaporation Ponds, Present Landfill, and Old Landfill.

Table Ex-1. Summary of LCDB Scenarios

Scenario	Industrial Area Configuration	Hydrologic Features	Special Features
0	• Re-vegetated IA • ET Covers on Solar Ponds and Landfills • Re-grade Industrialized Portions of SID drainage	• Existing Drainage Features & Routing	None

Table Ex-1. Summary of LCDB Scenarios - Continued

Scenario	Industrial Area Configuration	Hydrologic Features	Special Features
1	Same as Scenario 0	• Install Engineered Wetlands • Replace Ponds B-1, B-2, B-3, B-4 with Energy Dissipation Structures	• Off-channel wetland in Woman Creek east of Pond C-2 • SID routed to Woman Creek via Pond C-2
2	Same as Scenario 0	• Replace all existing detention ponds with one new pond in Walnut Creek and one new pond in Woman Creek.	• SID routed to Woman Creek through new, expanded Pond C-2
3	• Re-vegetate IA • ET covers on solar ponds and landfills • Realign northern IA tributary to North Walnut Creek.	• Replace all existing detention ponds with armored engineered channels • Eastern SID watershed re-grading	• SID routed directly to Woman Creek • Reduced surface-soil actinide concentrations in eastern SID due to re-grading.

IA = Industrial Area, SID = South Interceptor Ditch, ET = Evapotranspiration

Evaluation of the modeling results provides the following conclusions.

- Re-vegetation and re-direction of overland flow in the IA combined with watershed channel modifications can produce lower actinide yields (i.e. mass movement) and surface-water concentrations than post-remediation (Scenario 0) levels for Walnut Creek and Woman Creek. Therefore, re-vegetation of the IA will likely benefit surface-water quality with respect to actinides.

- Actinide yields and concentrations increase in Scenario 0 for the SID due to increased erodible surface area combined with reduced runoff from the re-vegetated IA. Therefore, IA re-vegetation will reduce SID flow that currently dilutes contaminated sediments.

- Detention ponds are likely the best available control of actinide yields (mass transport), but not necessarily for actinide concentrations (mass per unit volume e.g. pCi/L). Channel scouring downstream from the dams, combined with actinides transported to the stream downstream from the dams (i.e. from erosion and overland flow) will continue to impact surface-water quality.

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- Wetlands may be effective controls of actinide yields and concentrations in Walnut Creek, but not necessarily in Woman Creek. This report presents results for a 100-year, 6-hour, 97.1mm (3.82 inches) storm event, which show that contaminated sediments in prototype wetlands could be flushed from the wetlands. Modeling smaller storm events might provide a threshold for wetland effectiveness in controlling actinide transport.

- Installing energy dissipation structures in Walnut Creek is predicted to be effective technique for reducing actinide yields and concentrations.

- Re-grading the eastern SID watershed to reduce the slope of the hillslopes would reduce erosion and the surface soil actinide concentrations. In turn, Woman Creek actinide mass transport (yields) and surface-water concentrations would be reduced.

The results contained herein are for a single, extreme storm event. Therefore, the results cannot be directly compared to RFCA action level compliance at 0.15 pCi/L Pu-239,240 and Am-241, which is based an a 30-day moving average of measured concentrations of flow-weighted composite samples. The model results are accurate to within one order of magnitude for actinide yields and concentrations (KH/RMRS, 2000), and therefore, provide a relative comparison of the Site land configuration bounding scenarios. The estimated peak discharges and runoff yields are not appropriate for structural or civil engineering design purposes.

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INTRODUCTION

The Land Configuration Design Basis Project (LCDB) project was initiated to provide the design basis to develop the final Rocky Flats Environmental Technology Site (Site) topography and closure configuration (including drainages, ponds, roads, and other post-closure components) that is consistent with Site closure, remediation, and final land use. The principle objective for the final land configuration is compliance with the surface-water quality standards identified in the Rocky Flats Clean-up Agreement (RFCA) at the points of evaluation (POEs) and points of compliance (POCs) specified in RFCA (Figure 1). An erosion and hydrologic evaluation was conducted, and is reported herein, to quantitatively compare the sediment loading and associated surface-water concentrations of the actinides plutonium-239,240 (Pu) and americium-241 (Am) for each land configuration scenario. Each scenario addresses specific hydrologic impacts on meeting surface-water-quality requirements for the Site at regulatory closure.

The actinides are associated with particulates due to their extremely low solubility (KH/RMRS, 2000). Therefore, mobility of the actinides in overland runoff and streams can be estimated using mathematical erosion and sediment transport models. Between FY98 and FY00, the Actinide Migration Evaluation (AME) erosion and sediment transport models were built and calibrated to provide engineering estimates of actinide mobility due to overland flow, erosion, and sediment transport in streams for existing conditions (KH / RMRS, 2000). The models predict where actinide-contaminated sediments are introduced to streams from overland runoff and erosion, deposited from the water column to the streambed, and/or re-suspended from the streambed to the water-column.

This hydrologic evaluation uses the knowledge, methods, and software developed by the AME erosion and sediment-transport modeling project to evaluate the four bounding LCDB scenarios., which are summarized in Table 1 and described below.

- **Scenario 0** is a baseline scenario, which incorporates a re-vegetated Industrial Area (IA) and changes to the surrounding Buffer Zone (BZ) that are consistent with the anticipated conditions at completion of active remediation, including evapotranspiration (ET) covers for the original landfill, present landfill, and solar ponds. No re-contouring of the land surface other than the ET covers was included in Scenario 0. The existing routing of surface-water runoff is maintained in Scenario 0.

- **Scenario 1** utilizes passive flow-through ponds, energy dispersion structures, and natural wetland treatment systems to detain runoff and allow gravity settling of contaminated sediments, to improve water-quality . Runoff is routed through the existing terminal ponds and existing, modified, or constructed wetlands within North and South Walnut Creeks, and Woman Creek, . The SID is routed to Woman Creek prior to Pond C-2 with the combined flow routed through Pond C-2 and excess flow to the off-channel wetlands.

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- **Scenario 2** adds two detention basins in the Site watersheds. One detention basin was placed just upstream from the confluence of McKay Ditch and Walnut Creek to retain flow from North Walnut Creek, South Walnut Creek, No Name Gulch, and overflow from the McKay Diversion. The other detention basin was placed in the Woman Creek channel, incorporating Pond C-2, and is designed to retain the combined flow of the SID and Woman Creek. The detention basins are located and designed to retain the runoff, entrained sediment, and contaminants associated with the sediment. Both detention basins have the capacity to store the combined volume of pre-event runoff and a 6-hour, 100-year runoff event. The pre-event detention volume is defined as the maximum runoff that occurred from 1993 to 1998 over a 30-day period.

- **Scenario 3** is based on source isolation. This scenario utilizes engineered drainages, slope reduction and re-vegetation to reduce erosion of contaminated surface soils to surface water. Drainage controls in the IA and slope reduction erosion control measures are applied to specific sectors that are susceptible to migration and have the potential to cause an exceedance of the surface-water quality standards. These areas include the IA and the B881 / 903 Pad hillslope. Surface water controls for sediment removal (such as settling ponds) are not used in this scenario. The SID is routed directly to Woman Creek in this scenario.

The AME calibrated the Water Erosion Prediction Project (WEPP) model to predict overland flow and erosion for Site hillslopes, and the WEPP-estimated sediment and runoff yields are routed through Site streams using the Sedimentation in Stream Networks (HEC-6T) model (Flanagan et al, 1995, Thomas, 1999). Figure 2 illustrates the AME modeling process (KH/RMRS, 2000). WEPP input files provided by the AME erosion models were modified by the LCDB project to be representative of the conditions associated with each scenario.

The WEPP input files and output results for a 6-hour, 100-year precipitation event for each of the four scenarios were provided to the AME project for evaluation and quality control. The WEPP runoff and sediment yields for each scenario were converted to input for the HEC-6T sediment transport models, which is used to route the runoff and sediment through the Site streams and detention ponds to estimate sediment concentrations and yields. for Walnut Creek, Woman Creek, and the SID. The MS Excel™ –based actinide transport models (ATMs), developed by the AME, were modified for each scenario, and the results of the HEC-6T modeling were entered into the ATMs. The ATMs predict actinide surface-water concentrations from the combined WEPP and HEC-6T modeling output. The ATM results are used to evaluate the bounding scenarios for surface-water quality compliance.

This hydrologic evaluation compares the four scenarios developed by the LCDB. This report contains erosion maps, actinide mobility maps, and average actinide concentrations and loads at selected surface-water Points of Evaluation (POEs) and Points of Compliance (POCs).

WEPP Model Evaluation

All WEPP modeling input and output files were reviewed and evaluated for consistency with the AME models to ensure that differences in results are from differences in land configuration features, not arbitrary differences in modeling parameterization. Each scenario was reviewed and comments were provided as the LCDB Project proceeded. Portions of Scenario 0 were reviewed in June and July, 2001. Scenarios 1, 2, and 3 were reviewed in August, 2001. A comment resolution teleconference was held on August 28, 2001. These documents and the meeting minutes are provided in Appendix A.

The final modeling package was delivered to the AME by the LCDB project personnel for review on October 24, 2001 (RFETS, 2001). The WEPP input and output files were reviewed and a few minor corrections were applied. The WEPP output was then prepared for input to the HEC-6T models for each scenario.

The original calibration of the WEPP model for Site conditions was maintained throughout the LCDB modeling process. Selected WEPP hillslope dimensions were changed, and new hillslopes were created for the IA and the Present Landfill.

HEC-6T Model Development

New HEC-6T models were developed for the four LCDB bounding scenarios. Characteristics of the new HEC-6T models for each scenario are described below.

Scenario 0

Scenario 0 incorporated a re-vegetated IA and changes to the BZ related to covers for the original landfill in the SID drainage and the present landfill in the Walnut Creek drainage. The main change to the HEC-6T model for this scenario was the inclusion of the WEPP-estimated runoff and erosion output for the IA at the upstream end of the model. Previously, surface-water-monitoring data had been extrapolated and input to the upstream end of the HEC-6T models.

The Scenario 0 model includes all existing detention ponds except for the Landfill Pond. The Present Landfill is modeled with an ET cover, which drains directly to No Name Gulch. The SID is routed to Pond C-2 in this scenario.

Scenario 1

In Scenario 1, the non-terminal B-series ponds are re replaced with energy dispersion structures in engineered channels. Terminal ponds, A-4 and B-5, and the C-Series ponds are converted to passive flow-through systems. A wetland was added to the model between Pond A-3 and Pond A-4 on North Walnut Creek. A new wetland was also added below Pond B-5 on South Walnut Creek; extending downstream into Walnut Creek below the confluence of

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North Walnut Creek and South Walnut Creek. In Walnut Creek, the runoff coefficient for the T-130 trailer complex was reduced from 0.7, in the model for existing conditions to 0.1 to account for re-vegetation of the drainage area.

Pond C-1 remains in place and the SID is routed to Woman Creek in the Scenario 1 model. Two wetlands were added to Woman Creek near pond C-2; one immediately upstream from the confluence with the SID, and another off-channel wetland, located just east of Pond C-2. In the Scenario 1 model, up to 0.7 m^3/sec (25cfs) is routed through Pond C-2, and flow exceeding 0.7 m3/sec is diverted to the off-channel wetland. The flow from the off-channel wetland and Pond C-2 outlet are recombined and routed into the Woman Creek main channel. The wetlands are modeled as wide channels filled with vegetation. However, the wetlands have an approximate 2% slope, which is considered steep.

Scenario 2

Scenario 2 adds two detention basins, created by new dams, to Site watersheds. One dam was placed on Woman Creek near the headgate of the Mower Ditch and dovetails with the existing Pond C-2 dam to create an extended Pond C-2 On Walnut Creek, a dam was placed below the confluence of North Walnut Creek, South Walnut Creek, and No Name Gulch. The detention basins are designed to hold all runoff from a 100-year 6-hour event. The original HEC-6T models for Walnut Creek and Woman Creek were truncated at the location of the dams, and only runoff and sediment flowing into the channels below the dams were routed in these models. Baseflow from the dams was held constant at 0.01 m^3/sec (0.5 cfs). Sediment concentrations and suspended sediment activities associated with the baseflow were estimated from Site monitoring data for gaging stations GS11 (Pond A-4 outlet), GS08 (Pond B-5 outlet), and GS31 (Pond C-2 outlet) for the dam discharges.

Scenario 3

Scenario 3 includes engineered drainage channels, slope reduction and re-vegetation to reduce erosion of contaminated surface soils to surface water. The areas modified include the IA, the 903 Pad, and 903 Lip area hillslopes. Surface-water controls for sediment removal (such as settling ponds) are not included in this scenario. The northern IA tributary to North Walnut Creek is modified to capture more runoff from the west by realigning the channel to the east. This modification to the surface hydrology puts more runoff from the IA into North Walnut Creek.

In Scenario 3, the eastern half of the SID watershed is re-graded to reduce the slope of the land surface and reduce runoff and erosion. During re-grading the actinide surface contamination is mixed with the cleaner, underlying soil to an assumed depth of 30 cm, thereby reducing the surface soil actinide concentration in the SID watershed. The SID is routed directly to Woman Creek in Scenario 3.

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Preparation of WEPP Output for the New HEC-6T Models

The WEPP output data were converted to HEC-6T input to route the runoff and sediment through the Site drainage channels. The WEPP runoff, peak discharge, storm intensity distribution, and sediment yields from the WEPP output were formatted for HEC-6T using a triangular unit hydrograph method (KH/RMRS, 2000). WEPP hillslopes are treated as tributary inflows to the streams, which are routed together in a network. HEC-6T computes the stream power in the channels using Yang's Equation, which determines the sediment transport capacity of the stream flow (Thomas, 2001). The model computes the quantities of sand, silt, and clay (distributed among nine particle sizes) that are transported and/or deposited in the stream channel network. Chromec et al (2001), describe the process of integrating WEPP and HEC-6T.

The LCDB Project Team consultant (Parsons) provided WEPP output data and GIS data for the WEPP hillslopes, new drainage channels, and wetlands. The KH AME modeling group (Wright Water Engineers, Inc., Destiny Resources, Inc., and Dyncorp) formatted the data for HEC-6T, ran the HEC-6T models, mapped the data, and estimated surface-water actinide concentrations. The WEPP input and output data files, HEC-6T input and output files, and the Actinide Transport Model (ATM) spreadsheets are contained in Appendix C (CD-ROM in pocket) so that the work may be checked, reproduced, or modified for other scenarios if necessary.

Actinide Transport Models

The sediment and flow data are combined with the estimated quantities of actinides delivered to the streams in the ATM spreadsheets, which are programmed in MS Excel™ (KH / RMRS, 2000). The HEC-6T output file (i.e. files with .t6 file name extensions) contains sediment and runoff yields for the Site streams. The WEPP erosion data and soil actinide data are mapped in grid form in ArcInfo™ (GIS), and a GIS program is run to compute the quantity of actinides delivered to the streams from each hillslope based on the grid values. The particle-size distributions of the actinides on the sediment particles are also included in the ATM spreadsheets. Event-mean actinide concentrations and total actinide yields are estimated and graphed in the ATM spreadsheets. The ATMs are included in Appendix C.

Industrial Area Yields for Existing Conditions

Industrial Area runoff, sediment yields, and actinide concentrations for existing conditions were derived using Site monitoring data for gaging stations GS10, SW093, GS21, GS22, GS24, and GS25. The average total suspended solids concentration measured at each station was multiplied by the event precipitation depth and measured runoff coefficient for each gaging station to create sediment discharge rates for design storms (e.g. 100-year, 6-hour (97.1mm) storm).

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Triangular unit hydrographs for each IA sub-basin were computed using the storm depth (e.g. 97.1mm), storm duration (e.g. 6 hours), and the average runoff coefficient estimated from measured data. The peak discharge of each IA sub-basin runoff hydrograph is located at one-sixth of the storm duration (e.g. 1 hour), which is consistent with hydrographs provided in the Rocky Flats Plant Drainage and Flood Control Master Plan (EG&G, 1992). Actinide concentrations measured in surface water samples at each IA gaging station were divided by corresponding TSS values to obtain the actinide content of the suspended solids in pCi/g. The average actinide content of the suspended solids was computed for each IA gaging station.

LCDB Scenario Conditions

New ATM models were produced for each scenario. In Scenario 0, changes were made to the ATM to incorporate a re-vegetated IA, landfill covers and direct routing to Woman Creek. For Scenario 1 changes to the ATMs were made to account for the removal of the non-terminal B-series ponds, addition of wetlands in Walnut Creek and Woman Creek, and re-routing of the SID to Woman Creek. In Scenario 2, the ATM models were truncated at the detention ponds in the Walnut Creek and Woman Creek Watersheds. Estimation of actinide yields and concentrations are not computed upstream of the hypothetical dams in Scenario 2.

All ponds were removed from the watersheds for Scenario 3. The slope and soil actinide concentration data for the SID were also reduced to simulate soil grading. Re-grading the eastern SID will also result in a reduced surface soil actinide concentration, which is discussed later herein.

In Scenarios 0, 1, and 3, the WEPP model was used to estimate IA runoff and sediment yields to the streams. The kriged surface-soil actinide concentration grids were used to estimate the actinide content of the delivered sediments using GIS techniques. The modeling data are used in place of the IA gaging station measurements for re-vegetated conditions represented in Scenarios 0, 1, and 3.

In Scenario 2, the average measured actinide concentrations for gaging stations GS08 and GS11 are used for the baseflow discharged from the new hypothetical dam in Walnut Creek. Similarly, average actinide concentrations measured at gaging station GS31 are used for baseflow discharged from the hypothetical expanded Pond C-2 dam in Scenario 2 for Woman Creek. Baseflow from the hypothetical dams is set to 0.03 m^3/sec (1 cfs) at steady state.

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Modeling Results for the LCDB Scenarios

Erosion and Actinide Mobility

The erosion maps in Figures 3 and 4 show the results of the WEPP modeling for LCDB Scenarios 1 and 3. On the erosion maps, the warm colors indicate areas with high erosion, and cool colors indicate areas with deposition. Gray areas indicate where data were not obtained from the WEPP model. The boundaries of the erosion models are shown in red.

Figure 3 shows the WEPP erosion modeling results for Scenario 1, which are similar to results for Scenarios 0 and 2. Figure 3 shows the locations of the wetlands near Pond A-4 in Walnut Creek and near Pond C-2 in Woman Creek. The wetland erosion is estimated by HEC-6T, not WEPP. Therefore, erosion estimates for the wetlands are not mapped in Figure 3.

Figure 4 shows the WEPP erosion modeling results for Scenario 3. The hillslopes in the IA and up-gradient of the SID are different from Scenarios 0, 1, and 2. The IA drainage pattern in Scenario 3 directs more runoff to the northern portion of the IA, which drains to North Walnut Creek. Diversion of the surface-runoff to North Walnut Creek slightly increases erosion in the northern IA and decreases erosion in South Walnut Creek sub-basin in the IA. Figure 5 compares the erosion and associated actinide mobility for Scenarios 1 and 3.

Figure 5 shows that there is more erosion in the eastern SID watershed in Scenario 1 than in Scenario 3. This is due to the fact that the eastern SID watershed is re-graded to reduce erosion in Scenario 3. Figure 5 shows that there is lower predicted actinide mobility for Scenario 3 than for Scenario 1 in the SID watershed. The reduced actinide mobility and surface-water concentrations are due to reduced slope of the eastern SID watershed hillslopes (i.e. less erosion) combined with reduction of surface-soil actinide concentrations from re-grading and tilling of the surface-soil.

The effects of re-grading the surface soil in the eastern SID watershed are illustrated in Figure 6. Data collected by Dr. M. Iggy Litaor and others, indicates that the actinide concentrations decrease with soil depth (Litaor et al, 1994 and DOE, 1995). If this soil was tilled, the actinide concentration would become more evenly distributed with depth by dilution of the surface concentrations with the deeper, cleaner soil. Therefore, sediment yields to streams from soil erosion would have lower actinide content, which would lower surface-water concentrations. The modeling results are consistent with this logic.

For this analysis, the average surface soil Pu-239,240 and Am-241 concentrations were calculated for each of four sectors (A, B, C, and D) using GIS. The measured vertical distribution of actinides in the soil was used to estimate what the surface concentration would be if the top 30cm of soil was homogenized by grading. The Pu-239,240 and Am-241 soil concentration grids were edited in GIS such that the surface concentration in each sector is a homogeneous mixture of the top 30cm of soil. Figure 7 illustrates the resulting modified surface soil actinide grids used to estimate actinide yield to the SID in Scenario 3.

The independent effects of reducing the slope of the eastern SID hillslopes and surface-soil actinide concentrations were evaluated. Figure 8 shows the results of this evaluation. Predicted concentrations for Pu-239,240 and Am-241 are given for two different modeling conditions: 1) no predicted channel erosion (i.e. no streambed scour) and 2) including predicted channel erosion (i.e. streambed sediment scour and re-suspension). The actual concentrations are expected to be within the range of the values for the two channel erosion conditions. The results shown in Figure 8 indicate that surface-soil actinide concentration reduction by re-grading the eastern SID watershed will reduce surface-water concentrations in Woman Creek by about 30 percent. The slope reduction alone has a negligible effect on actinide concentrations. This is explained by the fact that the slope reduction not only reduces erosion, but runoff as well; producing no net change in actinide concentration.

Surface-Water Actinide Transport

Sediment and associated actinide yields are given for each of the channel erosion conditions. The yields are sum quantities of sediment (in kg) or actinides (in pCi) transported in the surface water to a given point in the watershed. For this report, the sediment and actinide yields are computed for the outlets of each watershed: Walnut Creek at Indiana Street (a.k.a. POC station GS03), Woman Creek at Indiana Street (a.k.a. POC station GS01), and POE gaging station SW027 at the mouth of the SID. Sediment yields and actinide concentrations and yields are also presented for POE stations SW093 and GS10 on North Walnut Creek and South Walnut Creek, respectively, and for POC station GS08 on South Walnut Creek below Pond B-5.

Currently, the Site is regulated by the RFCA requirement that surface-water concentrations of Pu-239,240 and Am-241 be less than 0.15 (picocuries per liter (pCi/L)), based on a 30-day moving average. The analysis presented herein is for a single 100-year, 6-hour, 97.1mm storm event, not a 30-day moving average of continuous-flow-composite samples. Each of the bounding scenarios is evaluated based on the predicted, event-mean actinide concentrations in the flow (in pCi/L) and the total actinide yields (in pCi). The predicted actinide concentrations and yields in surface water are presented for each scenario in Table 2 and in Figures 9, 10, 11, and 12.

The predicted actinide concentrations shown in Figures 9 through 12 indicate how concentrations vary along the reach of a stream channel from upstream to downstream. Once again, predicted concentrations for Pu-239,240 and Am-241 are given for two different modeling conditions: 1) no predicted channel erosion (i.e. no streambed scour) and 2) including predicted channel erosion (i.e. streambed sediment scour and re-suspension), with actual concentrations expected to be within the range of the values for the two models.

In Table 2, comparison of modeling results for Scenario 0 and existing conditions for Walnut Creek and the SID shows that sediment and actinide yields may decrease after IA re-vegetation (Scenario 0). However, runoff is also greatly reduced in Scenario 0. Therefore, concentrations of actinides are predicted to increase in the streams due to decreased runoff and dilution in Scenario 0.

Walnut Creek

Results for Walnut Creek modeling in Table 2 and Figures 9 and 10 show that all bounding scenarios (1, 2, and 3) produce lower actinide yields and concentrations than the baseline configuration (Scenario 0). In Scenario 0, actinide yields at Walnut Creek at Indiana Street (GS03) are reduced by more than a factor of two in both Scenario 1 (wetlands and energy dispersion structures) and Scenario 3 (IA drainage modifications and SID slope-reduction). The Scenario 1 and 3 actinide concentrations at GS03 are nearly a factor of four lower than the Scenario 0 concentrations.

The Walnut Creek wetland channels, installed in Scenario 1, are predicted to have a beneficial effect on actinide yields and concentrations. Comparison of the Scenario 0 and Scenario 1 actinide yields, in Table 2, shows that the wetlands decrease actinide yields by 48 percent at GS03. Typically, and a flood like the 100-year event would be expected to flush sediment and associated constituents from the wetlands, which is the result obtained for Woman Creek. However, for Walnut Creek, the wetlands are predicted to be effective for controlling actinide yields.

The energy dissipation structures in South Walnut Creek are also predicted to be effective at reducing sediment and associated actinide yields for the 100-year event. Comparison of the Scenario 0 and Scenario 1 actinide yields in Table 2 shows that the predicted yields at GS08 are reduced by 65 percent by installation of the energy dissipation structures located between GS10 and GS08 (Figures 9 and 10).

In Scenario 2 (detention basins), predicted actinide yields at GS03 are about a factor of 30 lower than in Scenario 0. Walnut Creek Scenario 2 produces the lowest actinide yield and concentrations; indicating the effectiveness of detention ponds on actinide yields and concentrations (Figure 9).

Predicted actinide yields at GS03 for Scenario 3 are slightly lower than Scenario 1 yields. Predicted actinide concentrations are similar for Scenarios 1 and 3. Replacement of the ponds with non-erodible, engineered channels causes less actinide re-suspension and transport (Figure 9).

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South Interceptor Ditch

Modeling results for the SID in Figure 11 show actinide concentrations and yields at gaging station SW027 for existing conditions and Scenario 0. Scenario 0 concentrations are nearly double those for existing conditions for the 100-year event. This is due to an increase in erodible surface area in the SID drainage in Scenario 0 combined with reduced runoff entering the SID.

Woman Creek

Results for the Woman Creek scenario modeling indicate that none of the LCDB scenarios control surface-water actinide concentrations better than either the existing or Scenario 0 configurations (Figure 12). Scenario 0 is similar to existing conditions for Woman Creek because the IA runoff to the SID is captured by Pond C-2 and not routed into Woman Creek in Scenario 0. Routing the SID into Woman Creek in Scenarios 1 and 3 cause actinide yields and concentrations in Woman Creek to increase due to introduction of runoff from the 903 Pad area, which contains soil with the highest actinide concentrations at the Site. Table 2 shows that routing the SID into Woman Creek in Scenarios 1 and 3 causes actinide yields at Indiana Street (GS01) to increase by two- to five-fold compared to Scenario 0.

Scenario 1 and 3 models for Woman Creek assume that Pond C-2 can contain the 100-year event without spilling to Woman Creek. There is a potential for Pond C-2 to spill runoff over the emergency spillway to Woman Creek in the 100-year event, but for this study it was assumed that Pond C-2 contains the 100-year event.

Installation of wetlands in the Woman Creek channel and in the Woman Creek Bypass Canal is not predicted to affect actinide yields and concentrations. The slope of these wetlands is about two percent, which is steep for a wetland area. Furthermore, wetlands would be expected to be flushed from a large flood like the 100-year event (Dr. Katherine Walton-Day, U.S. Geological Survey, Water Resources Division, personal and written communications). Therefore, the results for Woman Creek Scenario 1 modeling are consistent with prototype wetlands. Modeling a smaller storm events for Scenario 1 might provide a flow threshold for wetland effectiveness in controlling actinide yields and concentrations.

Predicted Woman Creek actinide yields for Scenario 2 (new, expanded Pond C-2 dam) are 50 percent lower than the Scenario 0 yields, but there is a slight increase in actinide surface-water concentration for Scenario 2. This is because the detention pond holds most of the stormwater runoff, which reduces the total yield, but also makes the Woman Creek flow more concentrated with actinide activity by reducing the flow. Table 1 shows that Woman Creek Scenario 2 runoff yield is about one-third of the predicted runoff yields for Scenarios 1 and 3. These results are similar to the results obtained for Walnut Creek Scenario 2, which indicate that detention ponds are likely the most effective way to control actinide transport in streams at the Site.

Conclusions

- The modeling results indicate that re-vegetation and re-direction of overland flow in the IA combined with watershed channel modifications can produce lower actinide yields and concentrations than post-remediation (Scenario 0) levels for Walnut Creek and Woman Creek. The converse was true for the SID. In the SID, an increase in erodible surface area combined with a loss of runoff from the IA resulted in less dilution of the actinides and thus higher post-remediation surface-water concentrations.
- Modeling results indicate that detention ponds are likely the best available control of actinide yields, but not necessarily for actinide concentrations. The modeling indicates that continued channel erosion combined with actinides transported from overland flow downstream from the dams, combined with reduced / attenuated flows, will increase actinide concentrations in the streams below the dams.
- Modeling results indicate that wetlands and/or energy dissipation structures in Walnut Creek are effective controls of actinide yields. However, modeling of wetland controls in Woman Creek indicated that they had little effect on actinide yields and concentrations for the 100-year, 6-hour storm event. This large event, consisting of 97.1mm of precipitation in six hours, would be expected to flush prototype wetlands. Therefore, the modeling results for Woman Creek are consistent with natural wetland processes. Modeling smaller storm events might provide a threshold for wetland effectiveness in controlling actinide transport.
- Comparison of modeling results for Scenarios 1 and 3 in Woman Creek indicate that re-grading the eastern SID watershed to reduce the slope of the hillslopes would reduce erosion and actinide mobility. In addition, tilling the soil will lower the surface-soil actinide concentrations. Consequently, the predicted Woman Creek actinide yields and concentrations are reduced, as shown in Scenario 3. The Scenario 3 models for Woman Creek demonstrate that re-grading the contaminated soil is an effective technique for controlling actinide transport at the Site.
- The results contained herein are for a single, extreme storm event. Therefore, the results cannot be directly compared to RFCA action level compliance at 0.15 pCi/L Pu-239,240 and Am-241, which is based an a 30-day moving average of measured, composite sample concentrations. Modeling smaller storm events and extrapolation of those model results to continuous climate record could provide an evaluation of RFCA compliance based on 30-day moving average concentrations.
- The modeling results provide a relative comparison of the Site land configuration bounding scenarios. The accuracy of the results is believed to be within one order of magnitude for actinide yields and concentrations (KH/RMRS (2000)). The estimated peak discharges and runoff yields are not appropriate for structural or civil engineering design purposes, but the hydrology and channel hydraulics predicted by the models are realistic and reasonable. Culvert sizing, bridge design, and other design engineering should rely on standardized engineering techniques, not the flows predicted by these models.

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FIGURES

Figure 2. Schematic Diagram of the AME Erosion, Sediment, and Actinide Transport Modeling Process

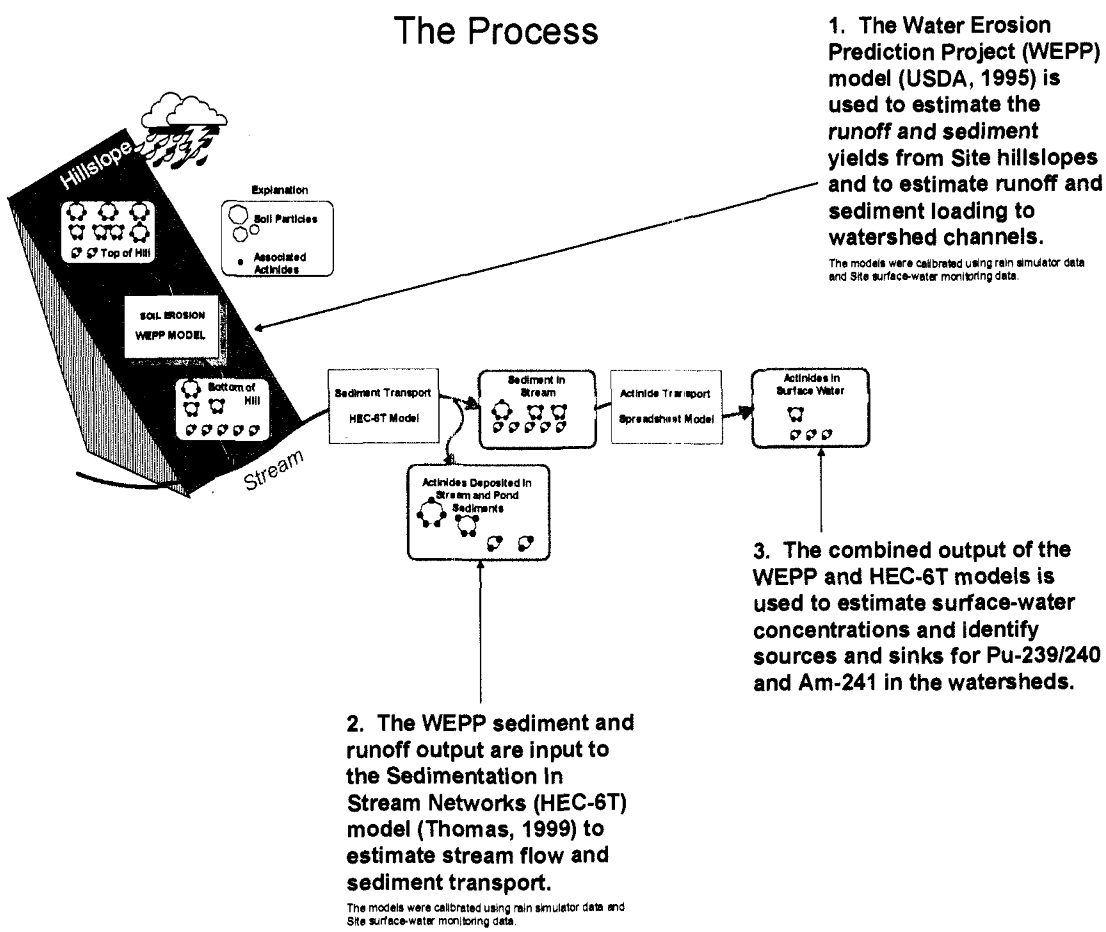

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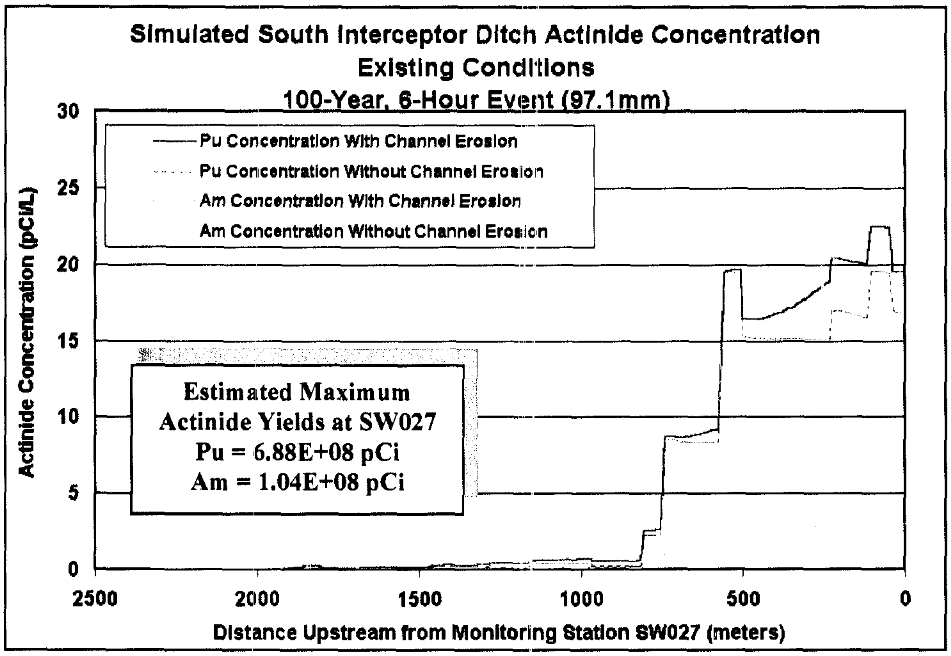
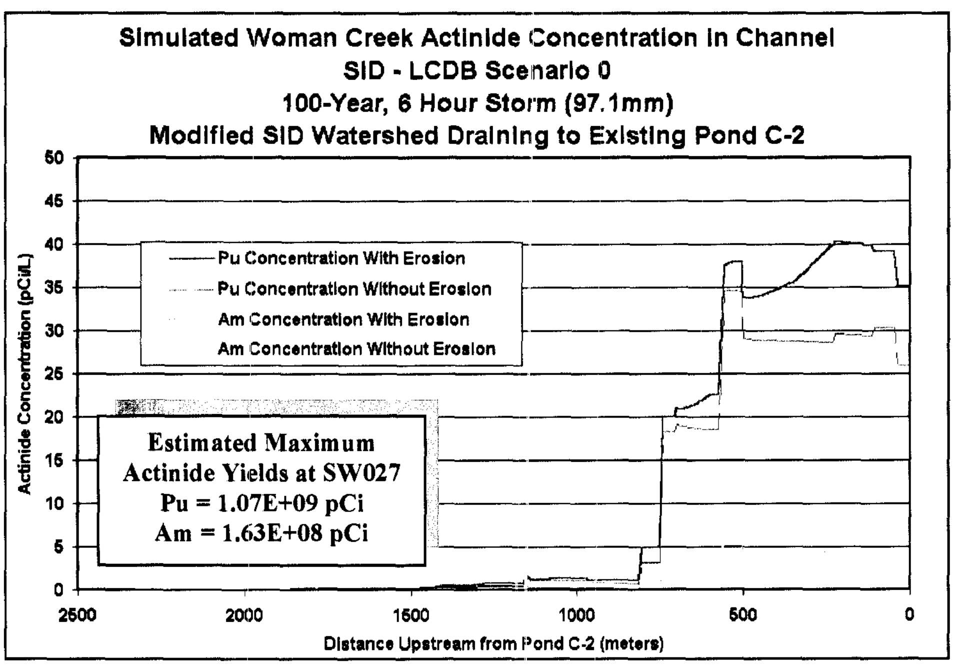
Figure 11. South Interceptor Ditch Scenario Model-Predicted Actinide Concentrations for Existing Conditions and Scenario 0, 100-Year, 6-Hour Storm Event (97.1mm)





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TABLES

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Table 1. Summary of LCDB Scenario Characteristics

Scenario	Industrial Area Configuration	Hydrologic Features	Special Features
0	• Re-vegetated IA • ET Covers on Solar Ponds and Landfills • Re-grade Industrialized Portions of SID drainage	Existing Drainage Features & Routing	None
1	Same as Scenario 0	• Install Engineered Wetlands • Replace Ponds B-1, B-2, B-3, B-4 with Energy Dispersion Structures	• Off-channel wetland in Woman Creek east of Pond C-2 • SID routed to Woman Creek via Pond C-2
2	Same as Scenario 0	Replace all existing detention ponds with one new pond in Walnut Creek and one new pond in Woman Creek.	• SID routed to Woman Creek through new pond
3	• Re-vegetate IA • ET covers on solar ponds and landfills • Realign northern IA tributary to North Walnut Creek.	Replace all existing detention ponds with armored engineered channels Eastern SID watershed re-grading	SID routed directly to Woman Creek Reduced surface-soil actinide concentrations in eastern SID due to re-grading.

IA = Industrial Area, SID = South Interceptor Ditch, ET = Evapotranspiration

Table 2. Summary of Results for LCDB Scenario Modeling

Scenario	Watershed	Gaging Station	POE or POC	Estimated Runoff (m^3)	Estimated Sediment Yield[1] (kg)	Estimated Range Pu Concentration (pCi/L)	Estimated Range Am Concentration (pCi/L)	Estimated Range Pu Yield (pCi)	Estimated Range Am Yield (pCi)
Existing	Walnut Creek	SW093	POE	64,175	27,667	0.121 - 0.151	0.122 - 0.142	7.76E+06 - 1.02E+07	7.84E+06 - 9.33E+06
Existing	Walnut Creek	GS10	POE	68,914	4,975	0.06 - 0.065	0.07 - 0.076	4.14E+06 - 4.54E+06	4.82E+06 - 5.21E+06
Existing	Walnut Creek	GS08	POC	91,832	19,827	0.13 - 0.43	0.04 - 0.17	1.12E+07 - 3.70E+07	3.49E+06 - 1.47E+07
Existing	Walnut Creek	GS03	POC	254,271	257,543	0.14 - 0.64	0.04 - 0.25	3.61E+07 - 1.65E+08	1.12E+07 - 6.48E+07
Existing	Woman Creek	GS01	POC	145,923	113,219	1.72 - 1.75	0.203 - 0.204	2.11E+08 - 2.45E+08	2.39E+07 - 4.08E+07
Existing	SID	SW027	POE	37,842	106,084	16.9 - 19.5	2.5 - 3.0	6.39E+08 - 7.37E+08	9.52E+07 - 1.12E+08
0	Walnut Creek	SW093	POE	23,758	34,601	0.31 - 0.36	0.13 - 0.16	7.30E+06 - 8.54E+06	3.10E+06 - 3.69E+06
0	Walnut Creek	GS10	POE	14,917	7,454	2.7 - 3.2	0.74 - 0.86	4.00E+07 - 4.69E+07	1.11E+07 - 1.29E+07
0	Walnut Creek	GS08	POC	32,009	21,798	1.4 - 3.3	0.44 - 0.93	**4.56E+07 - 1.15E+08**	**1.40E+07 - 3.23E+07**
0	Walnut Creek	GS03	POC	163,314	264,789	0.64 - 2.8	0.21 - 0.80	**1.05E+08 - 4.55E+08**	**3.46E+07 - 1.31E+08**
0	Woman Creek[2]	GS01	POC	145,923	113,219	1.72 - 1.75	0.203 - 0.204	2.11E+08 - 2.45E+08	2.39E+07 - 4.08E+07
0	SID	SW027	POE	30,429	90,431	26 - 35	3.9 - 5.4	8.56E+08 - 1.07E+09	1.28E+08 - 1.63E+08
1	Walnut Creek	SW093	POE	25,121	34,601	0.29 - 0.34	0.12 - 0.15	7.00E+06 - 8.20E+06	2.89E+06 - 3.47E+06
1	Walnut Creek	GS10	POE	14,917	7,472	2.2 - 2.6	0.68 - 0.80	3.27E+07 - 3.88E+07	1.01E+07 - 1.19E+07
1	Walnut Creek	GS08	POC	37,596	10,463	0.54 - 1.3	0.16 - 0.36	**1.72E+07 - 4.06E+07**	**5.04E+06 - 1.16E+07**
1	Walnut Creek	GS03	POC	162,562	247,878	0.23 - 1.8	0.08 - 0.52	**3.82E+07 - 2.86E+08**	**1.22E+07 - 8.47E+07**
1	Woman Creek	GS01	POC	175,102	247,937	5.7 - 7.4	0.85 - 1.1	1.01E+09 - 1.29E+09	1.49W+08 - 1.92E+08
1	SID	SW027	POE	30,141	99,210	26 - 32	3.9 - 4.9	7.96E+08 - 9.72E+08	1.18E+08 - 1.46E+08
2	Walnut Creek	GS03	POC	38,655	59,745	0.29 - 0.37	0.08 - 0.11	1.11E+07 - 1.42E+07	3.19E+06 - 4.17E+06
2	Woman Creek	GS01	POC	42,006	36,206	2.7 - 2.9	0.30 - 0.33	1.12E+08 - 1.21E+08	1.26E+07 - 1.38E+07
2	SID[3]	SW027	POE	30,429	90,431	26 - 35	3.9 - 5.4	8.56E+08 - 1.07E+09	1.28E+08 - 1.63E+08
3	Walnut Creek	SW093	POE	39,514	34,496	0.04 - 0.05	0.02 - 0.03	1.5E+06 - 1.84E+06	9.60E+05 - 1.09E+06
3	Walnut Creek	GS10	POE	14,151	6,079	0.34 - 1.6	0.38 - 0.61	4.88E+06 - 2.32E+07	5.36E+06 - 8.63E+06
3	Walnut Creek	GS08	POC	32,029	34,423	1.4 - 2.3	0.05 - 0.07	4.65E+07 - 7.24E+07	1.69E+06 - 2.33E+06
3	Walnut Creek	GS03	POC	180,005	308,630	0.36 - 0.87	0.06 - 0.09	6.43E+07 - 1.57E+08	1.05E+07 - 1.59E+07
3	Woman Creek	GS01	POC	334,171	137,574	1.4 - 1.8	0.21 - 0.28	4.71E+08 - 6.08E+08	6.96E+07 - 9.50E+07
3	SID	SW027	POE	30,366	74,134	16 - 21	2.8 - 3.8	4.78E+08 - 6.39E+08	8.45E+07 - 1.15E+08

Energy Dissipation Structures Decrease Actinide Yield to GS08 by About **65%**

Wetlands Decrease Actinide Yield to GS03 by About **48%**

SW093 = North Walnut Creek above Pond A-1
GS10 = South Walnut Creek above Pond B-1
GS08 = South Walnut Creek below Pond B-5
GS03 = Walnut Creek at Indiana Street
GS01 = Woman Creek at Indiana Street
SW027 = South Interceptor Ditch at Mouth above Pond C-2
POC = Rocky Flats Cleanup Agreement Surface Water Point of Compliance; POE = Rocky Flats Cleanup Agreement Surface Water Point of Evaluation

[1]Value includes sediment yield due to channel erosion (scour).

[2]Same as existing conditions.

[3]Same as Scenarios 0 and 1. Note that SID yields to Woman Creek are larger than Yields in Woman Creek, indicating removal of SID actinide load in Pond C-2.

APPENDIX A

WEPP Modeling Review and Meeting Summaries

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June 28, 2001

Review of Scenario 0 Erosion and Runoff Modeling for the Industrial Area (IA)

The overall impression is that the input and output are consistent with the previous Actinide Migration Evaluation (AME) Erosion Modeling Report. The results of the review are detailed in the following bullets.

- Soil and vegetation input parameters were checked and were consistent with the previous AME WEPP modeling. I was unable to verify the slope values from the *.dbf files that were sent and I do not have a topographic map of the Site after final remediation, but the transect lines appear reasonable and well placed.
- I have two comments on the delineation of hillslopes: 1) There may be more hillslopes than necessary for the resolution of the model; 2) It appears that many of the hillslopes drain onto other hillslopes, not into drainages. This may make estimating amounts of sediment and actinides reaching surface water difficult. I have not been involved in the process, so this may have been discussed and an approach decided upon previously. If an approach has not been decided upon, this should be discussed with the HEC-6T modeler immediately.
- The hillslope models were run and the output checked against the tables provided by Parsons. Five hillslopes were found to have discrepancies in runoff and/or sediment yield when compared to the table "modelvalid2.xls." Four hillslopes, 217, 218, 224, and 225 had lower Ke's than in the table. The Ke's in the table were in red perhaps indicating that they were to be changed. The table, soil files, and out put should be reconciled. The "Sediment Originating in the OFE" result for hillslope 128, OFE B, in the table did not have the sediment value for OFE A subtracted from it. This should be corrected.
- The footnotes for the tables for the other watersheds were not consistent and should be updated if these tables are distributed more widely.
- Summary statistics for runoff and sediment output were calculated for the model and the three other watersheds and used to determine if the model output for Scenario 0 was consistent with output for the three previously modeled watersheds. The Excel file, "Model review.xls" is attached. The first spreadsheet has the mean, standard deviation, maximum, minimum and median values for runoff (mm), sediment originating in the OFE (kg/m), sediment yield (kg/ha), and slope (m/m) for the topslope and sideslope soils for the four modeled areas. The second sheet is a graph of runoff versus slope and the third is sediment yield versus slope. It is recognized that neither independent variable is solely related to slope, but the results are helpful for deciding if the four modeled areas are behaving similarly. I am satisfied that the results of the Scenario 0 IA model are reasonable.

July 13, 2001

Review of Scenario 0 Erosion and Runoff Modeling for the South Interceptor Ditch (SID) and Current Landfill (CLF)

South Interceptor Ditch Review

The input and the output for the SID hillslopes are inconsistent with the previous Actinide Migration Evaluation (AME) Erosion Modeling Report. Figure one shows a comparison of runoff and sediment loss for the original configuration and the modified SID hillslopes. The figure clearly shows that on several hillslopes (especially 1, 6, 10, 12, 13 15) sediment loss has increased dramatically while runoff is generally lower.

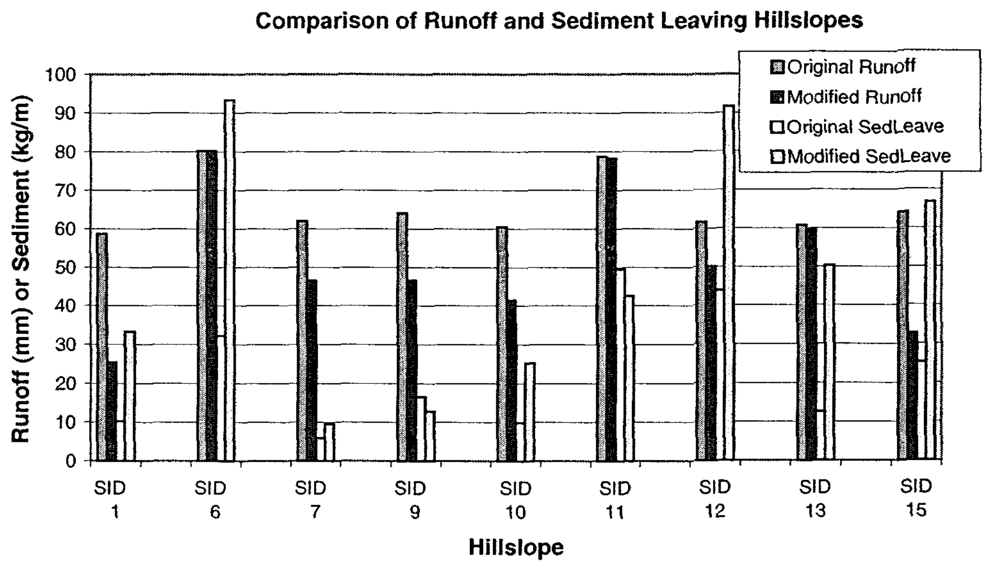

Figure 1

The results of the review are detailed in the following bullets.

- It is the opinion of the reviewer that changing management and slope files on OFEs that have not been altered due to addition of covers (e.g. the old landfill) or removal of buildings and the addition of area at the top of the slope have nothing to do with the changes in land configuration and make it very difficult, if not impossible, to identify the effects of the important changes (building removal etc). Ii is suggested that the SID hillslopes be modeled with only the modifications that are truly necessary, using the original SID single-storm hillslope management slope and soil input files as the base for the modified input files. Figure 1 illustrates the problems created by using completely new hillslope files. Tracking down the causes is time consuming. The following bullets discuss some of the causes.
- Soil and vegetation input parameters were checked and were consistent with the previous AME WEPP modeling, although vegetation type was changed on some OFEs. There were two exceptions: 1). The random roughness variable in the soil file for SID6m was changed from 0.02 to 0.01. Runoff and sediment loss are sensitive to this parameter and it was probably increased in the original model on this hillslope to calibrate the hillslope. 2) The rill basal cover for the xeric tall grass prairie vegetation inputs is 0.035. This value agrees with Table A-3 in the AME Erosion Report but all Walnut Creek hillslopes have a value of 0.05. You might want to check with Greg Wetherbee and see if the 0.05 value is an update that should be used throughout the modeling.
- There appears to be some problems with slope values: 1) Sediment leaving Hillslope 1 has more than tripled. The slope on OFE 4 seems excessive. The slope for the first two-thirds of the OFE is between 36 % and 40%. This may be necessary for the landfill cover design. If so, it demonstrates the need for applying erosion control such as armoring to the steep slope. 2) Sediment leaving Hillslope 6 has almost tripled. This appears to be the result of a 50% slope over 25% of the distance (from slope file:0.000,0.157 0.250,0.157 0.500,0.509 0.750,0.099 1.000,0.111). It doesn't look like the road was modified, therefore, the original files for SID6 could be used and results would be consistent. 3) In the original slope files for the SID the flow was routed across the roads that were OFEs (e.g. SID1, SID10, SID 12, SID 13, and SID15). Therefore, the road OFEs were kept to 3 to 5 meters in length and set at a

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lower slope value than the hillslope (Example: SID1m has a road 30 meters wide). To facilitate the evaluation of important changes in land configuration, it is suggested that road widths be kept reasonable and the slope values used in the original SID modeling be used when available, unless the hillslope has been graded significantly.

- Some of the problems with decreased runoff and increased erosion shown in Figure 1 are due to a model interaction with slope length (i.e. long slope lengths).The AME Modeling Project had previously identified this as an artifact of the WEPP model. The developers were consulted but the problem persists. This is a problem with the model that can be worked around. It is possible that by increasing the number of OFEs, thereby decreasing the lengths of the long OFEs the runoff and erosion could be brought in line with the original model. Another fix might be to model the long top-slope areas as separate hillslopes and then add the runoff and erosion results to the areas below. This appears to be a problem on Hillslopes 1, 7, 9, 10, 12, and 15 (and maybe 13).

  An example is that the sediment leaving Hillslope 10 has increased by more than a factor of 2.5 while runoff is decreased by one third. Reducing the lengths of OFEs 1 and 2 to 24 and 49 meters, respectively, with the lengths of other OFEs unchanged produced the results below. These results are very similar to the original SID results for both runoff and erosion. The results would be even closer if the slope of the unimproved road were changed to that of the original.

		-------Modified-----------		--------Original-----------	
OFE	Precip	Runoff	SedLeave	Runoff	SedLeave
	mm	mm	kg/m	mm	kg/m
1	97.1	58.941	0.122	----	---
2	97.1	57.164	1.384	9.288	.334
3	97.1	57.787	5.076	9.057	.250
4	97.1	58.333	6.544	9.591	.086
5	97.1	59.014	2.699	0.472	.953

- In summary, it is suggested that, in order to facilitate comparison to the original SID model and to understand the effects of the important land configuration changes, the original SID single-storm hillslope input files be used with changes incorporated only as a result of proposed Site configuration alterations. It may also be necessary to model the long Hillslopes in more than one segment or add OFEs to compensate for the instability of the WEPP model on long hillslopes.

Present Landfill Review

The proposed configuration of the Present Landfill makes it a difficult area to model for runoff and erosion. The cap drains in three directions and is circumscribed by a road.
The current hillslope model for the Present Landfill is not very meaningful from a watershed modeling perspective.

Conceptually OFEs are planes that drain from one to the next and decrease in elevation. In the current model OFE 1 is in reality at the base of the slope but is modeled at the top of the slope. It seems more reasonable to designate the current OFE 2 as the top or first OFE.

The model should be reconfigured after an analysis is done to determine the most-likely drainage patterns. The question to be answered is: How much runoff and sediment will reach the drainage at the eastern end of the landfill and where does it originate? The current model does not provide the answer to this question.

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August 19, 2001

Review of Scenarios 1, 2, and 3.

In general the WEPP output looks reasonable. There are a couple of concerns, based on a limited review of the input text files and the graphics that were provided.

1. I do not have the information of tools necessary to state with certainty that the changes in the hillslopes are reflective of the scenarios. I suggest that RFETS GIS personnel familiar with the previous model examine the hillslope configuration data and scenario configuration changes. Greg Wetherbee and/or I can then review their findings.

2. In Scenario 2 it appears that in Woman Creek hillslopes 31, 32, 33, and 35 have been kept intact although in this scenario a dam or a drainage swale splits them. If the hillslopes are indeed split by proposed features that will greatly influence surface drainage patterns they should be reconfigured to reflect the changes. New hillslope may need to be designated.

3. In Scenario 3 the hillslope configurations for the SID area do not appear to be consistent with the Scenario description. A review of the WEPP input files indicates that the IA positive drainage and the grade reduction for the SID area have been incorporated. However drainage improvements and controls have not been incorporated into the WEPP model for the SID.

General Comments

None of the WEPP hillslope input files for the three scenarios have been named or annotated to describe to which Scenario they specifically apply. For example, the slope files for hillslopes that change attributes between scenarios all have the same name. The files should be renamed and annotated or there is a high potential for confusion of input files among scenarios.

The most important aspect of the information provided for review of the three bounding scenarios is whether the changes in landscape configuration discussed under each scenario is accurately reflected in the WEPP hillslope input files. If the changes are not well described by the input files, the erosion and surface water modeling for each scenario will have little meaning. I have looked through many of the input files that were changed for each Scenario. It is difficult to tell from the input text file if the many changes correctly reflect the described scenarios.

I suggest that for Scenarios 1 and 2 the RFETS GIS personnel who have been assisting on the WEPP modeling project take a close look at the changes in landscape configuration for the proposed bounding scenarios. Overlay these on the existing hillslopes and check to be sure that the changes made in the WEPP input files are representative of the scenarios. If not, changes can easily be made to the input files before the final WEPP run and input of results to HEC-6T.

I have documented some changes I noted in the input files for the scenarios below. Comments on the WEPP input and output for each scenario are included in the following discussion.

Scenario 1 Comments

The runoff and sediment yield output looks reasonable and is in the range of previous modeling for the drainages. In Woman Creek, the results for hillslope 32 indicate that runoff is similar to the previous configuration but erosion per unit area has increased considerably, even thought the hillslope is much

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shorter. In general, it appears that when hillslopes were modified for length in Scenario 1 the slopes were not adjusted accordingly. This may account for the changes in output for hillslope 32.

Walnut Creek

Some of the changes noted in some slope files for scenario 1 for Walnut Creek are listed below. This is not a comprehensive list of changes but is representative of the types of changes made.
Hillslope 75 is 1 m shorter but the slope values have not changed.
Hillslope 74 is 4 m shorter but the slope values have not changed.
Hillslope 68 is 3 m shorter but the slope values have not changed.
Hillslope 67 is 34 m shorter but the slope values have not changed.
Hillslope 63 is 22 m shorter but the slope values have not changed.
Hillslope 55 is 2 m shorter but the slope values have not changed.
Hillslope 66 is 15 m shorter. The OFE 1 was shortened but the slope values have not changed.
Hillslope 46, OFEs 3 and 4 have been shortened, from the limited graphics available it appears that OFE 4 may disappear completely due to incorporation in the proposed wetland.

Woman Creek

The majority of Hillslope 32 appears to be in the new wetland area, east of Pond C-2, yet there are still three OFEs for the new hillslope, OFE 2 is much shorter but the slopes in the slope file are unchanged. It is unclear if the wetland is being modeled as part of the hillslope or as part of the drainage.

I don't believe my doing much more at this time is fruitful. The RFETS GIS personnel familiar with the approach used in the previous WEPP modeling should take a look at the hillslope changes to be sure they are consistent with previous approaches. For example, it appears that if area was lost on a hillslope it was shortened to compensate. In previous modeling the length of the hillslope was the flow length for runoff and the width was adjusted if necessary.

Scenario 2 Comments

I was not provided with a graphic for Walnut Creek that shows both the proposed retention structure and the WEPP hillslopes. Therefore, I cannot address the appropriateness of changes to hillslopes in the Walnut Creek drainage for Scenario 2. Generally the output looks to be reasonable compared to previous results.

In Woman Creek it appears that hillslopes 31, 32, 33, and 35 have been kept intact although in this scenario a dam or a drainage swale splits them. If I understand the graphics correctly, this configuration does not make hydrologic sense. If the hillslopes are indeed split by proposed features that will greatly influence surface drainage patterns they should be reconfigured to reflect the changes. New hillslope may need to be designated.

Again, I suggest that the RFETS GIS personnel familiar with the drainages and the approach used in the previous WEPP modeling should take a look at the hillslope changes to be sure they are consistent with the proposed landscape changes and previous approaches.

Scenario 3 Comments

Scenario 3 does show an overall decrease in sediment leaving the SID hillslopes, compared to the original model. However, the hillslope configurations do not appear to be consistent with the Scenario description.

Three main components are included in Scenario 3:

- Land re-contouring to provide positive drainage away from the IA VOC Plume.
- Grade reduction and drainage controls of the B881 / 903 Pad hillslope to improve slope stability and decrease soil erosion.
- Drainage improvement and controls to provide runoff diversion and channel stabilization.

A review of the WEPP input files indicates that the IA positive drainage has been incorporated. The grade reduction for the SID area has been incorporated, with grades generally reduced to between 9% and 11%. However drainage improvements and controls have not been incorporated into the WEPP model for the SID.

Four components to the reconfiguration scenario for the SID area are mentioned in the *Draft Appendix C, Scenario Development and Evaluation for Land Configuration Design Basis Project.* These include:

- **Grade Reduction**

The grade reduction appears to have been incorporated into the current WEPP model.

- **Toe Buttress and Subsurface Drain**

It is not clear from the description in Appendix C if the toe buttress will have an impact on the hillslope profile. If it does, the impact should be incorporated into the current model. Currently, it does not appear that it is.

- **Hillslope Contouring, Terracing, and Drainage**

The current model has little evidence of terracing. In the current model the areas of reduced slopes are in areas with existing roads and are quite similar to the original AME model. It is not clear that terracing has been incorporated into the model as an intentional and engineered response to control erosion. There is no evidence of the drainage channels mentioned in Appendix C.

- **Re-vegetation**

None of the roads have been re-vegetated in this WEPP scenario. In fact the road that runs along the North side of the SID on hillslopes 18, 19, and 20 has been converted from an unimproved road with partial vegetation to an improved road with no vegetation. All roads, except for hillslope 11 and part of hillslope 12, appear to be unaffected by this scenario. I suggest they all be removed unless there is a pressing need for them after closure.

The current WEPP model for Scenario 3 may show the effect of slope reduction on the SID. Sediment loads are reduced for the 100-year storm. The reviewer did not determine if this reduction may be partially due to model artifacts. However, it must be recognized and will be explicitly stated in the report on the WEPP and HEC-6T modeling that the model does not address the potential effects of hillslope drainage controls or re-vegetation. These are two very important components of Scenario 3. Their potential effects on runoff and erosion may be greater than slope reduction alone. The reviewer does not understand how this scenario can be adequately evaluated if these components are not included in the modeling. The WEPP and HEC-6T modeling to be done for Scenario 3 will not evaluate the Scenario as presented in Appendix C.

The IA slope input files for Scenario 3 indicate some very large changes from Scenario 0 in hillslope configurations including width, length and area. These changes are not are not shown in the figures provided by Parsons. The OFE outlines shown for the IA in the latest graphics (Labeled Scenario 3)

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are the same as for Scenario 0. Perhaps the changes had not been incorporated as of the transmittal date. It is very important that all changes between Scenarios be documented and clearly indicated in any graphics of the hillslopes. The following are a few examples of changes not shown on the scenario 3 GIS maps for the IA.

Hillslope 228 is new and is not on the OFE map for Scenario 3 provided by Parsons.
Hillslope 121 shortened significantly. Slope has changed slightly.
Hillslope 86 is narrower, longer, and has larger area. Slopes generally steeper.
Hillslope 88 is longer and narrower.
Hillslope 141 is wider and shorter with slightly steeper slopes.
Hillslope 218 is narrower and longer with steeper slopes.
Hillslope 225 has become narrower and longer with a larger area.
Hillslope 225 is more than twice as wide and less than a third as long.

Any graphics showing the hillslopes for this scenario should show these changes. They are significant.

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Meeting Minutes

Date: August 28, 2001
Location: RFETS, T130-C North Conference Room
Attendees: Greg Wetherbee
Win Chromec (intermittent teleconference)
Bruce Curtis
Georgia Vondra
Paul Frink

Subject: Outstanding Modeling Issues for LCDB Scenarios

Purpose: Review open concerns regarding the modeling efforts to date for Scenarios 0, 1, 2, & 3 of the LCDB Project. Discuss the path forward for completion of those activities. The overall objective is to gain concurrence that, all outstanding issues with regard to modeling activities for Scenarios 0, 1, 2 & 3 will be adequately resolved.

Process: Issues, concerns and suggestions for each scenario were covered in separate discussions and are listed here. General items are included at the end of the minutes. Each issue/concern is listed along with the resolution accepted by the group. Action items, responsibilities and proposed completion dates are also listed.

Scenario 0 (conditions at end of active remediation)

Issue #1 – Significant changes to WEPP input files. During modeling of Scenario 0, a significant number of changes were made to the WEPP input files for the SID hillslopes. The extent of these changes may have invalidated the calibration activities that were previously performed by AME. Parsons has performed a sequential analysis of the changes that were made using SID Hillslope 10 to determine the impact of each change and to verify that changes are not an artifact of the WEPP Model.

Resolution: After reviewing the preliminary results it was determined that the changes appeared to be logical, reasonable and defendable. Win Chromec asked that the analysis be formalized for his review and documented in the final report.

Action: Parsons will document this analysis in the modeling approach section of Appendix E to the CDR " Erosion and Actinide Evaluation Report" and forward a draft to Mr. Chromec. Due: September 7, 2001.

Issue #2 – Appearance of Erosion Map. It was previously identified that when modeled erosion rates for the IA for Scenario 0 were plotted spatially on a site map, the results provided erosion rates that were not consistent for adjacent hillslopes at two locations. . Hence, Parsons adjusted the input parameters for these hillslopes to generate a smoother output that would make the erosion rates more consistent across the IA.

Resolution: After reviewing the new erosion map plotted as a result of these changes, there was concurrence that this action had been effective.

Action: No additional action.

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Issue #3 – Generation of IA Hillslopes. No data exists to calibrate the OFEs and hillslopes generated by Parsons for the Industrial Area. Those files were verified by comparing the generated results to similar OFEs previously modeled and calibrated in the Buffer Zone.

Resolution: It was agreed that the approach and results were reasonable and acceptable.

Action: No additional action

Issue #4 – Modeling approach for the present landfill. The present landfill is currently modeled as a single hillslope containing three OFEs (Topslope, road, and Sideslope). There was a concern that, although the approach is reasonable from a modeling point of view, it may appear illogical to a casual reviewer. There are several other ways this area might be modeled, but they would likely involve considerably more effort and would not improve modeling results.

Resolution: After discussion it was agreed that the current approach was acceptable and defendable due to the lack of any significant actinide concentration in the landfill cover.

Action: Parsons will explain this approach in the modeling approach section of Appendix E. Due with final scenario model package.

Scenario 1 (Flow-through Ponds and Wetlands)

Issue #5 – Changes to Walnut and Woman Creek Hillslopes. It appears that Parsons has shortened the previous lengths of OFEs in the Walnut and Woman Creek basins without changing the slopes. The purpose was not understood.
When wetlands were modeled in this scenario the drainage channel was widened. The wetland themselves will be modeled in HEC-6T. Therefore the OFEs adjacent to the channels were shortened to accommodate the wetland areas. The slope changes were not significant and were therefore not adjusted.

Resolution: After discussion it was agreed that this approach was logical and acceptable. However, it needs to be documented in the modeling approach.

Action: Parsons will document this approach in the modeling approach section of Appendix E. Parsons will also confirm that all transects snap to an OFE boundary.

Issue #6- OFE #4 in hillslope 46 should be deleted due to its incorporation as a wetland area.

Resolution: Walnut Creek Hillslope 46 OFE # 4 should have been deleted and was an oversight on Parsons part.

Action: Parsons will delete the OFE. Due with final scenario model package.

Scenario 2 (Detention Basins)

Issue #7 - Splitting hillslopes. It was not clear whether hillslopes that were effected by the proposed Woman Creek Detention Basin embankment or dam were split.

Resolution: On Woman Creek, hillslopes were split for both the embankment and dam. On Walnut Creek, because of the location of the dam there was on a small amount of area affected and the hillslopes were not split. It was agreed that this was acceptable.

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Action: Parsons will explain this approach in the modeling approach section of Appendix E.

Issue #8 - Files. There was some confusion whether GIS data files contained transects that were reflective of the split hillslopes and if they did were these transects snapped to OFE boundaries.

Resolution: Provided coverages do have transects included and the transects were snapped appropriately.

Action: AME will check with site GIS to perform QA on the coverages provided by Parsons to verify the above. AME will notify Parsons if there are any concerns.

Scenario 3 (Source Isolation, Drainage Diversion, and Erosion Controls)

Issue #9 - Scenario features not modeled. Parsons has not modeled all the features (components) described in the Scenario 3 description as some were included in the write-up as contingencies. This was not clearly stated in the write-up. It is felt that the description and the modeling effort need to be consistent. Missing features included toe buttress at base of 903 Pad hillside, terracing of 903 pad hillside, and removal of roads.

Resolution: It is agreed that the model activities must be consistent with the write-up. Either need to model the features or explain in the text why a given component is a contingency or will be considered/addressed later. Specifically:

1. Toe Buttress, This feature has no effect on the model so there nothing to model.
2. Terracing of 903 Pad, It was agreed that this would have a strong potential to cause significant changes in the erosion results and modeling should be evaluated if it is kept as part of the scenario description.
3. Removal of roads, although some roads will be removed, this aspect will be determined by the sector reconfiguration strategy for the ICD and is thus not a specific feature of this scenario.

Action: Parsons will model the terracing and will revise scenario description text to explain road removal. The Toe Buttress will be explained in the modeling approach section of Appendix E. Due with final scenario model package.

Issue #10 - Too much detail in Scenario 3. The Scenario 3 write-up included significantly more technical detail than the other two scenarios. Much of the technical information was not needed at this level.

Resolution: Remove unnecessary technical information.

Action: Parsons will revise the Scenario description. Due with final scenario model package.

Issue #11 - Culvert Removal. Description of culvert removal and areas where engineered channels will be constructed is not clear.

Resolution: Need to explain details better (specifically which ones are removed by Scenario 0 and Scenario 3 and where engineered channels are constructed). Also need to provide channel information to AME.

Action: Parsons will explain culvert removal more explicitly in the modeling approach section of Appendix E. Additionally, Parsons will revise the description of anticipated condition at completion of active remediation (scenario 0) in the design basis to identify culvert status. Due with final scenario model package. Parsons will provide HEC-GeoRAS cross-sections of the open channels to AME. Due 8/30/01

General

Issue #12 – GIS **Scenario coverages are not complete**. Complete GIS coverages were not issued for each scenario.

Resolution: Only the changed or effected GIS coverages for each scenario have been issued to date, however, it would be beneficial and improve documentation if a complete GIS coverage was issued/archived for each scenario

Action: Parsons will determine if complete GIS coverages of all hillslopes for each scenario can be transmitted. If possible Parsons will transmit entire coverage for each scenario. Due with final scenario model package.

Issue #13 - File Identification. Similar files for OFEs/Hillslopes have been assigned the same name across all scenarios. Although the files should always be segregated in folders by scenario, this could possibly lead to confusion.

Resolution: Agreed, assigning scenario specific file names and adding text to the files to identify which scenario the files belongs to would improve documentation and quality assurance for the project.

Action: Parsons will make appropriate changes to the files so they can be readily identified by scenario. Due with final scenario model package.

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APPENDIX B

Actinide Mobility Maps for Scenarios 1 and 3

TAB 3
ATTACHMENT C

INITIAL CONCEPTUAL DESIGN COMPONENT DESCRIPTION

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INITIAL CONCEPTUAL DESIGN COMPONENT DESCRIPTION

TABLE OF CONTENTS

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1.0 INTRODUCTION

This attachment provides a description of the components that could be included in an initial conceptual design (ICD). The rationale for inclusion of individual components is also discussed where appropriate. It is recognized that significant data gaps exist (see Tab 2, Appendix C) and that resolution of these data gap could influence the components that will be ultimately selected for the final land configuration of the Site during detailed design.

This ICD description is intended to provide preliminary information that can be used by the United States Department of Energy (DOE) and Kaiser-Hill Company, LLC (Kaiser-Hill) to guide decisions for the final closure and land configuration for the Site. This ICD description is also intended to provide the RFCA parties and stakeholders with a viable reference point to begin discussing the final land configuration design.

Although this ICD description may be used to support the development of the Corrective Action Decision/Record of Decision (CAD/ROD) for the Site, it is not intended to be the decision document for the final land configuration. This ICD description may be further developed into a conceptual or final design or may be appropriately modified to incorporate any changes to meet the closure requirements established for the Site identified in the CAD/ROD and other approved RFCA decision documents. It is also noted that some of the components included in this ICD description may be incorporated into the decision documents for other remedial and closure actions.

The bounding scenario evaluation results (see Tab 3, Attachment A) were used to identify the components that could be combined together and expanded as an ICD. A summary of the components included in this ICD description and their potential locations are presented in Table C-1 and Figure C-1, respectively. The components included in this ICD description are intended to satisfy the following major functional design objectives listed in the LCDB Design Basis (Tab 2, Appendix B).

- Provide a high degree of reliability to maintain compliance surface water quality standards at POCs.
- Minimize negative qualities or impacts on the following secondary performance functions.
  - Achieve a cost-effective and reliable final land configuration for the Site,
  - Reduce long-term stewardship responsibilities,
  - Minimize impacts to ecological resources, and
  - Provide a robust design capable of accommodating uncertainties in the future conditions of the Site.

Scenario components were included in this ICD based on their individual/combined performance for each drainage (North and South Walnut Creeks, SID, and Woman Creek) considering the unique drainage characteristics, historical compliance with RFCA surface water action levels, planned closure/remedial actions, and potential contribution of the drainage basin to future exceedences. The following general guidelines compiled from the bounding scenario evaluation results to aid in identifying the components to include in this ICD description.

- Use detention basins (batch release) only where a high degree of reliability and control is required.
- Avoid siting components adjacent to potentially unstable hillsides or, when necessary, stabilize adjacent hillsides.
- Avoid siting components in or adjacent to ecologically sensitive areas unless absolutely necessary.
- Avoid excessive changes to existing ecological resources.
- Consider any component limitations with respect to the characteristics of the drainage. For example, source isolation components, while preventing actinides from entering surface water, may not adequately address resuspension of legacy actinide-bearing sediments that may already be present in the drainage channels.
- Utilize existing structures to the extent practical and cost-effective. For example, convert existing ponds into flow-through detention ponds rather than constructing new detention ponds.
- Use positive drainage features to limit infiltration in areas where migration of groundwater contaminants may adversely impact surface water (IA VOC Plume).
- Use positive drainage and diversion features to minimize soil erosion from areas that may be susceptible to contaminant migration (903 Pad area).

Several of the components included in the ICD were modified to improve the overall performance of the ICD. For example, it was determined that the higher degree of reliability provided by a detention basin with batch release was only warranted for South Walnut Creek based on historical monitoring results and calculated actinide loads. Detention components were not included for North Walnut and Woman Creeks because stringent detention controls do not appear to be required to maintain compliance with the surface water quality standards at the POCs based on historical monitoring data.

In some instances, the component to include in an ICD could not be definitively identified at this time because of missing information or data gaps. In these cases, the specific missing information and cross-references to the data gaps documented in Tab 2, Appendix C are provided. Listed below are the more significant data gaps.

- Predictions of base flow and water availability in drainages after Site closure (see Data GAP-010).
- Predictions of changes to existing groundwater levels and seep flows after Site closure (see Data GAP-010).
- Extent and location of legacy actinide-bearing sediments in existing drainage channels (see Data GAP-030).
- Extent of remedial activities at the 903 Pad (see Data GAP-150).

The information and results being compiled by the Site Wide Water Balance (SWWB) and Actinide Migration Evaluation (AME) Project Teams will be factored into resolving the above data gaps and incorporated into the detailed design for the final land configuration. For example, the SWWB studies are expected to provide the necessary information to predict the amount of water available after closure to sustain wetland components within individual drainages. The SWWB results will also be used to assess potential migration of the IA VOC plume. Additional erosion and hydrologic evaluation of the ICD components may be performed using WEPP and HEC-6T computer codes to further assess the ability of the ICD to maintain compliance with the surface water quality standards at the POCs over a variety of conditions.

2.0 INDUSTRIAL AREA RECONFIGURATION

The current RFETS baseline includes the completion of specific activities within the IA prior to Site closure as identified in Section 2.2.2 of the Design Basis (see Tab 2, Appendix B). Based on these planning activities, the following scenario components were included in this ICD description to supplement the closure of the IA.

- Smooth existing IA topography to provide gentle sheet flow to drainages,
- Enhance North and South Walnut Creek as stable, open-channel drainages within the IA, and
- Divert drainage away from the IA VOC plume.

In many cases, these activities represent modifications of activities already contained in the RFETS closure baseline or an integration of those activities across a number of Site closure projects. To the extent practicable, the identified IA components should be integrated into the planned D&D/ER projects already included in the IA baseline. To facilitate project integration and planning for the removal of buildings, foundations, parking lots and other existing structures, a Grading and Drainage Concept was developed for the IA and is presented as Tab 3, Attachment E. This concept establishes a preliminary final topography for the IA based on the ICD components presented in this description.

2.1 Pediment Grading to Smooth Topography in IA

This ICD description includes regrading the IA pediment, where appropriate, to promote gentle sheet flow of surface water to engineered drainage channels. Smooth topographical surfaces tend to minimize the concentration of surface water and subsequent rill formation. Portions of the IA would also be revegetated to slow the flow of surface water and to reduce soil erosion.

2.2 Hillside Stabilization

Hillsides within the IA should be cut and graded, where appropriate, to promote long-term stability and by reducing the potential for mass wasting (slope movement, slumping) that could degrade engineered drainages, damage remediation systems, or expose sub-grade structures. Stabilization of the IA hillsides that are adjacent to North and South

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Walnut Creeks should be included in the detailed design for the final land configuration. The recontouring would also be designed to minimize slumping that could induce gully formation and promote incision of the IA pediment. Hillside regrading would also be conducted in areas to promote controlled sheet flow down the hillsides to minimize concentration of surface water. In some areas, the recontoured surface may need to be lower than the existing grade and, therefore, may impact the closure of individual buildings.

2.3 Enhance IA Drainage Channels

Prior to Site construction, the North Walnut Creek Tributary and South Walnut Creek conveyed the majority of the runoff from the pediment where the IA now resides. During construction, portions of these drainages were extensively modified to provide suitable areas for site construction. Of notable interest is the reconfiguration of the North Walnut Creek Tributary and South Walnut Creek to accommodate the construction of Buildings 371 and 991, respectively. It is neither cost-effective nor desirable to return these drainages to pre-RFETS natural conditions. Instead, the drainages at these two locations should be converted to open-channels with engineered controls, including adequate armoring and, where appropriate, stabilize the channel bottom/banks to retard stream incision/erosion and to reduce long-term maintenance.. The stabilized channel and engineering controls should be configured and designed with natural-looking materials to support the final land usage of open space/National Wildlife Refuge. The IA Grading and Drainage Concept (see Tab 3, Attachment E) provides additional details for configuring the drainages within the IA.

2.4 Positive Drainage Provisions

The infiltration rate is anticipated to increase within the IA due to removal of impervious surfaces. Because plutonium and americium (the primary threat to exceedence of the surface water quality standards) are not mobile via a subsurface pathway, infiltration increases should not result in additional migration of plutonium and americium to the surface water from subsurface sources. As such, positive drainage features would only be included to preclude the adverse alteration of mobile groundwater constituents that may result in the exceedence of the surface water quality standards at a POC.

Currently, three groundwater plume collection systems have been installed to control the migration of identified plumes to surface water. It is envisioned that the operation of these plume systems will not be adversely impacted by any increased infiltration rate. Remedial plans for the IA VOC plume have not been finalized. Sufficient characterization and SWWB information is currently not available to assess the nature and extent of the IA VOC plume and the potential affects that infiltration increases may have on this plume (see Data GAP-010). The SWWB information would be used to determine if the infiltration rate would increase or decrease the groundwater flux through the IA VOC plume area.

A groundwater plume system may be installed if future characterization and SWWB information indicate the need for such a system. Alternatively, positive drainage provisions may be included as a component of the final land configuration to counter-act potential increases in the amount infiltration caused by removal of impervious surfaces in the IA. The positive drainage component options presented in Scenario 3 (see Tab 3, Attachment A) include:

- Forming a mound over the IA VOC plume to increase the runoff coefficient,
- Enhancing the vegetation and/or soil rooting media to increase ET, and
- Providing upstream drainage diversion to minimize runon.

Given the lack of information and extent of remedial actions that may be required, identifying an appropriate course of action is pre-mature at this time. However, in developing the IA Grading and Drainage Concept, the North Walnut Creek Tributary was extended towards the north for the following reasons.

- To stabilize the drainage channel,
- To intercept and divert clean runoff away from areas that may be more likely to contribute to actinide loads via surface soil erosion (such as the GS10 drainage basin),
- To allow diversion of additional runoff into North Walnut Creek to facilitate the wetland ICD components and ecological resources located in this drainage, and
- Reduce the amount of runoff that flows into South Walnut Creek to reduce the size of the detention basin that is included as an ICD component for this drainage.

Although not specifically required, the North Walnut Creek Tributary was routed along the western (upstream) boundary of the IA VOC plume to minimize runon, thereby reducing infiltration into the IA VOC plume.

The inclusion of additional positive drainage features (recontouring) described by Scenario 3 should be reassessed based on the SWWB results and other data developed to predict changes to the IA VOC plume (see Data GAP-010). The location and extent of any recontouring (if required) would be evaluated based on these results. If implemented, recontouring over the IA VOC plume could require a significant amount of fill, which may need to be obtained from an off-site borrow area. The IA Grading and Drainage Concept provides an initial cut and fill balance for regrading activities in the IA without additional recontouring for the IA VOC plume. Reconfiguration of this area does not impact any environmentally sensitive habitats, nor does it impact the Preble's mouse or other threatened or endangered species.

3.0 NORTH WALNUT CREEK

The following scenario components were included in the ICD description for North Walnut Creek:

- New and enlarged wetlands,
- Passive flow-through detention pond, and
- Possible reconfiguration of North Perimeter Road.

Historically, North Walnut Creek has not been a significant contributor of actinide loads to Walnut Creek. There are no recorded exceedences at GS11. In addition, remediation activities in the IA should further reduce actinide loads to North Walnut Creek. As such, it is anticipated that enlarging existing wetlands and developing some new wetlands combined with a flow-through detention pond would be adequate to maintain compliance with the surface water quality standards.

Based on historic flow data, a significant portion of the flow in North Walnut Creek appears to be from groundwater seepage. As such, it is anticipated that the water availability within North Walnut Creek would be more reliable and would be of sufficient quantity to support the new/enlarged wetlands. Reconfiguration decisions for the existing A-series ponds (especially Ponds A-1, A-2, and A-3) should be deferred until the results of the SWWB are available to verify that the amount of water available after Site closure is adequate and dependable to support these existing wetlands (see Data GAP-010). The application of the Pond Reconfiguration Strategy to the detailed design would be used to guide final reconfiguration for these existing ponds.

3.1 Wetlands

Both new and enlarged wetlands could be constructed in the North Walnut Creek as described in Scenario 1 (see Tab 3, Attachment A) and combined with a flow-through detention pond to provide for settling, filtration, and retention of particulates, suspended materials, and sediments. Additionally, the wetlands and deep-water ponds could be utilized to reduce other concentrations that may be deemed desirable (see Data GAP-120).

Although existing wetlands and Preble's mouse habitat could be temporarily impacted during construction, the new/enlarged wetlands in North Walnut Creek would enhance existing ecological resources. Measures should be taken to minimize impacts during construction and to rapidly re-establish these areas at the completion of construction activities. As a secondary consideration, the wetlands and habitat added to this drainage could be used to offset reductions that might occur in other portions of the Site during closure.

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3.2 Flow-Through Detention Pond

A passive flow-through detention pond was included to provide primary sediment removal and retention during storm events. It is envisioned that the flow-through detention pond could be located at or near Pond A-4. This location has a negligible impact on ecological resources because the fluctuating water levels caused by the current mode of operation of Pond A-4 (detention and batch release) limits the ability to sustain high-quality ecological resources in this area. The feasibility of using and modifying Pond A-4 as the detention pond would be assessed during the detailed design in conjunction with application of the Pond Reconfiguration Strategy. For the purpose of this ICD description, it is assumed that Pond A-4 can be adequately modified to serve the required flow-through functions (see Data GAP-100).

The flow-through detention pond would also enhance the ecological/wetland values of existing Pond A-4 by maintaining a relatively constant water level in the flow-through pond versus the constantly changing levels as now experienced with the current batch release operations. The permanent pool would encourage establishment of wetland vegetation along the banks of the pond. An aquatic bench could also be added to enhance the amount of area available for vegetative growth and to restrict access to the pond. A stable and continuous discharge from the flow-through ponds would also positively enhance downstream Preble's mouse habitats.

Off-site water management is a significant factor in preparing the detailed design for the North Walnut Creeks flow-through pond. In order to proceed with developing this ICD description, it is assumed that maintaining downstream diversion of water is required (see Data GAP-080). As such, the outlet structure of the flow-through pond and its storm event detention capacity would be designed to ensure that downstream diversion structures (such as the Broomfield Diversion Ditch) would not be subject to excessive flooding. To verify this design requirement, the long-term off-site water management plans should be discussed with the local communities. If this assumption is incorrect, the design basis should be adjusted during detailed design.

3.3 North Perimeter Road

The North Perimeter Road is included in this ICD description in its current location per the LCDB Project constraints. However, the road's current configuration is susceptible to accelerated deterioration due to the geomorphic and erosional processes that are shaping the North Walnut Creek drainage channel. The need to retain the North Perimeter Road for access and the trade-offs between incurring the capital cost to relocate this road to reduce future O&M costs should be further evaluated during detailed design.

If the North Perimeter Road is not relocated, the 72-inch diameter culvert located in North Walnut Creek just north of the IA should be removed, except for the portion that crosses under the road. The removed culvert should be replaced by an open channel to reduce long-term stewardship obligations and enhance its ecological value. Additional details are provided in the IA G&D Concept (see Tab 3, Attachment E).

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3.4 West Diversion Dam and Ditch

The West Diversion Ditch/Dam and McKay Bypass Canal were constructed to divert the runoff from the upstream reaches of North Walnut Creek and water conveyance associated with the McKay Ditch around the IA and Present Landfill. The diversion structures include several 90-degree bends, which could require significant long-term maintenance. A 1993 assessment of the McKay Bypass Canal recommends that the 90-degree bend at the confluence of the West Diversion Ditch, North Walnut Creek, and McKay Bypass Canal be straightened to allow a more natural flow.

Although not specifically addressed in this ICD description, the need to maintain these diversion structures after Site closure should be addressed during the detailed design phase. Input from City of Broomfield should be attained to determine diversion requirements and long-term maintenance responsibilities for the future operation of the McKay Ditch/Bypass Canal. If possible, the West Diversion Dam should be removed and West Diversion Ditch reconfigured to eliminate potential long-term problems associated these diversion structures. The additional flow of runoff from the currently diverted portions of the watershed would also benefit wetland components located in North Walnut Creek and further enhance existing ecological resources. Modification of McKay Ditch and McKay Bypass Canal may also be required to allow the continue transfer of water by the City of Broomfield into the Great Western Reservoir.

4.0 SOUTH WALNUT CREEK

Surface water sources into South Walnut Creek are currently a significant source of the actinide load. This is evidenced by the magnitude of repeated historical exceedences at GS10. Additionally, Ponds B-1, B-2, and B-3 contain the highest actinide activity levels for sediments located at the Site. The following two changes are planned to be implemented prior to the completion of active remediation and could significantly alter the current configuration of this drainage.

1. There will be a significant decrease in the quantity of surface water based on ceasing imported water usage and terminating WWTP effluent discharge. Additionally, the removal of impervious surfaces in the IA will increase infiltration and thus decrease run-off from storm events. It is unclear what portion of this infiltration this will seep into South Walnut Creek versus North Walnut Creek. Furthermore, extending the North Walnut Creek Tributary across the IA will decrease the area of the drainage basin associated with South Walnut Creek. As such, the future water supply may not be adequate to sustain wetland components in South Walnut Creek. Reconfiguration decisions for the B-series ponds (especially Ponds B-1, B-2, B-3, and B-4) should also be deferred until the results of the SWWB are available to determine if the amount of water available after Site closure is adequate to sustain these existing wetlands (see Data GAP-010). The application the Pond Reconfiguration Strategy to the detailed design would be used to guide final reconfiguration for these existing ponds.

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2. D&D/ER activities in the IA would reduce sources of actinide contamination and eliminate migration pathways (culverts, process piping, utility corridors, footing drains and trench backfill).

Based on the above considerations, the following scenario components were included in this ICD description for South Walnut Creek:

- South Walnut Creek detention basin, and
- Engineered enhancements to stabilize the drainage channel.

4.1 Batch-Release Detention Basin

A detention basin as presented in Scenario 2 is included in the ICD description to provide the high degree of reliability because of the greater actinide loads present in South Walnut Creek than the other drainages. The detention basin should be operated in the batch release mode as required to maintain capacity for the design 100-year, 6-hour storm event. The discharge of accumulated water should be verified by the collection and analysis of pre-discharge samples. Therefore, if additional settling or treatment is necessary it can be accomplished prior to release.

It is envisioned that the South Walnut Creek detention basin could be located at or near the present location of Pond B-5 to reduce the ecological impact associated with construction of the new basin as discussed for Pond A-4. The feasibility of using and modifying Pond B-5 as the detention basin would be assessed during detailed design in conjunction with application of the Pond Reconfiguration Strategy. For the purpose of this ICD description, it is assumed that the existing Pond B-5 can be adequately modified to serve the required detention functions.

Furthermore, the batch-release detention basin would be administratively controlled so that the discharge would not exceed the capacity of any required downstream diversion structures or adversely impact off-site water management.

4.2 Channel Stabilization

There are several factors that threaten the continued existence and stability of the wetlands provided by the existing B-series ponds following site closure.

- Cessation of imported water, termination of WWTP effluent, and reduced base flow from the IA to the drainage.
- The potential increased instability of adjacent hillsides due increased groundwater seepage from greater IA infiltration.
- Potential disturbance to existing wetlands and compromising the structural integrity of the embankments if sediments are removed from Ponds B-1, B-2, or B-3 as currently planned.

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It is anticipated that the flow to this drainage will not be adequate to sustain the existing wetlands after Site closure. If this assumption were correct, the existing ponds should be breached to minimize long-term stewardship obligations. If these existing ponds were to be breached, the resulting configuration of South Walnut Creek would require engineered features to stabilize the drainage channel. These engineered features would be designed to minimize channel erosion and may include riprap armoring, drop structures, and check dams.

Alternately, if the results of the SWWB indicate that there is a sufficient base flow in this drainage to support wetlands, then modifying all of some of the B-series ponds (Ponds B-1, B-2, B-3, and B-4) to passive flow-through detention devices as described in Scenario 1 should be considered.

5.0 WALNUT CREEK

The surface water quality for plutonium was exceeded at GS03 (located on Walnut Creek at Indiana Street) in May/June 1997. The monitoring results since this exceedence have been consistently below the surface water quality standards for plutonium and americium. Although the scenario components included for North and South Walnut Creeks would reduce the flow velocity in Walnut Creek during storm events, these measures may not be adequate to preclude future exceedences at GS03 if significant sources of legacy actinide-bearing sediments are present in the lower reaches of Walnut Creek. As discussed in the description for Scenario 2 (see Tab 2, Attachment A) the confirmation of legacy actinide-bearing sediments in Walnut Creek between the confluence of North and South Walnut Creeks and Indiana Street is considered a data gap (see Data GAP-030).

Taking additional reconfiguration actions for Walnut Creek is not warranted at this time because the exceedence at GS03 appears to have been a one-time occurrence during low-flow conditions and Preble's mouse habitats are known to be present within the lower reaches of Walnut Creek. If the alleged legacy actinide-bearing sediments are confirmed to be present, then it may be necessary to provide additional controls to diminish the potential to resuspend sediments within this stretch of Walnut Creek.

6.0 WOMAN CREEK

The predominant source of actinide load in Woman Creek appears to originate from the wind blown dispersion area east of the 903 Pad. Runoff from this area is currently intercepted by the South Interceptor Ditch (SID) and directed to Pond C-2 for settlement prior to batch discharge. Due to the size of the SID drainage basin and diversion of Woman Creek, discharge from Pond C-2 is normally required only once per year. However, both the SID and the Woman Creek Diversion Dam/Ditch have suffered from significant erosion and deterioration under their current configuration. As such, significant long-term stewardship could be required to maintain the integrity of these man-made features.

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Ideally, the Woman Creek drainage should be reconfigured with a passive flow-through detention pond rather than the current batch-release operations to significantly reduce long-term stewardship responsibilities and costs. With this in mind, the following configuration was included in this ICD description for Woman Creek:

- Construct a flow-through detention pond at or near the current location of Pond C-2,
- Eliminate the SID and combine its flow with Woman Creek, and
- Eliminate the Woman Creek Diversion Dam and Ditch.

Regrading and recontouring the 903 Pad hillside was evaluated as a component under Bounding Scenario 3. However, this scenario component was not included in this ICD description because the extent of remediation activities that will be taken for the 903 Pad has not been finalization (see Data GAP-150). As such, further hillside stabilization may not be required. The need to stabilize the 903 Pad hillside to reduce erosion should be further evaluated during detailed design when the extent of remediation actions for the 903 Pad is identified.

6.1 Flow-Through Detention Pond

To provide additional settling capability and operational flexibility, a passive flow-through detention pond similar to Scenario 1 is included in this ICD description for Woman Creek. It is envisioned that the flow-through detention pond could be located at or near the present location of Pond C-2. This overlap will minimize the impact to existing wetland and riparian areas and known Preble's mouse habitats. This area also has low level of residual actinides so there is less concern with contaminant transport by wind or water erosion during construction.

The flow-through features could enhance the existing ecological/wetland values already present in the drainage since the relatively constant water level in a flow-through pond (versus the constantly changing levels in a detention pond) would encourage establishment of permanent wetland vegetation. An aquatic bench could also be added to enhance the amount of area available for vegetative growth and to restrict access to the pond. Recombining the SID and Woman Creek flows into the flow-through pond would increase the amount of water available to sustain the wetland vegetation.

An additional wetland could be constructed downstream of the flow through detention pond if excess surface water is available and there is a desire or need to increase the amount of wetlands and/or habitat for ecological resources. The added wetland could also increase the reliability and performance of the flow-through pond in maintaining compliance with the surface water quality standards during storm events. The need for, and ability to sustain, additional wetlands would be dependent on the SWWB results (see Data GAP-010).

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6.2 *Eliminate SID and Woman Creek Diversion Dam/Ditch*

The SID was not constructed to be a permanent facility and is expected to require extensive long-term maintenance to prevent significant degradation. As such, it is desirable to recombine the Woman Creek and SID flow by eliminating the SID and the Woman Creek Diversion Dam/Ditch to reduce future maintenance requirements and stewardship responsibilities, and to enhance the longevity of the Woman Creek drainage features. Recombining Woman Creek and the SID should not present any significant off site water management issues since both drainages currently flow to the Woman Creek Reservoir, which has ample capacity to handle the design storm event from both drainage basins.

6.3 *903 Pad Diversion Ditches*

A diversion ditch located just west of the 903 Pad was included in Scenario 3 to provide a physical barrier to preclude the flow of runon onto the 903 Pad area. This diversion ditch was not included in this ICD description because remediation plans for the 903 Pad have not been finalized. The 903 Pad remediation may sufficiently reduce potential sources of actinides, thus eliminating the need for drainage diversion. In addition, the recontouring of this area as proposed in the IA Grading and Drainage Concept is designed to direct drainage away from the 903 Pad without construction of a diversion ditch.

However, the diversion ditch located down-slope of the 903 Pad that was presented in Scenario 2 was included in this ICD description to further reduce potential actinide loads that may be originating from the wind dispersal area located to east of the 903 Pad. This diversion ditch extends from the flow-through pond in a northeasterly direction along the base of the hillside as shown in Figure C-1. The inclusion and extent of this diversion ditch is dependent on the final remedial actions that are implemented for the 903 Pad. As such, the need for this diversion ditch should be re-evaluated during detailed design after the remedial actions for the 903 Pad are determined (see Data GAP-150).

6.4 *Phased in Approach*

Given the number of data gaps and uncertainties, a phased approach may be appropriate to reconfigure the Woman Creek drainage. Under the phased approach, the SID and Pond C-2 would be initially retained in their current configuration until additional data regarding the performance of the implemented remedial actions for the 903 Pad are attained. The upper portion of the SID near Building 881 could be breached to allow direct flow to Woman Creek since this portion of the SID is not a major contributor of actinide loads based on historical monitoring data. The remaining portion of the SID flow would continue to be routed to and detained in Pond C-2 pending verification sampling and batch release. Woman Creek would continue to bypass Pond C-2. As such, the breaching of the SID would reduce the volume of runoff managed in Pond C-2.

The final configuration of the SID and Woman Creek drainages would depend on monitoring results obtained following the completion of the 903 Pad remedial action. If the Woman Creek Diversion Dam were to be breached, the combined SID/Woman Creek flow could be retained in Pond C-2 for batch release after sampling. When sufficient

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sampling results are available to demonstrate that less stringent controls are required, Pond C-2 could be transitioned to flow-through operations. If the Woman Creek Diversion Dam were breached, maintenance of the SID could be terminated to allow the SID to naturally fill-in over time and revert to the Woman Creek channel.

7.0 OTHER CONSIDERATIONS

The considerations that will be evaluated and appropriately factored in the detailed design for the final land configuration include, but are not limited to:

- The appropriateness of the monitoring locations to determine if any existing POC should be relocated.
- Long-term inspection and maintenance requirements for maintaining the integrity of dam structures.
- Potential for depletions to the South Platte River resulting from implementation of this ICD description and, if required, developing a recommended approach to mitigate any depletions.
- Identification of access roads in the buffer zone that are required to be maintained for long-term stewardship and to facilitate final land usage as open space/National Wildlife Refuge.
- Recycling of existing Site materials for incorporation in the final land configuration of the Site, including possible reuse of existing security boulders for stabilization of drainage channels.

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TABLES AND FIGURES

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Table C-1
Initial Conceptual Design Components

Scenario Component	Bounding Scenario	Components Included in ICD Description [1/]
Enhance North Walnut Creek Tributary drainage between Buildings 371 and 771 up to Building 130.	1, 2, 3	**O** (Route IA tributary to the north instead of Building 130)
Enhance South Walnut Creek between North Perimeter Road and Building 750.	1, 2, 3	**X**
Regrade and stabilize IA hillsides, recontour IA top slopes to provide sheet flow to drainages.	1, 2, 3	**X**
Install ET covers over the Original Landfill, Present Landfill, and Solar Evaporation Ponds. Relocate existing flagstone steps used to passively treat the Present Landfill Seep.	1, 2, 3	**X**
Continue operation of existing three plume treatment systems.	1, 2, 3	**X**
Revegetate IA and BZ disturbed areas and closed roads.	1, 2, 3	**X**
Flow-through detention pond / wetlands in North Walnut Creek.	1	**X**
Flow-through detention pond / wetlands in South Walnut Creek.	1	--- [3/]
Flow-through detention pond / wetlands in Woman Creek / SID.	1	**X**
Terminal detention basin in Walnut Creek.	2	**O** (South Walnut Creek only)
Terminal detention basin in Woman Creek.	2	---
Grade reduction and stabilization of the 903 Pad hillside.	3	----
Diversion ditch west of 903 Pad.	3	---
903 Pad hillside diversion ditch north and east of Pond C-2.	2	**X** [2/]
IA VOC plume infiltration controls (contour for positive drainage, diversion ditch, and ET provisions).	3	**O** [3/] (Diversion ditch is included only)
Culvert removal and drainage channel stabilization for IA.	3	**X**

1/ **X** = Included in ICD description.
O = Included in ICD description, but modified.
--- = Not included in ICD description.

2/ Contingent of the extent of final remedial actions implemented for the 903 Pad.

3/ Contingent on SWWB results.

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TAB 3
ATTACHMENT D

POND RECONFIGURATION STRATEGY

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POND RECONFIGURATION STRATEGY

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1.0 INTRODUCTION

Several ponds have been constructed at RFETS over the years to control runoff from the IA. As remediation of RFETS progresses, modifying the configuration and/or operational mode of the existing ponds may be required to achieve the final land configuration or may be beneficial to support other long-term closure objectives (minimization of long-term stewardship obligations, preservation of ecological resources, flood control, etc.) This Pond Reconfiguration Strategy was developed to identify the information, considerations, and other factors that should be assessed to determine the preferred final configuration for each pond. Final configuration options include retaining the existing pond in its current configuration, reconfiguring the pond to serve a new/different function, or breaching the pond. The mode of operation (manual versus passive) and the need to modify, replace, or rebuild the existing ponds are other considerations that are included in this strategy to determine the appropriate final configuration for the ponds. The Pond Reconfiguration Strategy was not intended to develop design details for the preferred final configuration of the ponds or to devise an implementation plan (including time phasing during D&D, remediation, and post-closure) to convert the existing configuration into the final configuration. Instead, the Pond Reconfiguration Strategy would be applied (with input from the various stakeholders) to identify the preferred final configuration for the ponds.

A flowchart (see Figure D-01) was developed to assist with identifying the preferred final configuration for each pond. The flowchart is intended to be applied on a pond-by-pond basis taking into consideration the integrated functional requirements established for any water control feature included as design component to maintain compliance with the surface water quality standards at a point of compliance (POC). That is to say, the ponds will be assessed on an integrated and combined basis to determine if they support the overall Site closure objectives established in the Design Basis for Final Land Configuration (see Tab 2, Appendix B). In addition, each pond will be assessed on an individual basis to determine its cost-effectiveness to contribute to the overall Site closure objectives taking into consideration the safety, adequacy, and long-term stewardship requirements to maintain each existing pond. This individual and integration application of Pond Reconfiguration Strategy will be achieved by:

- First applying the Pond Reconfiguration Strategy to the existing configuration of the ponds to develop a preferred final configuration for the ponds, and
- Then applying the Pond Reconfiguration Strategy a second time to the preferred final configuration to allow further refinement and integration considering the interdependence between individual ponds.

This Pond Reconfiguration Strategy is not intended to address every possible integration and individual consideration, but to provide the framework and key considerations that would be adopted and addressed to systematically identify the preferred final configuration for the existing ponds. As such, professional judgment will need to be exercised when applying this strategy and evaluating supporting information upon which reconfiguration decisions will be based on. In general, the strategy was developed to consider the value of each existing pond to support one of the following objectives:

- Maintaining compliance with the surface water quality standards at the POCs through sedimentation or other constituent reduction processes,
- Providing flood control,
- Preserving ecological resources (habitats and wetlands), and
- Facilitating downstream water uses and restrictions.

If an existing pond has no foreseeable beneficial function, would not be cost-effective to maintain, or presents other unreasonable long-term liabilities, then that existing pond would be eliminated. If the existing pond serves a long-term function, then its adequacy and safety would be assessed to determine what, if any, modifications would be required to place the pond in the desired final configuration and operational mode. Such modifications may include, but are not limited to: adding new structures, altering existing structures, selective demolition, or replacement/rebuilding of structures.

The application of the Pond Reconfiguration Strategy is based on the premise a complete initial conceptual design (ICD) has been developed and that the required information to resolve significant data gaps are available including investigation results from the AME and SWWB Project Teams. If multiple ICDs are developed, different preferred final configuration for the existing ponds could be identified through the application of this strategy. Because the ICD is developed on an individual drainage basis and this strategy will be applied on an individual pond basis, a combination of various configurations may be incorporated into the final land configuration for the Site. For example, some ponds may be reconfigured to allow flow-through operation while others may be retained in their current configuration or breached. The reconfiguration of peripheral structures (bypasses, outlet structures, spillways, etc.) will also be addressed in conjunction with decisions to reconfigure each individual pond.

The intent of applying the Pond Reconfiguration Strategy to the ICD is to provide a basis for discussions and decisions on the disposition of the individual ponds, associated dams, and peripheral structures. After the preferred reconfiguration for the existing ponds has been established, a reconfiguration implementation plan and schedule would be developed during detailed design. The need to phase the reconfiguration efforts over time would be considered in developing the implementation plan and schedule.

This attachment is divided into four Sections including this introduction. Section 2 provides information regarding the development of an ICD. Section 3 presents the pond reconfiguration strategy flowchart. Section 4 briefly discusses the current configuration and operation of the existing ponds and illustrates how the pond reconfiguration strategy would be applied to an existing pond.

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2.0 INITIAL CONCEPTUAL DESIGN DESCRIPTION

As discussed in the Introduction, the application of the Pond Reconfiguration Strategy is based on the premise a complete ICD has been developed. In general, the ICD identifies the components that have been included for each drainage that will be used to meet the functional design objectives (FDOs) described in the Design Basis for Final Land Configuration (see Tab 2, Appendix B). The components included in the ICD description developed by the LCDB Project Team are discussed in Tab 3, Attachment C. The need to include water controls (such as detention ponds) as a drainage-specific design component to maintain compliance with surface water quality standards at the POCs was addressed during the development of this ICD description. The key considerations associated with determining the need to include water controls for each individual drainage are presented in the following sections. It is noted that these considerations were addressed in the development of the ICD description, but are presented in the event that the basis and assumptions used to develop the ICD description are revised dictating the need to re-evaluate the inclusion of ponds as a design component.

Historical Exceedences at POCs and POEs

The following historical surface water monitoring information was considered during the development of the ICD description to identify the nature and extent of previous exceedences that have occurred at POCs and POEs.

- The location and frequency of historical exceedences at the POCs and POEs.
- The nature, concentration, and form (e.g., dissolved or suspended) of the exceedences.
- Whether the excceedences are associated with any specific weather conditions (e.g., storm intensity, dry or wet) or other events (e.g., season).

Additional information regarding the historical exceedences is provided in Section 2.5.1 of the Design Basis (see Tab 2, Appendix B).

Probability of Future Exceedences

The following information was considered to assess the probability and nature of future exceedences.

- The location, extent, and concentration of the potential sources after completion of planned remediation/closure activities.
- The potential pathways that could transport contaminants from the various source areas to surface water. The mechanisms include transport of suspended solids to surface water via soil erosion and migration of dissolved groundwater components to surface water via seep discharges.
- Investigation and modeling results conducted by the LCDB, AME, and SWWB Project Teams to predict potential for future exceedences considering completion of various remediation and closure actions.

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- The removal of the temporary surface water standards at the completion of active remediation.
- Existing and long-term effectiveness, effluent flows, and discharge concentrations associated with groundwater treatment and other remediation systems.
- The potential contribution of background concentrations in causing exceedences.

Need for Water Controls

The following items were considered in determining if water controls should be utilized within a particular drainage as a component in the ICD description to preclude future exceedences.

- Nature of predicted exceedences with respect to storm event magnitude and frequency.
- The level of performance and operational mode (batch-detention, flow-through, retention time, etc.) of the water controls that needs to be implemented to reliably achieve the surface water quality standards at the POCs for the design storm event. Investigation and modeling results from the LCDB, AME, and SWWB Project Teams would be used to determine the required level of performance and operational mode for the water control devices.
- Level of confidence that the water controls or other design components will maintain compliance with the surface water quality standards at the POCs.
- Consideration of the 30-day averaging period allowed by RFCA as it relates to any predicted exceedences that may occur based on storm return periods.
- Consideration of the storm return period for any predicted exceedence as it relates to overall risk.

3.0 POND RECONFIGURATION STRATEGY FLOWCHART

The Pond Reconfiguration Strategy flowchart is provided as Figure D-01. The flowchart is intended to identify a series of questions that should be considered in determining the preferred final configuration for each existing pond. The flowchart is not intended to address all possible decision points and considerations, but is intended to guide the path forward to resolve significant issues. A description of each key decision point identified on the flowchart is provided in the following sections. Where appropriate, specific design solutions that could be utilized to mitigate the identified concerns/issues are also presented.

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3.1 Existing Pond as Design Component

The first series of questions listed on the flowchart are aimed at determining the need to include the existing pond as part of the final land configuration and to fulfill the FDOs established in the design basis. The existing pond would be included as a drainage-specific design component if it were required to:

- Maintain compliance with the surface water quality standards at the POCs,
- Provide flood control,
- Preserve ecological resources (habitats and wetlands), or
- Facilitate downstream water uses and restrictions.

3.1.1 Contaminant Migration Considerations

The following items will be considered to determine if each existing pond should be included as a design component (either on an individual or combined basis) for use as the drainage-specific water control devices included in the ICD description.

- Location of the existing pond with respect to potential sources.
- Implications and cost associated with breaching the existing dam/pond (see Section 3.2).

3.1.2 Flood Control Considerations

This portion of the flowchart considers the value of the existing pond to prevent downstream flooding. The considerations associated with this decision include:

- The need for the existing pond to control downstream flooding to prevent property damage.
- Intensity and rainfall characteristics for the design storm event.
- Runoff coefficients and channel routing for the watershed at Site closure (including changes due to removal of impervious surfaces in the IA and construction of ET covers).
- Potential future development of upstream, offsite reaches of the watershed.

3.1.3 Ecological Resource Considerations

This portion of the flowchart considers the value of the existing pond to preserve existing ecological resources (including wetlands and habitats). The considerations associated with this decision include:

- The need for the existing pond to preserve or enhance existing ecological resources including wetlands and habitats, especially with respect to final land use of RFETS.

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- The need to modify the existing pond (design or operation) to optimize the quantity or quality of the present wetlands and ecological habitats.
- Post-closure availability of water to maintain existing pond to preserve or enhance existing ecological resources including consideration of post-closure water availability predictions developed by the SWWB Project Team. If water supply is not adequate, modifying specific sectors to increase availability of runoff could be considered as long as the modifications would not increase the potential for exceedences at the POCs.
- Potential ramifications to ecological resources and mitigation requirements if the existing pond is eliminated.

3.1.4 Water Use Considerations

This portion of the flowchart addresses potential impacts on downstream water uses. The considerations associated with this decision include:

- Historical provisions (such as Woman Creek Reservoir and Broomfield Diversion Ditch) to control runoff from RFETS to protect the water supplies associated with Standley Lake and the Great Western Reservoir.
- Stakeholder positions and expectations for long-term surface water controls at RFETS including post-closure requirements for continued diversion of runoff around Standley Lake and Great Western Reservoir.
- Capacity of downstream culverts at Indiana Street, diversion structures, and ditches, such as the Broomfield Diversion Ditch.
- Plan future operation of onsite water conveyance ditches (Kinnear, McKay, Upper Church, Smart, and Mower Ditches) and structures (McKay Ditch Pipeline and Mower Ditch Valve).
- Current and potential future use classifications for surface waters onsite and downstream of RFETS.
- Potential impacts resulting from controlled and uncontrolled release of runoff from RFETS on downstream water rights and uses.
- Available alternatives to providing on-site controls.

3.2 Elimination of Ponds

If the existing pond does not serve one of the long-term functions identified above or does not otherwise contribute in achieving the LCDB Project FDOs, the existing pond would be breached based on the following considerations.

- Management of sediment removed from the existing pond.
- Submission of the appropriate notifications, applications, and plans to breach the dam for regulatory review and approval.
- POC relocation in the event that an existing terminal pond is breached.

3.3 Long-Term Stewardship Obligations

This portion of the flowchart is used to consider the trade-offs of retaining the existing pond against the long-term stewardship obligations and liabilities that would be required to maintain the pond after Site closure. These long-term stewardship obligations and liabilities include:

- Monitoring dam integrity. Monitoring efforts may include collecting pond and piezometer water levels and performing visual surveillances.
- Conducting periodic inspections in accordance with State requirements to assess the integrity and operation of the dam structures. [Note: The terminal ponds are currently subjected to annual inspection and testing by FERC.]
- Performing maintenance as required. Maintenance activities may include removing accumulated sediments, adjusting water levels, removing debris from inlet/outlet structures, mowing and repairing dam embankments, removing invasive vegetation and wildlife, and providing mosquito controls.
- Providing water augmentation for any depletion to the South Platte River.
- Controlling access to ponds to prevent unauthorized use (fishing or swimming) and drowning accidents.

If the long-term stewardship obligations, liabilities, and associated O&M cost do not justify the benefit or need to retain the existing pond, then it would be breached in accordance with the considerations listed in Section 3.2.

3.4 Design Function and Criteria

This portion of the flowchart is used to establish the design functions and criteria for the existing ponds that are included as design components for the final land configuration. The design criteria would be tailored to the specific functions that the existing pond would need to meet as specified in the ICD description (see Tab 3, Attachment C). The key considerations associated with this decision are presented in the following sections.

3.4.1 Determine Required Pond Function

An existing pond may be retained to perform one or more of the following functions:

- Providing water controls to maintain compliance with the surface water quality standards through sedimentation or other constituent reduction process.
- Providing flood control.
- Preserving or enhancing ecological resources.
- Protecting downstream water uses.

3.4.2 Design Criteria

After establishing the functional requirements for each retained existing pond, pond-specific design criteria would be established consistent with LCDB Project FDOs listed in the Design Basis (see Tab 2, Appendix B), State of Colorado Regulations (2 CCR 402), and other appropriate engineering codes and standards. The design criteria that would be considered include:

- **Nature of Constituents:** Dissolved or suspended constituents, particle size distribution, constituent concentration/activity by fraction, settling velocities, and other physical / chemical properties.
- **Level of Performance:** Require sediment or constituent removal effectiveness, design storm event, runoff characteristics, sediment/actinide loads, and required hydraulic retention time.
- **Type of Pond Design:** Wetland, wet detention (permanent pool), extended dry detention, or other designs.
- **Mode of Operation:** Passive flow-through, gravity settling, manual batch release, total retention (zero discharge), automatic controls, etc.
- **Design Parameters:** Capacity, surface area, water depth, peak flow, evapotranspiration rates, water supply availability, etc.
- **Ancillary Features:** Inlet/outlet structures, energy dissipaters, spillways, freeboard, dam embankment erosion protection, monitoring equipment, etc.
- **Other Considerations:** Long-term stewardship obligations, life cycle cost (capital and operating), flood controls (see Section 3.1.2), potential impacts to ecological resources (see Section 3.1.3), downstream water uses (see Section 3.1.4), water augmentation, consistency with open space usage/National Wildlife Refuge and aesthetics, and protection of structures from unauthorized use and vandalism.

3.5 Safety, Longevity, and Adequacy Considerations

The final portion of the flowchart is used to determine if the existing pond is safe and adequate to meet the established design function and criteria as a long-term component of the final land configuration. The considerations associated with this decision include:

- Comparison of as-built features of existing dam to the design requirements for the dam against the type and hazard classification as specified in State of Colorado Dam Regulations (2 CCR 402). The current as-build features, type, and hazard classifications for the existing dams is summarized in Table D-01.
- Review of historical inspection records.
- Dam stability with respect to its location (e.g., slumping, erosion, or faults).
- Adequacy of existing dam/pond to safely achieve the design function and criteria identified in accordance with Section 3.4.

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- Reconfiguration of peripheral structures including bypasses, outlet structures, and spillways.
- Long-term stewardship obligations and O&M requirements for long-term safety of the existing dam.

Additional information for some of the longevity considerations is presented in Appendix 1 to this Attachment. These longevity considerations are not intended to imply that the existing dams are inadequate as currently configured or operated, but are intended to present factors that should be considered to determining the long-term adequacy of an existing pond, especially under the premise that long-term stewardship obligations are to be minimized.

3.5.1 Retain Existing Pond

If the existing pond were determined to be safe and adequate in its current configuration to one of serve the long-term functions identified in Section 3.1, then it would be retained as part of the final land configuration. The pond/dam structure would be retained in its current configuration with no or minor physical modifications. However, operation of the existing pond may be modified to accommodate its long-term design function. For example, the bypasses around Ponds A-1/A-2 may be closed to allow runoff to flow through these ponds.

3.6 Modification versus Replacement

If the existing pond were determined to be unsafe or inadequate, then modifying or replacing the existing pond would be considered. The considerations associated with this decision include:

- Technical feasibility and cost of modification versus new construction.
- Maintaining operations during modifications versus new construction.
- Ecological, aesthetic, and other impacts of modification versus new construction.
- Management of any sediment removed from the existing pond.
- POC relocation in the event that an existing terminal pond is replaced.

3.6.1 Modification of Existing Pond

The existing pond would be modified if determined to be cost-effective. An example of a potential modification for Pond C-2 may include installing a manual gate valve on the upstream side of the discharge pipe or increasing the height of the inlet riser. Other modifications may be implemented in response to operational changes. For example, the spillways for Ponds A-1/A-2 may be armored to accommodate a flow-through mode of operation for these ponds via overflow since the outlet works for these existing ponds are non-functional. Another modification may include adding upstream erosion controls to reduce sediment loading and to prolong the operating life of an existing pond.

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3.6.2 Replacement of Existing Pond

A new dam/pond would be constructed or the existing dam would be rebuilt if the existing pond is determined to be unsafe or inadequate and cannot be cost-effectively modified. Replacement or rebuilding may be required in situations where the existing embankment cannot be heightened to increase storage capacity. The longevity of embankments that are not keyed into the underlying bedrock or are not equipped with underdrains to prevent saturation and seepage erosion should be considered, especially if the pond will be operated with a permanent pool that has sufficient head to weaken the existing embankment. The replacement or rebuilding of pond/dam (if required) would be designed to meet the most recent regulations and engineering codes, standards, and practices.

4.0 EXAMPLE APPLICATION OF POND RECONFIGURATION STRATEGY

The following twelve (12) existing ponds are actively operated by DOE to manage surface water runoff from the Site and to maintain compliance with the surface water quality standards at the POCs:

- North Walnut Creek: A-series Ponds (A-1, A-2, A-3, and A-4).
- South Walnut Creek: B-series Ponds (B-1, B-2, B-3, B-4, and B-5).
- Woman Creek: Pond C-1.
- South Interceptor Ditch: Pond C-2.
- No Name Gulch: Present Landfill Pond.

A detailed description of the current operation and characteristics for each pond is provided in Section 2.3.7 of the Design Basis (see Tab 2, Appendix B) and the *Pond Operations Plan* (RMRS, 1996). This section describes how the Pond Configuration Strategy would be applied on a pond-by-pond basis to identify the preferred configuration for the above existing ponds.

Other ponds located at RFETS that are not actively managed as part of the Site's water management system include, but are not limited to, the Lindsay Ranch Pond, Ponds D-1 and D-2 in the Smart Ditch Drainage, the quarry ponds, and the Walnut Creek flume pond at Indiana Street. As such, these ponds are specifically considered for reconfiguration under the LCDB Project. However, the Pond Reconfiguration Strategy could be applied to each of these ponds if desired. In addition, the Pond Reconfiguration Strategy could be applied to other drainage structures, such as, the West Diversion Dam and Woman Creek Diversion Dam, either individually or as a peripheral structure to one of the existing ponds.

The Pond Reconfiguration Strategy was tentatively applied to Pond A-4 to illustrate how it could be used to determine a preferred configuration for this existing pond. An example format to compile and present the results of the Pond Reconfiguration Strategy to each of the existing ponds is provided as Table D-02. It is recognized that additional information to resolve significant data gaps and the results from studies that are in

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progress (including investigations and studies being performed by the AME and SWWB Project Teams) have direct implications on the preferred configuration of the existing ponds. As such, the information presented in this section is only to illustrate the approach for applying the Pond Reconfiguration Strategy to an ICD.

Initial Conceptual Design Components

In general, the ICD description (see Tab 3, Attachment C) incorporates the following water controls as the basis to maintain compliance with the surface water quality standards at the POCs.

- **North Walnut Creek:** Passive flow-through detention ponds with enhanced/new wetlands.
- **South Walnut Creek:** Terminal detention basin.
- **SID/Woman Creek:** Combined passive flow-through detention ponds with enhanced/new wetlands or segregated detention basin for SID.

Final selection of design components for the above drainages is pending resolution of data gaps regarding extent of 903 Pad hillside remediation (see Data GAP-150) and water availability after closure (see Data GAP-010).

From this point forward, the discussion regarding application of this Pond Reconfiguration Strategy is restricted to utilization of Pond A-4 as the water control device for North Walnut Creek as presented in the ICD description (see Tab 3, Attachment C). During the development of the ICD description, it was determined the using passive flow-through detention ponds would be adequate to maintain compliance with the surface water quality standards at the POCs within North Walnut Creek based on the lack of historical exceedences for this drainage. In addition, historical gauging data suggests that a significant portion of the flow in North Walnut Creek is supported by groundwater seepage. As such, this drainage is considered a good candidate for sustaining wetlands combined with a flow-through pond. The amount of water available to sustain wetlands would be based on the information developed by the SWWB Project Team (see Data GAP-010).

Inclusion of Pond A-4 as a Design Component

Based on the ICD description, the passive flow-through detention pond could be located in the area of existing Pond A-4. As discussed in the ICD description, locating the passive flow-through detention pond further downstream is not warranted based on current information. However, should a source of legacy sediment contamination in the lower onsite reaches of Walnut Creek be identified and significantly contribute to the actinide loads at GS03, then alternatives to locating a passive flow-through pond in North Walnut Creek would be considered (see Data GAP-030).

Under the configuration presented in the ICD description, Pond A-4 is considered a potential candidate to fulfill the design functions and criteria for the North Walnut Creek flow-through pond. The potential inclusion of Pond A-4 to serve this contaminant

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migration control function is denoted by the "yes" as identified in Table D-02. Because Pond A-4 would be considered for inclusion as a water contaminant migration control device, use of Pond A-4 to provide flood control, preserve ecological resources, or facilitate downstream water usage was not considered as denoted by the "---" in Table D-02.

Long-Term Stewardship Obligations

Because Pond A-4 would be used as a water control to maintain compliance with the surface water quality standards as a passive flow-through pond, the long-term stewardship obligations for this pond would be minimal. As such, the breaching and elimination Pond A-4 is not considered appropriate.

Design Function and Criteria

The specified design function for Pond A-4 would be a passive flow-through detention pond. The flow-through pond would be sized to handle the runoff from a 100-year, 6-hour storm event. Based on the WEPP information developed for bounding Scenario 1, the amount of runoff at Pond A-4 from a 100-year, 6-hour storm event is estimated to be approximately 55.6 acre-feet. This capacity requirement should be verified during detailed design using another accepted standard engineering method for determining the expected amount of runoff from the design storm event.

Tests performed by the AME Project Team indicate that settling of suspended sediment occurs within 3 to 4 days. The settling test data should be further evaluated to estimate a settling velocity with respect to particle size. Particle size distribution versus activity should also be reviewed to determine the hydraulic retention time required to achieve the required removal effectiveness (see Data GAP-100). Previous required settling determinations are discussed in Section 6 of the *Pond Operations Plan* (RMRS, 1996) and Section 2 of the *Source Control Alternatives Analysis, Phase 2 Progress Report* (WWE, 1998). Various computer programs are available to calculate removal effectiveness of various detention pond configurations and sediment loading conditions (see Data GAP-100).

Longevity Considerations

The following longevity considerations should be addressed to ensure that Pond A-4 is suitable to maintain its long-term functionality with minimal long-term stewardship:

- Pond A-4 was constructed with a cutoff key but does not have an underdrain system to preclude saturation or seepage through the embankment. Analysis of the long-term hydraulic affects of having a permanent pool in Pond A-4 should be further assessed.
- This pond was also constructed with a convex-downstream curved embankment, which is less stable than a straight or convex-upstream embankment. Long-term stability of the current configuration should be further assessed.

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- The upstream and downstream embankment slopes 2:1 and 2.5:1, respectively. Flattening of the slopes should be considered to provide longer-term stability of the embankment and to facilitate maintenance.

Adequacy Considerations

The following adequacy considerations for Pond A-4 need to be addressed:

- The current storage capacity and surface area of Pond A-4 is approximately 98.6 acre-feet and 8.7 acres, respectively. This capacity is adequate to store the amount of runoff expected from a 100-year, 6-hour storm event of 55.6 acre-feet. Up to 43 acre-feet of storage could be devoted to a permanent pool. The surface area at this capacity is approximately 5.3 acres with an average pool depth of 8.1 feet, which is equivalent to an elevation of 5750 feet above msl. At this elevation, Pond A-4 would be approximately 45 percent full.

  Ideally, the maximum depth of the permanent pool should be approximately 3 feet to minimize sediment resuspension. As such, a lower water level for the permanent pool would be adequate. The existing pond could be excavated to maintain a minimum 3-foot water depth over the inundated area of permanent pool. A shallow bench around the perimeter of the permanent pool could also be established to support growth of wetland vegetation thus reducing the potential for bank erosion and to restrict access to the pond.

  The outlet works is currently at 5741.3 feet above msl. At this elevation, the maximum and average water depths are approximately 12.3 and 4.5 feet, respectively. The pool volume and surface area at this elevation are approximately 10.2 acre-feet (about 10 percent of pond capacity) and 2.3 acres, respectively. As such, there is a sufficient margin to modify the outlet structure (if required) to improve passive flow-through settling characteristics while maintaining ample storage capacity for the design storm event. However, if the preferred final configuration for the Site is to breach the West Diversion Dam, the adequacy of the available storage capacity in Pond A-4 should be re-evaluated. Hydrographs should also be generated during detailed design to verify that this capacity would be adequate to provide the required detention time and to restrict discharge flow to prevent downstream flooding.

- The riprap protection on the upstream side of the embankment should be evaluated to verify that it provides adequate long-term protection of the embankment. If required, additional riprap should be added or the existing riprap replaced.

- The spillway is adequately sized to pass about 50% of the current PMP flood. However, erosion protection of the spillway may be inadequate to met long-term closure objectives. Further evaluation should be performed.

The adequacy of the existing ponds and need to upgrade existing dams for long-term operations and reconfiguration of the upper ponds and associated bypasses will be further assessed during development of the detailed design.

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Preferred Configuration for Pond A-4

Based on the above information, the preferred configuration for Pond A-4 would be to retain the primary structures/embankment in their current location and modify certain components to facilitate passive flow-through operations.

5.0 REFERENCES

The following documents were used to develop this attachment.

Materials & Substructures, 1971. *Soils Investigation for Increased Water Retention, Rocky Flats Plant, Jefferson County, Colorado (Job No. 1019-1578).* Materials & Substructures, Consulting Engineers. Denver, Colorado. June.

Merrick, 1992. *Detention Pond Capacity Study.* Merrick & Company. Denver, Colorado. September.

RMRS, 1996. *Pond Operations Plan: Revision 2 (RF/ER-96-0014.UN).* Rocky Mountain Remediation Services, L.L.C., Rocky Flats Environmental Technology Site, Golden, CO. September.

WWE, 1998. *Source Control Alternatives Analysis, Phase 2 Progress Report.* Wright Water Engineers, Denver, CO. September.

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TABLES AND FIGURES

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Table D-01
Existing Dam Information and Hazard Classification

Pond No.	Dam Height [a/] (feet)	Surface Area at Spillway Crest [b/] (acres)	Volume at Spillway Crest [b/] (acre-feet)	State of Colorado Jurisdictional Dam [c/]	Type of Dam [d/]	Hazard Classification [e/]
A-1	17	1.09	4.3	Yes – Height	Minor	Class IV
A-2	29	3.31	28.0	Yes – Height	Small	Class IV
A-3	37.5	4.55	38.1	Yes – Height	Small	Class IV
A-4	46	8.65	98.6	Yes – Height	Intermediate	Class III
B-1	18	0.94	3.5	Yes – Height	Minor	Class IV
B-2	26	1.17	6.63	Yes – Height	Small	Class IV
B-3	16	0.54	1.72	Yes – Height	Minor	Class IV
B-4	17	0.39	0.55	Yes – Height	Minor	Class IV
B-5	54	6.02	73.7	Yes – Height	Intermediate	Class III
C-1	15	1.54	5.28	Yes – Height	Minor	Class IV
C-2	35.5	8.90	70.0	Yes – Height	Small	Class III
Landfill Pond	35	2.80	23.1	Yes – Height	Small	Class III

a/ Source: State Engineer Inspection Reports. Dam height is vertical distance measured from downstream base of dam to spillway crest.

b/ Source: Merrick, 1992. *Detention Pond Capacity Study*.

c/ Jurisdictional dams have a capacity greater than 100 acre-feet, dam height greater than 10 feet, or surface area at high water level greater than 20 acres. [see 2 CCR 402-1, 4.A.(6)(a)].

d/ Dam types as defined in 2 CCR 402-1, 4.A.(6):
Minor dams have a capacity less than 100 acre-feet and a hydraulic dam height less than 20 feet.
Small dams have a capacity between 100 and 1,000 acre-feet with a hydraulic dam height less than 40 feet or capacity less than 1,000 acre-feet with a hydraulic dam height between 20 and 40 feet.
Intermediate dams have a capacity between 1,000 and 50,000 acre-feet with a hydraulic dam height less than 100 feet or capacity less than 50,000 acre-feet with a hydraulic dam height between 40 and 100 feet.
Large dams have a capacity greater than 50,000 acre-feet or a hydraulic dam height greater than 100 feet.

e/ Hazard Classifications as filed with the State Engineer. Classifications are defined in 2 CCR 402-1, 4.A.(5) and include:
Class I – Loss of life expected in event of dam failure.
Class II – Significant offsite property damage, but no loss of life expected in event of dam failure.
Class III – No loss of life or offsite property damage is expected in event of dam failure.
Class IV – No loss of life expected in event of dam failure. Damage restricted to owner's property.

Table D-02
Example Application of Pond Reconfiguration Strategy

Reconfiguration Considerations	A-1	A-2	A-3	A-4	B-1	B-2	B-3	B-4	B-5	C-1	C-2	Present Landfill Pond
Inclusion of Existing Pond as a Design Component												
Use for Contaminant Migration				Yes								
Use to Provide Flood Control				---								
Use to Preserve Ecological Resources				---								
Use to Facilitate Downstream Water Uses				---								
Long-Term Stewardship Prohibited				No								
Design Function/Criteria A/				F-T								
Existing Pond Safe and Adequate				--- B/								
Proposed Reconfiguration of Existing Pond												
Breach Dam And Eliminate Existing Pond				---								
Retain Existing Dam/Pond Configuration				---								
Modify Existing Dam/Pond Structures				X								
Construct New Dam/Pond				---								
Revise Existing Pond Operation				X								

A/ F-T = Passive flow-through pond; WET = Wetland area; DB = Detention basin.

B/ Final determination depends on results of on-going studies and further evaluation to be performed during detailed design.

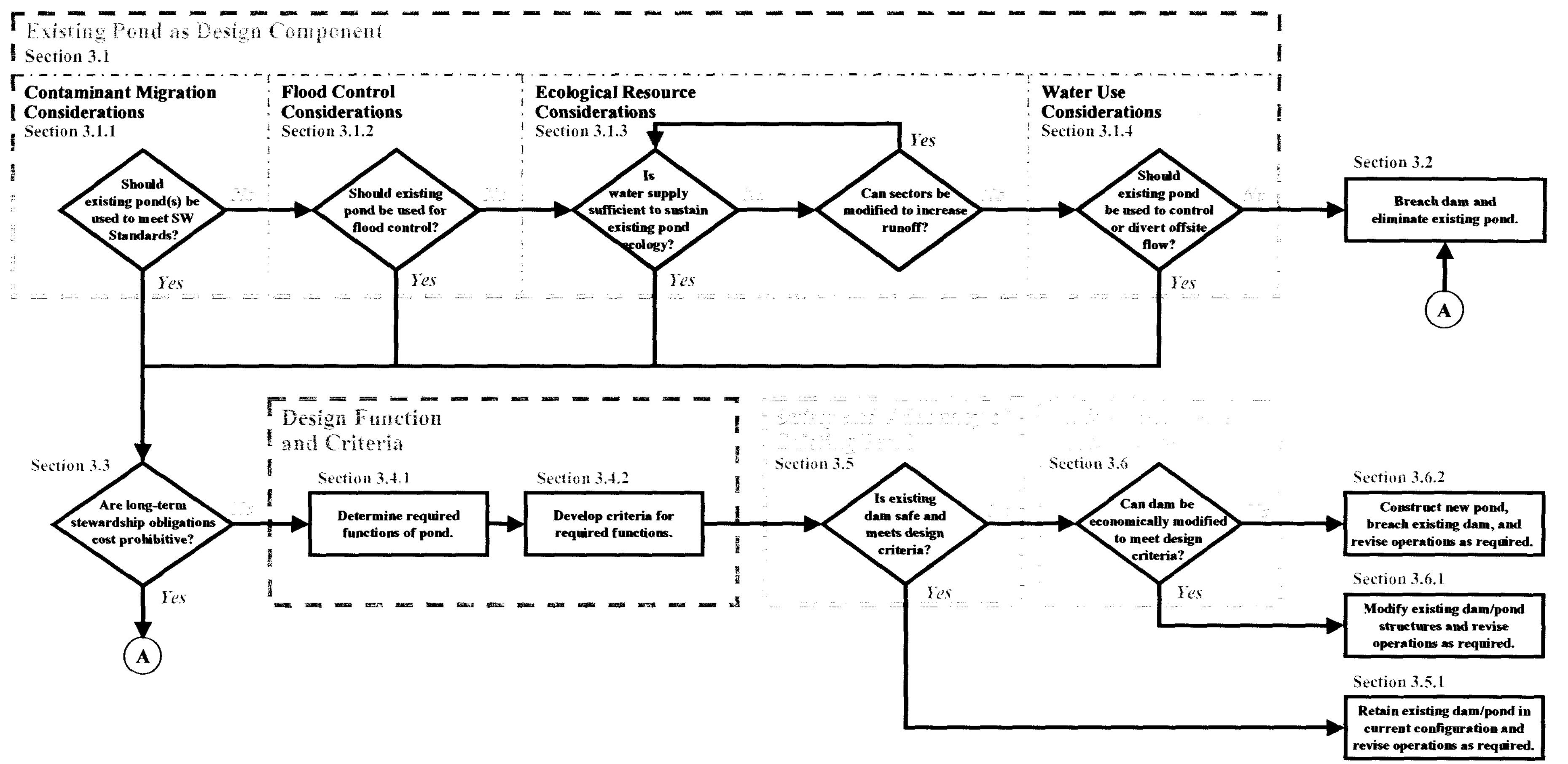

FIGURE D-01

Pond Reconfiguration Strategy Flowchart

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

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December 27, 2001

Drawing Name: Tab 3, Att D, Flow Chart.ppt

TAB 3, ATTACHMENT D
APPENDIX 1

LONGEVITY CONSIDERATIONS

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TAB 3, ATTACHMENT D
APPENDIX 1
LONGEVITY CONSIDERATIONS

1.0 INTRODUCTION

This appendix provides a more detailed description of various factors that should be considered to assess the long-term longevity of the existing dam structures during the application of the Pond Reconfiguration Strategy. This appendix is intended to supplement the considerations presented in Section 3.5. These longevity considerations are not intended to imply that the existing dams are inadequate as currently operated, but are intended to present factors that should be considered to determining the final reconfiguration of the existing ponds, especially under the premise that long-term stewardship obligations are to be minimized.

2.0 BACKGROUND

Within Colorado, the safety of dam structures is regulated by the State Engineer under the Colorado Division of Water Resources according to the Code of Colorado Regulations, Title 2, Regulation 402-1 (2 CCR 402-1). Jurisdictional dams[1/] are subject to the requirements of this regulation. All 12 existing ponds at RFETS are jurisdictional dams based on the height criterion (see Table D-01) and are subject to the State Engineer's regulations. As such, the dam owner must continue active operation, inspection, and maintenance, and must make any modifications or repairs deemed necessary by the State Engineer. The State Engineer can order breaching of any existing dam if its condition or performance becomes unsatisfactory.

The existing ponds are subjected to various man-made and natural influences that can affect long-term survivability. "Long-term survivability" pertains to influences that could cause the eventual deterioration or loss of a structure component that is not actively maintained. Some of the long-term survivability considerations for the existing ponds are discussed in the following sections. Given these considerations, several long-term configurations are still possible. For example, the height of some dams could be reduced to non-jurisdictional levels while others could be reconfigured as overflow weirs that are capable of passing floods while retaining sediment. The selection of the appropriate configuration depends on consideration of its environmental and economical benefits associated as it relates to the overall final land configuration for the Site.

1/ A "Jurisdictional Dam" is a dam which impounds water above the elevation of the natural surface of the ground creating a reservoir with a capacity of more than 100 acre-feet, or creates a reservoir with a surface area in excess of 20 acres at the high-water line, or exceeds 10 feet in height measured vertically from the elevation of the lowest point of the natural surface of the ground where that point occurs along the longitudinal centerline of the dam up to the flowline crest of the emergency spillway of the dam. For reservoirs created by excavation, the vertical height shall be measured from the invert of the outlet. The State Engineer shall have final authority over determination of the vertical height. [see 2 CCR 402-1.4.A(6)(a)].

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3.0 OUTLET LONGEVITY

Every existing pond, except Pond B-4, has at least one outlet conduit passing through the embankment. The presence of an outlet conduit creates potential pathways for concentrated seepage and a potential for embankment subsidence if the pipe collapses. Leakage from the joints between the pipe segments could erode the bedding surrounding the conduit leading to eventual failure of the embankment.

At Ponds A-1 and B-1, the conduits are permanently sealed. At several of the other ponds, the conduits have been fitted with blind flanges. The safety of a dam requires ongoing operation and maintenance including regular exercising, lubrication, and periodic replacement of valves and gates. The following components may pose potential longevity considerations for the existing conduits.

Materials of Construction

The conduits consist of reinforced concrete pipe at the terminal ponds and corrugated steel pipe at the interior ponds. Corrugated steel pipe is more susceptible to corrosion and other deterioration over time than concrete pipe. For some of the older ponds, the corrugated steel pipe may be approaching its design life and may require replacement to facilitate long-term operation of the ponds after Site closure. Potential long-term deterioration of concrete pipe should also be considered.

Pressurization of Conduit

Most of the conduits are fitted with valves or gates (which may or may not be serviceable) at the upstream end, the downstream end, or both. At Ponds A-3 and C-2, only downstream valves or gates are provided and the conduits for these ponds may be pressurized. If these ponds are retained, the upstream outlet valves or gates should be installed to reduce the potential for seepage and internal erosion should the conduit develop leaks.

4.0 EARTHEN EMBANKMENT

All of the ponds were formed by constructing an earthen dam across the drainage. The following components may pose potential longevity considerations for the existing earthen embankments.

Slope Considerations

Some embankments (especially Ponds A-1, B-1, B-2, and B-4) may need to be regraded to flatter slopes to enhance the long-term stability of these embankments.

The longevity of the riprap protection on the upstream faces and the abutments should be reviewed. Minor erosion, beaching, or other damage has apparently occurred on the upstream faces at Ponds B-1, B-2, and perhaps B-3.

Seepage Considerations

Historical dam inspections commonly identify the presence of seepage at the downstream toe, an abutment, or both. Some amount of seepage is normal and expected at almost any dam. However, seepage should be controlled because it can lead to piping (subsurface erosion), dissolution of soluble minerals (if present), and softening of soil materials in the dam, foundation, and abutments. Although a number of methods exist to control seepage, the best method for the existing RFETS ponds may be to excavate the seepage areas and install graded filters and aggregate drain blankets, covered with riprap of appropriate size. Seepage was most often reported at the older interior ponds, although landslides south of the Pond B-5 dam exhibited significant seepage as well. The largest seepage exists at the Pond C-1 dam.

Cutoff Keys

To prevent subsurface seepage flow, the earthen embankment should be keyed into a firm foundation. According to the design drawings, Ponds A-2, A-3, A-4, B-5, C-2, and the Present Landfill Pond were keyed into the underlying claystone of the Larmine Formation. The presence of cutoff keys for the remaining ponds could not be determined.

Removal of sediments from ponds without a cutoff key could result in increased leakage under the dam embankment and could result in piping, internal erosion, or collapse of the dam if the leakage is severe (Materials & Substructures, 1971). As such, it is recommended that the dam structures associated with Ponds B-1, B-2, and B-3 (where sediment is proposed to be removed) be further evaluated to determine potential impacts and evaluate the need to breach, reconfigure, or reconstruct these dams.

5.0 OVERTOPPING AND SPILLWAY EROSION

Dams are typically designed to balance the risk/cost of flood damage against the construction costs to accommodate a larger flood event. In the case of RFETS, most of the dams were designed with a philosophy that the spillways would be infrequently used and that any resulting damage would not threaten the dam structure and would be promptly repaired. While this philosophy is acceptable and desirable for dams under active maintenance, it may not be consistent with minimization of long-term stewardship obligations.

Most of the spillways were designed with minimal or no erosion protection. As such, erosion could be an ongoing maintenance issue. Erosion damage has previously occurred in the spillway chutes at Ponds A-1, A-3, B-3, and C-1. Minor erosion has also occurred at the upstream north abutment of the dam at Pond A-3.

Several interior pond spillways were designed to withstand floods having return periods of 25 to 100 years. Accordingly, the dam would not expected to last longer than the return period of the design flood without maintenance and repair. If these embankments must survive longer without intervention, substantial upgrading to enlarge or redesign the spillways and perhaps even reconfiguring the dams as overflow weirs may be required.

The spillways and dam abutments could be lined, armored with riprap, or otherwise protected to prevent gully headcutting.

6.0 GEOMORPHIC PROCESSES

Over time, the slow erosional geomorphic processes (including mass wasting, channel shaping, and pedogenesis-related effects) present a threat to the long-term survival of the dam embankment.

Mass Wasting

Slope instability and mass wasting (slumps and landslides) appear to be the dominant geomorphic processes shaping the valleys along both forks of Walnut Creek. This has implications for many of the dams. At Pond A-1, a recently active landslide impinges on the spillway. At Pond B-5, landslide complexes flank the reservoir and influence the dam's south abutment. Although where or when a landslide event may occur cannot be accurately predicted, the geomorphic zones that are most susceptible to landslide activity can be identified. The long-term longevity of dams that fall within these active zones should be considered.

Stream Dynamics

Walnut and Woman Creeks are active fluvial systems that evolve interactively with their surroundings over time. Changes that can be expected in the future include channel incision, migration, aggradation, and trenching. The headcutting trench in the stream channel just downstream from Pond B-4 is an example of such an effect that has occurred within the relatively short period since the dams were built. A majority of the headcutting at Pond B-4 is attributed to the 17 May 1995 storm/runoff event. Additional riprap and other landscape stabilization measures may be required in specific areas to retard the long-term evolution of the streams.

Pedogenesis-Related Effects

Weathering and biological processes will eventually alter the earthen embankments. Soils near the ground surface will gradually become less dense due to frost action and shrink-swell effects. The development of root systems will contribute to loosening of the soil, and will create macropores for the rapid movement of fluids through the embankments. Animal burrows can accomplish the same effects, but on locally larger scales. Distinct soil profiles will begin to develop as well. These effects are undesirable at earthen dams. The long-term stewardship plan should include inspection and maintenance to address these longevity considerations.

TAB 3
ATTACHMENT E

IA GRADING AND DRAINAGE CONCEPT

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IA GRADING AND DRAINAGE CONCEPT

TABLE OF CONTENTS

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1.0 INTRODUCTION

This Grading and Drainage (G&D) Concept was developed in conjunction with the Initial Conceptual Design Component Description (see Tab 3, Attachment C) to establish a potential final topography and drainage configuration for closing the RFETS Industrial Area (IA) and to facilitate the planning and integration of D&D and ER projects. The G&D Concept is based on the premise that the following water controls, as described in the Initial Conceptual Design Component Description, will be used.

- North Walnut Creek – Wetlands and passive flow-through ponds,
- South Walnut Creek – Batch-release detention basin, and
- Woman Creek and SID – Either wetlands and passive flow-through ponds for combined flow or batch-release detention basin for SID flow only.

Because of the above water controls, the G&D Concept was not specifically developed as a primary component to maintain compliance with surface water quality standards at the Points of Compliance (POCs) although it was an underlying consideration. The G&D Concept was developed to cost-effectively stabilize the final land surface and drainage channels taking into consideration maintaining long-term longevity of remediation systems, preventing migration of subsurface contaminants, minimizing impacts to ecological resources, and using natural materials that blend in with surrounding landscape to support final land use of open space/National Wildlife Refuge.

As discussed in the Geomorphic Evaluation Report (see Tab 2, Appendix G2), the most significant geomorphic process naturally occurring at RFETS is slope movement, which is partly driven by channel incision, undercutting of the adjacent hillsides, and soil saturation. As the channel advances, the slope of adjacent hillsides increases and eventually destabilizes resulting in slope movement/failure. While it is not possible to engineer completely static conditions within the IA, it is possible, to engineer and regrade the existing drainages and landscape to obtain a condition of dynamic equilibrium (balance between the driving and resistive forces) where the geomorphic processes are significantly slowed.

This attachment consists of seven sections. This introduction addresses the purpose, content, objectives, technical approach, assumptions and constraints for the G&D Concept. Section 2 describes the design criteria adopted for the G&D Concept. Section 3 presents the method and calculations used to estimate peak flow for IA runoff. Section 4 describes the grading and drainage features for the IA. Section 5 provides the initial cut and fill volume estimates. The G&D Concept represents the first step towards detailed design. The additional activities necessary to complete the detailed design for the Final Grading and Drainage Plan are discussed in Section 6. The references and source of information used to develop this G&D Concept are provided in Section 7.

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1.1 Objectives

The following objectives were adopted for the G&D Concept.

- Provide stable engineered channels for the major IA drainages (North and South Walnut Creek) to reduce stream incision and limit the headward advance. Because of the extensive alteration of the drainage channels from construction in the IA, leaving the drainage channels in their current configuration could result in accelerated erosion and destabilization of adjacent hillsides after Site closure. The G&D Concept was developed to provide low maintenance, stable, erosion resistant engineered channels in these areas in a cost effective manner utilizing natural materials to blend in with the surrounding landscape.
- Stabilize existing hillsides that are currently unstable and where slope movement or failure could adversely affect the engineered drainage systems, significantly increase sediment transport from areas with actinide-bearing soils and erosion characteristics that could result in significant actinide loads to surface water, or cause damage to remediation systems.
- Promote positive drainage and evapotranspiration in areas of the IA where increased infiltration may negatively impact the migration of contaminated groundwater or operation of existing plume treatment systems.
- Promote sheet flow of surface water to existing or stabilized drainage channels by smoothing all remaining surfaces in the IA. The surface topography would be designed to avoid concentrating flows that could induce rill and gully formation.

1.2 Technical Approach

The following technical approach was use to develop the G&D Concept.

1. The existing (1994) surface topography was obtained from Kaiser-Hill (Ref. 1) in AutoCAD format. Contour information was provided in 2-foot intervals for the IA and 5-foot intervals for the surrounding buffer zone. No attempt was made to reconcile any discrepancies between the 2- and 5-foot contour information. Additional contour details for the North and South Walnut Creek drainage channel low points were added based on TIFF files from the 1987 Scharf survey (Ref. 2).

2. Elevation information was added to contour lines that had no elevation specified. The existing elevation information was derived from the scanned (TIFF format) files of the original 1994 topographical drawings provided by Kaiser-Hill (Ref. 1). Information of location and sizes of existing culverts was obtained from the Industrial Area Drainage Improvement Plan (Ref. 3). Culvert inlet and outlet inverts were verified from additional survey information provided by Kaiser-Hill (Ref. 4).

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3. The existing contour lines were interpolated across building locations to represent the surface of the IA following building closures for estimating cut and fill volumes (see Figure E-01). The proposed final contours for the SEP ET cover obtained from Kaiser-Hill (Ref. 5) were included in the base map as existing contours.

4. A north-south and east-west cross-section was developed to graphically present the existing surface (see Figures E-02 and E-03, Sections A-A and B-B respectively).

5. The design criteria specified in Urban Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual* (USDCM), Volumes 1 and 2 dated June 2001 (Ref. 6) was used to develop profiles for three engineered drainage channels in the IA (see Figures E-04, E-05 and E-06). The engineered drainage channel located between existing Buildings 371 and 771 (North Walnut Creek Tributary) would convey runoff from the western portion of the IA to North Walnut Creek. A second engineered channel carrying the combined flow of the North Walnut Creek and the North Walnut Creek Tributary replaces the current 72-inch concrete storm water sewer (P-5000) that parallels the North Perimeter Road. A third engineered drainage channel would be provided south of the current Building 991 to convey runoff from the central portion of the IA to South Walnut Creek.

6. The slope of the drainage channel bottom was established based on the criteria provided in the USDCM based on the type of engineered channels (see Section 2.1) and the estimated peak flows that were calculated using the Rational Method (see Section 3.0). The channels were developed in sufficient detail to assess the adequacy of the channel type. Section 4.0 provides additional details for the engineered channels; however, specific design details such as selective use of riprap for erosion protection, riprap sizing, channel transitions, outfalls, and trickle channels are not provided.

7. A conservative width of the engineered drainage channels was established based on consideration of channel types and characteristics, channel hydraulics to handle estimated peak flows while maintaining non-erosive velocities, and methods to construct the drainage channel. The horizontal limits of the engineered channels shown on Figures E-04, E-05 and E-06 were developed in sufficient detail to demonstrate that the channel footprint provides adequate capacity. The specific dimensions shown on Figures E-04, E-05 and E-06 for the engineered drainage channels should be further refined and finalized during the detailed design (see Section 6.0).

8. The hillsides adjacent to the engineered channels were recontoured to provide a stable slope per the design criteria presented in Section 2.2. The profile elevations established for the engineered channels were used as the basis for determining the G&D Concept topography of the adjacent hillsides. The hillsides were also contoured to facilitate sheet flow.

9. The proposed final contours for the SEP ET cover were assessed and blended with the surrounding existing contour information based on the slope stability design criteria and to facilitate sheet flow.

10. The existing topography for the remaining portions of the IA was adjusted to smooth the terrain, which would include the removal of ditches, culverts, roadbeds, swales, building berms, and other artifacts from previous Site development. In general, culverts without a continued use under the G&D Concept have been removed/abandoned. Where culverts are retained, a specific rationale for their retention in identified in Section 4.0.

11. Cross sections (Figures E-07, E-08, and E-10) were developed through current buildings 371, 374, 771, 774, 881, 991 and associated tunnels to evaluate potential impacts of the proposed G&D Concept topography on D&D activities associate these buildings. Generalized foundation/footer depth information was taken from the Hydrogeologic Characterization Report (Ref. 9) or from specific building drawings. A generalized foundation envelope is shown as a crosshatched area in each cross section. The bottom of the envelope represents the bottom of the lowest elevation of the building footer/foundation. The top of the envelope represents the elevation at the top of the highest anticipated remaining building slab plus three feet.

12. Cross sections through the Mound Plume System components were developed (Figure E-09) to evaluate potential impacts of the proposed G&D Concept topography on this remediation system. Locations and elevations for the Mound Plume System components were taken from system design drawings (Ref. 8).

13. The cut and fill volumes were electronically estimated using AutoCAD based on differences between the existing and G&D Concept elevations (see Section 5.0). The cut and fill volume estimates represent the initial starting point to develop a Site-wide soil balance for all closure projects (see Section 6.0).

14. The proposed final topography for the G&D Concept is depicted on Figure E-01. For conceptual development, the G&D Concept contours are provided at 10-foot elevations at a scale of 1-inch equals 300 feet (300-scale). A more refined final grading map using 2-foot contours with a 30- to 50-scale should be developed during detailed design (see Section 6.0).

1.3 Assumptions and Constraints

The assumptions and constraints that were used to develop the G&D Concept are listed below.

1. The East and West Access Roads, North Perimeter Road (includes road sections designated north-west, north, and north-east) and the unimproved buffer zone road entering the Woman Creek drainage from west entrance road near the Original Landfill will be retained.

2. Maintenance roads are not required along the IA engineered drainage channels.

3. The Western Diversion Ditch and Dam Structure will remain intact after closure and continue to divert water from the upper portions of North Walnut Creek into McKay Bypass Canal.

4. Ponds and drainage channels outside the IA were not included in developing this G&D Concept. Any modifications to these features will be based on the completion of an Initial Conceptual Design and application of the Pond Reconfiguration Strategy.

2.0 DESIGN CRITERIA

The design criteria and details for the G&D Concept was adopted from the USDCM, Volumes 1 and 2 dated June 2001, and Volume 3 dated September 1999. These manuals provide storm water management guidance to local jurisdictions, developers, and contractors in the Denver Metropolitan area. The guidance is based on geological, hydrological, and climate conditions specific to the Denver area. The following sections identify some of the specific guidance contained in these manuals that were applied to develop the G&D Concept.

2.1 Engineered Drainage Channels

As discussed in Section 2.0, the purpose of engineered channels is to retard channel incision and headward advance of the major channels draining the IA pediment. The engineered channel types identified in USDCM adopted for the G&D Concept include grass-lined, composite (wetland bottoms), and riprap-lined. Concrete-lined channels will not be used and engineered drop structures will be avoided wherever possible. Further details for each channel type are provided below.

1. Grass-lined channels would be used predominantly within the IA on the top of the pediment where the slope is gentle (0.2 to 0.6%), flow velocities can be maintained less than 5 feet per second, and the flow is perennial or intermittent. The grass-lined channel will generally follow the guidance provided in the USDCM Volume 1, Major Drainage, Section 4.1. Riprap protection along the outside of bends, soil-riprap mix for lining for the bottom of the channel, and elements of bioengineering as discussed in USDCM Volume 1, Major Drainage, Section 4.5 would be considered during detailed design to control erosion and promote longevity.

2. Composite channels would be used where there is a suitably gentle grade (<0.6%) and sufficient base flow through seepage to sustain a wetland type environment. The composite channel is essentially a grass-lined channel where more dense wetland vegetation is encouraged to grow on the bottom of the low-flow channel. The design of these channels will generally follow the guidance provided in USDCM Volume 1, Major Drainage, Section 4.2. Elements of bioengineering as discussed in USDCM Volume 1, Major Drainage, Section 4.5 would be considered during detailed design for additional stream stability and erosion protection.

3. Riprap-lined channels would be used in instances where the channel grade will produce critical velocities in excess of allowable non-eroding values and significant relief is available. The riprap-lined channel is lined with ordinary riprap, grouted riprap, or wire-encased rock to control channel erosion. The design of these channels will generally follow the guidance provided in USDCM Volume 1, Major Drainage, Section 4.4. Selection of specific channel lining type, including recycling of existing Site security boulders, will be considered during detailed design.

The specific channel type and initial sizing for various sections of the major drainages is identified on Figures E-04, E-05 and E-06. However, these channel details should be verified during development of the detailed design for each drainage. The selection and preliminary sizing of the channel types was used to conservatively allocate a boundary width and routing for the drainage channel that was used to establish the toe of slope for recontouring of the adjacent hillsides.

2.2 Hillside Stability

As presented in the Geomorphic Evaluation Report (Tab 3, Appendix G2), several factors affect the stability of hill slopes at RFETS. These factors include stratigraphy, climate, geotechnical properties, slope grade, slope curvature, and soil saturation. Of these factors, one of the most dominant contributors to slope movement is the slope grade. As discussed in the Geomorphic Evaluation Report, hillsides that are steeper than 8 H:1 V are more likely to become unstable under typical conditions at RFETS. These slopes should be regraded where significant slope movement could result in significant degradation of a major drainage, significant increase in actinide migration, or damage to an existing remediation system. For long slope runs, benching of the hillside with secondary engineered drainage channels should be considered during detailed design.

2.3 Positive Drainage

The main drainage channels leaving the IA (North Walnut Creek Tributary and South Walnut Creek) have been extended to provide positive drainage in several areas where it is desirable to have surface water removed more rapidly than would occur by sheet flow or to minimize surface water flow over sensitive areas. The current concept does not include mounding or buildup of areas during recontouring to increase grade and promote runoff, however, this may be further evaluated and considered based on the results of the Site Wide Water Balance (SWWB) and other studies.

2.4 Evapotranspiration Provisions

In areas where it is desirable to further reduce surface water infiltration, changes in vegetation cover, plant species composition, and soil rooting media should be considered during detailed design as a means to maximize evapotranspiration (ET) rates. Methods to improve the ET rate may include alternating the plant assemblages to maximize the uptake and dissipation of infiltrated surface water, providing sufficient water storage capacity in the soil rooting media, and/or adding soil amendments to decrease the infiltration rate while accommodating good plant growth (e.g., increasing the clay content of sandy soils in the upper soil layers).

3.0 ESTIMATION OF PEAK FLOWS

Peak flows from the design storm event (100-year) were estimated using the Rational Method as prescribed in USDCM Volume 1, Runoff, Section 2.0. This analysis provides a peak flow of 255 cubic feet per second (cfs) with a concentration time of 70 minutes for the South Walnut Creek drainage and 128 cfs with a concentration time of 60 minutes for the North Walnut Creek Tributary. The combined peak flow in the engineered channel in North Walnut Creek (paralleling the North Perimeter Road) is estimated at 253 cfs with a concentration time of 62 minutes. The peak flow estimates were used to define a conservative width for the engineered drainage channels to maintain non-erosive velocities and to assess the adequacy of existing culverts crossings under the North Perimeter Road for North and South Walnut Creeks. Water level depths within the engineered drainage channel and flood mapping were not developed.

4.0 DESCRIPTION OF GRADING AND DRAINAGE FEATURES

This section describes the grading and drainage features for the IA included in the G&D Concept on an area-by-area basis. Additionally, areas and issues for future evaluation during detailed design are identified.

4.1 North Walnut Creek

The North Walnut Creek Tributary located between Buildings 371 and 771 would be enhanced as an engineered drainage channel. The existing culverts would be removed to reestablish an open channel consistent with low maintenance and keeping with final land use of open space/National Wildlife Refuge.

The existing basin at the confluence point of North Walnut Creek and the IA tributary would be utilized as a stilling basin. The stilling basin will provide a means of energy dissipation. Grouted boulder drop structures are proposed where these two channels enter the stilling basin.

The relatively flat section of the channel located between Station 10+50 and 16+25 is currently proposed as a grass-lined channel. The use of wetland vegetation in this area would be dependent on results of the SWWB to verify that sufficient seep flow will be available after Site closure. In that case, a composite (wetlands) channel could be substituted to provide additional water quality improvements through filtering and minimization of channel scour. Alternately, a bioengineered channel may be developed during detailed design.

The steep portion of the channel running down the hill between Station 16+25 and 25+65 would be riprap-lined to resist erosive velocities that are likely to occur within this portion of the channel.

The top portion of the channel between Station 25+65 and 34+50 would be riprap-lined and be routed in a southern direction to intercept surface water that would otherwise flow over the surface area above the IA VOC plume. During detailed design, results of the SWWB study should be used to determine the necessity of providing an impermeable liner in this portion of the channel to further reduce infiltration in the vicinity of the IA VOC plume.

The vertical concrete drop structures located in northern reach of North Walnut Creek drainage (along the south side of the North Perimeter Road) would be retained. These structures are adequate for their intended use and will not experience a significant change in flow based on the current G&D Concept. Modification to these structures should be reevaluated during detailed design if any significant changes are made to the North Perimeter Road or if the West Diversion Dam is eliminated. However, the removal of the concrete drop structures will destabilize this channel and alternate engineered features would need to be included in the detailed design.

The existing 72-inch diameter storm water sewer (P-5000) between the existing stilling basin and the North Perimeter Road crossing would be removed and replaced with an engineered channel. The existing 72-inch culvert (P-5000) running under the North Perimeter Road would be replaced with 400 feet of 60-inch diameter reinforced concrete pipe. This modification raises the culvert elevation to minimize grading requirements, to stabilize the drainage channel at the culvert inlet, and to provide a drop inlet structure for the surface water for the SEP hillside to the east.

4.2 South Walnut Creek

This drainage between Station 10+00 and 32+50 would be slightly straightened and converted to an open riprap-lined channel for erosion control and to promote channel stability.

All culverts upstream of the Northeast Perimeter Road would be removed. The existing twin 30-inch culverts (C-179A and C-179B) under the Northeast Perimeter Road are replaced by a single 54-inch diameter reinforced concrete pipe to provide additional capacity and reduce the potential for blockage during storm events.

The upper end of the channel between Station 32+50 and 37+25 would be a grass-lined, broad swale to intercept run-off from the SEP ET cover.

4.3 SEP ET Cover Area

Preliminary topography for the areas north and east of the SEPs is shown consistent with the contouring identified in the conceptual design drawings developed under the ET Covers Project (Ref. 5). The culvert (C-114) located in the northeast corner of the IA that runs under the old PA security fence and the Northeast Perimeter Road would be removed or plugged in-place. An open ditch would be constructed along the Northeast Perimeter Road to convey runoff to the west into North Walnut Creek near the proposed drop inlet structure. Should the ET cover for the SEPs not be implemented, the topography and drainage in these areas will require re-evaluation.

4.4 IA VOC Plume Area

Revegetation of the area directly over the IA VOC plume will include additional provisions to improve evapotranspiration. These provisions in conjunction with the southern extension of the engineered drainage channel for the IA tributary of North Walnut Creek will limit infiltration into the IA VOC plume. Additional mounding to increase runoff rates is not currently proposed. Detailed design in this area will be dependent on the findings of other Site studies including the SWWB and further delineation of the nature and extent of the IA VOC plume. Without this additional information it is premature to meaningfully evaluate the potential impact of the G&D Concept topography on the IA VOC plume. The removal of impervious surfaces in the IA during Site closure (increasing permeability of the ground surface) and the cessation of imported water will also significantly influence the IA VOC plume.

4.5 Building 371 Hillsides

The hillsides adjacent to Building 371 would be significantly regraded to stabilize the hillsides along North Walnut Creek and its associated IA tributary. This regrading effort would prevent accelerated hillside erosion that could fill in these drainage channels.

4.6 Building 130 Area

The small existing drainage channel running along the north side of the Northwest Perimeter Road will be retained. Unnecessary culverts running in this drainage would be removed to create an open channel. This drainage continues along the Northwest Perimeter Road until it crosses under the road.

The West Access Road will be terminated where it connects to the Northwest Perimeter Road. The existing paved road between the Northwest Perimeter Road and the intersection of First Street and Cactus Avenue will be removed, graded, and replaced with a gravel road, without ditches, to allow cross-slope sheet flow. The road is retained to provide access to the Original Landfill, however, eliminating the concentrating features avoids the necessity for additional channels draining to the south of the IA into the Woman Creek Drainage.

4.7 Hillside Building Foundations and Footers

Buildings 371, 881, and 991 were specifically selected to determine if the proposed G&D Concept topography could result in the need to remove subsurface building foundations and basement slabs to meet RFCA closure requirements. These buildings were selected because they are located along hillsides and have significant subsurface features that would be the most impacted by the proposed G&D Concept topography. As shown on the cross-sections presented in Figures E-07, E-08, and E-10, no significant impacts are anticipated and removal of subsurface building foundations and basement slabs would not be required for these three buildings. In several locations, the proposed G&D Concept topography is actually higher than the existing grade and would require less excavation of clean subsurface building walls, but would require additional backfilling.

Channel routing and profiles adjacent to Building 991 should be optimized during detailed design to minimize potential interference with subsurface features.

4.8 *Mound Plume System*

Based on the cross sections presented in Figure E-09, the proposed G&D Concept topography will impact existing components of the Mound Plume System. The major impact is due to the difference in the existing grade and proposed grades at the trench location. These differences would involve both filling over portions of the existing trench and excavating the top portion of the trench on the west end where it rises to meet the security road. Modification to the G&D Concept to eliminate this interference might involve rerouting the South Walnut Creek channel to the north, or installing a retaining wall along the channel. Both of these options would potentially impact the durability of the final site configuration. Detailed design in this area is dependent on the findings of the SWWB to assess if additional alterations of the Mound Plume System are required to compensate for removal of impervious surfaces and cessation of imported water.

5.0 CUT AND FILL BALANCE

An estimate of cut and fill volumes was calculated based on the initial topography and the proposed final grading shown on Figure E-01. Both sets of contours were developed using AutoCAD Land Development Desktop Software that allows for automatic determination of cut and fill volumes. The final topography presented in this G&D Concept would result in an excess of 290,000 cubic yards of soil.

The initial topography contour lines represent the surface of the IA after the removal of all buildings, parking lots and roads. The cut and fill estimates do not account for:

- Soil shortages from backfilling of removed building excavations,
- Excess soil that may result from demolishing buildings,
- Imported soil (quantity and quality) needed to construct the proposed ET covers for the Original Landfill, Present Landfill, Solar Evaporation Ponds and to enhance ET over groundwater plumes (if necessary), or
- The identified 6 to 9-inch topsoil layer that may be required to revegetate the IA.

6.0 ACTIVITIES TO COMPLETE DETAIL DESIGN

As previously noted, the G&D Concept provides preliminary estimates to regrade and stabilize the drainages and hillsides within the former IA after Site closure. The G&D Concept provides a conceptual design and is not intended as a final grading and drainage design or to be used for actual regrading/construction activities. The following additional steps/activities are necessary to develop the detailed design for the Final Grading and Drainage Plan for the IA.

1. Gain concurrence from stakeholders and various project teams on the general approach and proposed topography presented in the G&D Concept.

2. Determine need to reclassify existing jurisdictional wetlands within roadside ditches and other drainage-ways to facilitate drainage enhancements, especially in light of the recent Court ruling regarding the definition of wetlands. Reclassifications may require coordination/consultation with regulatory agencies responsible for wetlands oversight.

3. Identify engineering parameters for each type of material that is required for Site closure. Determine if excavated soils from regrading of hillsides and constructing the engineered drainages are suitable for reuse. Optimize the final topography with the goal of balancing cut and fill requirements on a Site-wide basis. Determine the extent of remedial actions to be taken for the 903 Pad, which could significantly impact the cut and fill balance if the hillside is extensively regraded or stabilized.

4. Assess changes to the final topography on surface water and groundwater hydrology. Refine the G&D Concept as required based on surface water availability predictions, changes to groundwater elevations, and potential migration of groundwater plumes.

5. Conduct field surveys to verify existing contour information. Reconcile any discrepancies between 2-foot IA contours and 5-foot Buffer Zone contours.

6. Incorporate final ET cover design for Solar Evaporation Ponds and Original Landfill (as available).

7. Prepare detailed Final Grading Drawings at a 30- to 50-scale with 2-foot contours.

8. Revise peak flow calculations using the more refined Colorado Urban Hydrograph Procedure (CUHP) specified in USDCM Volume 1, Runoff, Section 3.0 based on the more detailed Final Grading Plan.

9. Confirm drainage routing and profiles provided in the G&D Concept and develop design details for the engineered drainage channels based on the refined Final Grading Plan, corresponding drainage areas, and calculated peak flows using the CUHP method.

10. Develop a sequencing plan to implement the detailed design and cut/fill balance. It is recommended that this plan consider the status of the IA at the completion of the activities scheduled for each fiscal year through 2006 (Site closure). This will allow the evaluation of surface water controls that will remain during each specific time period to verify their adequacy to prevent flooding and other adverse condition during Site closure. A phased cut/fill balance would allow advance project planning for material availability, handling, and stockpiling.

11. Develop administrative procedures to control final land configuration activities and changes to allow integration of various D&D or ER projects.

12. Develop design standards and specifications for revegetation, imported soil, ET provisions, erosion controls, and drainage and hillside armoring/stabilization. The design standards and specifications should be included in bid packages to ensure consistency between projects implementing the final land configuration. Many specifications have already been generated and can be compiled and checked for consistency prior to being established as the Site standard.

13. Develop a Final Grading and Drainage Plan Report (detailed design) that documents all of the above steps.

7.0 REFERENCES AND SOURCES OF INFORMATION

The following references and information were used to generate the G&D Concept.

1. Topographical files from the 1994 aerial flyover in AutoCAD format and associated contour maps (TIFF files) that were received from Diana Woods on or about 18 October 2001.

2. Additional topography information (TIFF files) generated from 1987 Scharf survey.

3. Information from text and drawings from the Drainage Repairs and Improvements Plan, 1994.

4. Culvert invert information from RFETS Surface Water Group Culvert Map received from Diana Woods on or about 7 November 2001.

5. Solar Evaporation Pond ET Cover Conceptual Design drawing in AutoCAD format that was received from Bob Scheck on or about 29 October 2001.

6. *Urban Storm Drainage Criteria Manual, Volumes 1 and 2.* Urban Drainage and Flood Control District. Denver, CO. June 2001.

7. *Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices.* Urban Drainage and Flood Control District. Denver, CO. September 1999.

8. Mound Plume System Design, See Drawing Index #51520-X001. US Army Corp of Engineers, 1997.

9. *Hydrogeologic Characterization Report for the Rocky Flats Environmental Technology Site*, EG&G Rocky Flats, April 1995.

FIGURES

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TAB 3
ATTACHMENT F

SITE-WIDE WATER BALANCE REPORT FOR LAND CONFIGURATION DESIGN BASIS PROJECT

Note:

This attachment is pending completion of the evaluation for the ICD Description (Tab 3, Attachment C) and IA Grading and Drainage Concept (Tab 3, Attachment E) by the SWWB Project Team.

This attachment will be added when available.

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Table 2
Summary of Potential Land Configuration Options

Land Configuration Option	Relative Cost		Advantages	Disadvantages	Additional Considerations
	Capital	Operational			
1. **Total Retention (Zero Discharge)** Runoff from specified drainage is retained in onsite pond(s) for evaporation and infiltration. Runoff is not normally released from the Site, except when retention pond is full.	High	Moderate to High	High reliability to achieve standards since no discharge would normally occur. Provides flood control.	Elimination of offsite water flow would restrict downstream water rights/uses and could require water augmentation to supplement losses. O&M, inspections, and long-term stewardship for the dams / ponds would be required. Potential for dam failure presents safety concerns and liabilities. Existing dams are not designed to provide long-term water retention. New dam construction could cause significant disruption to habitats and may result in decrease in wildlife. Dam structure would be visible.	May not be feasible to construct a dam with sufficient capacity to ensure water retention for all storm events. Emergency overflow could occur or periodic discharges could be required to maintain adequate capacity. Long-term management of sediments. Potential accumulation of salts due to evaporation. Interaction between surface water and groundwater.
2. **Surface Water Detention** **A. Passive Settling (Flow-Through)** Runoff from specified drainage is routed through onsite pond(s) for gravity settling. Outlet structure is designed to passively discharge the accumulated runoff at a controlled rate to achieve the desired settling.	Low if existing structures can be used. High if new structures are required.	Low to Moderate	Minimize impact to wetlands. Additional wetlands may be established if constant-level wet operation design is used. Downstream water rights or uses would not be restricted. Allows a more continuous base flow to facilitate habitat preservation and improvement. Possible reuse of existing facilities and dams. Provides flood controls.	Flow controls may be prone to failure due to clogging. Potential for dam failure presents safety concerns and liabilities. O&M, inspections, and long-term stewardship for the dams / ponds would be required. Dam structure would be visible.	Existing outlet structures would need to be modified. Ponds would need to be taken off-line and emptied during modifications. New large capacity dam may be required to provide the necessary detention time. Long-term management of sediments. Interaction between surface water and groundwater.
B. Batch Release This option is similar to the current mode of operation where runoff from specified drainage is retained in onsite pond(s). Suspended solids are allowed to settle and pond waters are tested. If testing results are below standards, accumulated runoff is batch released for offsite discharge.	Low if existing structures can be used High if new structures are required.	High	High reliability to achieve standards. Current mode of operation has proven track record. Downstream water rights or uses would not be restricted. Possible reuse of existing facilities and dams. Minimize impact to wetlands. Provides flood controls.	Analytical results would be required to demonstrate compliance. Analysis requires additional cost and scheduling of discharge. Potential for dam failure presents safety concerns and liabilities. O&M, inspections, and long-term stewardship for the dams / ponds would be required. Dam structure would be visible.	New large capacity dam may be required to provide the necessary detention time. Need to upgrade existing dams for long-term operation. Long-term management of sediments. Interaction between surface water and groundwater.
C. Active Treatment Runoff from specified drainage is routed through onsite pond(s) for detention. Accumulated water would be treated by physical (filtration) or chemical (flocculation) to remove actinide-bearing solids. Active treatment could also be used to treat soluble constituents.	High	Very High	High reliability to achieve standards. Active treatment could reduce size of ancillary structures. Downstream water rights or uses would not be restricted. Possible reuse of existing facilities and dams. Minimize impact to wetlands. Provides flood controls.	Analytical results would be required to demonstrate compliance. Analysis requires additional cost. Potential for dam failure presents safety concerns and liabilities. O&M, inspections, and long-term stewardship for the dams / ponds would be required. Additional structures would be necessary to house treatment equipment. Dam structure and treatment facilities would be visible. Chemical (flocculants) may be used to enhance settling. Capital and operating cost would be high.	Additional testing information for flocculation or filtering may be required. Previous filtering trials have been conducted to treat pond water. Filter media could be prone to clogging. Waste stream may be generated. Interaction between surface water and groundwater.
3. **Removal of Surface Water Controls** Existing ponds, culverts, and other structures would be removed from specified drainages if not required to meet the surface water quality standards and do not serve any other beneficial function such as flood control, maintaining wetlands or ecological habitats, or water diversion.	Low	None to Low	Consistent with open space / low aesthetic impact. Maximizes the return of the Site to natural conditions. Downstream water rights or uses would not be restricted. Minimizes water depletion.	No contaminant reductions or flood controls would be provided. Low reliability in achieving standards. Elimination of ponds may result in loss of wetlands/wildlife habitat.	Breaching of existing dams requires notification to be provided to the State Engineer. If all ponds were removed, uncontrolled peak runoff could exceed capacity of downstream diversion structures and ditches for Great Western Reservoir.

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Table 2
Summary of Potential Land Configuration Options

Land Configuration Option	Relative Cost		Advantages	Disadvantages	Additional Considerations
	Capital	Operational			
4. **Wetlands** Runoff from specified drainage is routed through constructed wetlands to remove suspended solids by reducing runoff velocity and filtering. Wetlands could also be used to facilitate reduction of other concentrations such as nutrients (such as nitrate and phosphorus), some metals, and certain biodegradable VOCs (such as petroleum hydrocarbons).	Low	Low to Moderate	Provides uptake and reduction of other pollutant concentration and provides runoff retention for sedimentation. Consistent with open space / low aesthetic impact. Wildlife habitat would be preserved. Provides high ET, which will minimize runoff. Wetland vegetation is highly resilient and self-sustaining.	May require additional sources of water for sustaining wetland vegetation. May require upstream detention system to provide adequate base flow. Sediment may be resuspended during large storm events. Uptake of nitrate may vary with growing season. Reduction of offsite water flow may restrict downstream water rights/uses and could require water augmentation to supplement losses.	Use of aggressive non-native vegetation to optimize year-round uptake of nitrate. Type of wetlands essential for preserving Preble's mouse habitats. The amount of water available after closure may not be adequate to support establishment of wetland. Time required to establish the wetland. Type and level of monitoring to assess wetland performance. Long-term geomorphology and channelization of wetlands. Long-term management of sediments. Long-term effectiveness. Interaction between surface water and groundwater.
5. **Drainage Diversion / Land Recontouring** Runoff from specified sectors that are susceptible to contaminant migration is diverted. Alternatively, runon could be diverted around these sectors to minimize contaminant transport.	Low	Low to Moderate	Potential for contaminant transport would be reduced. Versatile option that can be tailored to specific sectors. Consistent with open space / low aesthetic impact. Additional fill soil and contouring may aid vegetation in IA.	May disrupt established habitats and vegetation when applied to sectors in the BZ. O&M and long-term stewardship may be required to maintain control structures.	This option would be used only in conjunction with other options. Drainage diversion between the Walnut and Woman Creek basins could impact downstream water rights. As such, water augmentation may be required to supplement losses.
6. **Source Isolation and Removal** Surface soil that is susceptible to contaminant migration is regraded, backfilled, excavated, or removed to minimize potential erosion.	Moderate to High	None to Very Low	Source controls are typically highly effective and reliable. Works well in combination with other options. Additional fill soil and contouring may aid vegetation in IA.	Isolation in BZ may restrict open space uses. Removal in BZ may disturb established habitats and vegetation.	Additional source removal is not required based on direct exposure pathways.
7. **Erosion Controls** Engineered structures would be used to control drainage and erosion from areas that are susceptible to contaminant migration. Controls may include, but not be limited to riprap, check dams, hillslope armoring, grade reduction, and ditches.	Low	Low to Moderate	Erosion controls are effective in reducing erosion. Downstream water rights or uses would not be restricted. Works well in combination with other options. Compatible with open space land use.	O&M and long-term stewardship may be required to maintain control structures. Engineered structures may have aesthetic impacts and would not be the primary choice for open space land use.	None identified.
8. **Vegetation Restoration** Barren areas that are susceptible to contaminant migration would be vegetated to reduce erosion. Areas to be vegetated would include the IA and roads/structures to be closed within the BZ.	Low	Low	Vegetation is effective in reducing erosion. Wind erosion is reduced with increased vegetative cover. Vegetation creates habitat for wildlife and is self-sustaining. Topsoils rich in organic material tend to bind soil particles. Works well in combination with other options.	Effectiveness of vegetation susceptible to drought, prairie fires, and animal grazing.	Use of organic rich soil may result in the establishment of non-native vegetation. Effectiveness of organic material to bind actinides may decrease over time.
9. **Evapotranspiration (ET) Provisions** ET provisions could be used for surface soils that are susceptible to contaminant migration to minimize runoff. ET provisions could also be used over ground water plumes to reduce infiltration thereby reducing subsurface contaminant mobility.	Low to Moderate	Low	Ground water treatment systems may not be required if ET controls are effective in reducing infiltration. ET controls are self-sustaining and designed to be drought resistant.	Reduced offsite water flow due to ET controls may restrict downstream water rights/uses and could require water augmentation to supplement any losses. Increased ET could reduce seep flows resulting in decrease in wetlands and habitats for the Preble's mouse. ET controls could require import of offsite borrow soils. Effectiveness of vegetation susceptible to drought, prairie fires, and animal grazing.	Use of non-native vegetation and establishment of monocultures.

Table 2
Summary of Potential Land Configuration Options

Land Configuration Option	Relative Cost		Advantages	Disadvantages	Additional Considerations
	Capital	Operational			
10. Infiltration Provisions Infiltration provisions could be used to reduce the amount and associated sediment load transported into surface water from specific sectors that are susceptible to erosion of actinide-bearing surface soils. Infiltration could also be used in conjunction with ground water treatment systems to flush contaminants.	Low	Low	Runoff and erosion would be reduced. Could enhance wetlands and habitats through increased seepage.	Hillsides may become unstable if infiltration is increased.	Possible mobilization of subsurface soil and groundwater contaminants. Ability and effectiveness of existing plume treatment systems to accommodate increased infiltration/contaminant flux. Potential alternations in ground water flow may effect operation of ground water treatment systems.
11. No Action No action would be taken if existing or planned controls are sufficient to achieve the FDOs. However, administrative or institutional controls may be added or revised to facilitate the application of the no action option. No action may be applied to specific sector, existing feature, drainage, or other portions of the Site.	None to Low	None to Low (Does not include O&M cost for existing controls)	Minimizes disruption of existing conditions. Minimizes capital expenditures.	May not provide best method to achieve FDOs.	Long-term effectiveness of existing controls. Application of no action is dependent on conditions at the completion of active remediation.

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Table B-06
Summary Information for Existing Ponds

Pond No.	Location of Dimensions	Width (ft)	Length (ft)	Height (ft)	Elevation (ft msl) a/	Volume (ac-ft) a/	Surface Area (ac) a/	Capacity (cfs)	Outlet Invert Elevation (ft msl)	Year Constructed or Modified	Safety and Long-Term Survivability Issues	Other Pertinent Information
A-1	Dam Crest	25+	180	17 *(structural and hydraulic)*	5,833.6	9.97	1.49	--	Outlet works grout sealed	Constructed ....1952 Raised & modified 1972	The entire right abutment is a recently active landslide mass. Landslide deposits impinge on spillway. Spillway lacks significant erosion protection and has eroded in past. Seepage may be present at downstream toe. Riprap on u/s face appears undersized.	Dam slopes designed as 3:1 to 2:1 u/s and 2.5:1 d/s; actually are 2:1 to 1:1 u/s, 2:1 d/s. The spillway can pass less than 10% of the PMP flood. Outlet consists of corrugated metal pipe (CMP), which is grout sealed. Embankment lacks d/s toe drain. A-1/A-2 bypass consists of 42" ϕ CMP. Inlet to A-1 from bypass headwall is via a separate gated 24" ϕ CMP.
	Spillway Crest	20	--	--	5,829.1	4.30	1.09	960				
A-2	Dam Crest	35+	250	36 *(structural)* 29 *(hydraulic)*	5,823.1	38.1	3.78	--	5,816.9 a/ (Upper outlet) Lower outlet is not functional	Constructed 1972	Seepage may be present at downstream toe. Spillway lacks significant erosion protection. Spillway is partly obstructed by access road.	Dam slopes are 2:1 u/s and 2:1 d/s. The spillway can pass less than 10% of the PMP flood. The outlet works has upper and lower inlets. Upper outlet consists of CMP. Lower outlet consists of 10" ϕ ductile iron (DI) pipe and is closed off with a blind flange.
	Spillway Crest	*20*	--	--	5,820.2	28.0	3.31	700				
A-3	Dam Crest	20+	380	42 *(structural)* 37.5 *(hydraulic)*	5,799.0	70.6	6.10	--	5,772.5 b/	Constructed 1974	Riprap on u/s face appears undersized. Spillway is very close to embankment; minor erosion damage to spillway chute has occurred in the past (1995). Minor erosion damage has occurred at the u/s left abutment. Outlet works has downstream valve only; conduit is pressurized.	Dam slopes are 3:1 u/s and 2.5:1 d/s. The spillway can pass about 10% of the PMP flood. Spillway is rip rapped and fitted with a concrete sill at crest. Outlet consists of 12" ϕ DI pipe.
	Spillway Crest	20	--	--	5,793.0	38.1	4.55	1,200				
A-4	Dam Crest	20 *(rt half)* 110 *(lt half)*	1,050	52 *(structural)* 46 *(hydraulic)*	5,764.0	159	11.1	--	5,741.3 c/ (Main gate) 5727 c/ (Lower drain)	Constructed ....1979 Crest monuments installed....1993 Outlet modified 1996	Riprap on u/s face may be undersized. No erosion protection along spillway. Convex-downstream embankment plan is somewhat less stable than a straight or convex-upstream plan.	Dam slopes are 2:1 u/s and 2.5:1 d/s. The spillway can pass about 50% of the PMP flood. Outlet consists of 18" ϕ reinforced concrete pipe (RCP).
	Spillway Crest	150	--	--	5,757.9	98.6	8.65	6,640				
B-1	Dam Crest	30+	200	18 *(structural and hydraulic)*	5,885.0	6.90	1.36	--	5,880 d/ (Upper outlet) 5870 d/ (Lower outlet) Outlet works grout sealed	Constructed ....1962 Raised & modified ....1972 D/S face flattened & toe drain installed 1992	Riprap on u/s face appears undersized and inadequate. Some erosion occurring on the u/s face at the waterline. Spillway partly blocked by access road.	Dam slopes designed as 2:1 u/s and 2.5:1 d/s; actually are 1.5:1 d/s. The spillway can pass about 70% of the PMP flood. The outlet works has upper and lower inlets. Upper outlet consists of 36" ϕ CMP, which is grout sealed. Lower outlet is 10" ϕ DI pipe, which is grout sealed. B-1/B-2 bypass consists of 48" ϕ CMP. Inlet to B-1 from bypass headwall is via a separate gated 24" ϕ CMP.
	Spillway Crest	15	--	--	5,882.0	3.50	0.94	900				
B-2	Dam Crest	25+	220	26 *(structural and hydraulic)*	5,875.5	13.7	1.75	--	5,868.9 d/ (Upper outlet) 5860 d/ (Lower outlet)	Constructed ....Prior to 1952 Raised & modified ....1972 D/S toe drain installed....1995	The u/s face is creeping downslope and eroding at waterline. Riprap on u/s face may be undersized. Seepage apparently occurs at downstream toe. Spillway lacks significant erosion protection.	Dam slopes were designed as 2:1 u/s and 2.5:1 d/s; but actually are somewhat steeper. The spillway can pass about 70% of the PMP flood. The outlet works has upper and lower inlets. Upper outlet consists of 36" ϕ CMP w/HDPE liner pipe. Lower outlet consists of 10" ϕ DI pipe.
	Spillway Crest	10	--	--	5,870.7	6.63	1.17	780				
B-3	Dam Crest	25+	140	16 *(structural)* 18 *(hydraulic)*	5,856.8	5.37	0.89	--	5,851.4 d/ (Upper outlet)	Constructed ....1952 Raised & modified 1972	Spillway chute is badly eroded by flows from the B-1 Bypass pipe; spillway lacks significant erosion protection. Riprap on u/s face appears undersized and inadequate. Embankment fill on u/s face is soft and poorly compacted. Seepage is present at downstream toe.	Dam slopes are 2:1 u/s and 2.5:1 d/s. The outlet works has upper and lower inlets. Upper outlet consists of 48" ϕ CMP and is located in the spillway approach channel. The spillway can pass about 60% of the PMP flood. WWTP effluent discharges to B-3 via 10" ϕ cast iron pipe.
	Spillway Crest	10	--	--	5,851.7	1.72	0.54	550				
B-4	Dam Crest	25+	200	17 *(structural)* 19 (hydraulic)	5,839.8	3.00	0.81	--	No outlet works	Constructed ....1952 Raised & modified ....1972 D/S toe drain installed....1995	Seepage is present at downstream toe. A gully is headcutting toward the outlet works. The closed-conduit spillway passes through the embankment. Riprap on u/s face is small and in poor condition.	Dam slopes were designed as 2:1 u/s and 2.5:1 d/s, but are actually somewhat steeper. Spillway is concrete lined and passes under roadway/dam crest in a 7'W by 6' H concrete box culvert. The spillway can pass about 20% of the PMP flood. The reservoir is shallow and overgrown with vegetation.
	Spillway Crest	7	--	--	5,835.8	0.55	0.39	200				

Table B-06 (Continued)
Summary Information for Existing Ponds

Pond No.	Location of Dimensions	Width (ft)	Length (ft)	Height (ft)	Elevation (ft msl) a/	Volume (ac-ft) a/	Surface Area (ac) a/	Capacity (cfs)	Outlet Invert Elevation (ft msl)	Year Constructed or Modified	Safety and Long-Term Survivability Issues	Other Pertinent Information
B-5	Dam Crest	20+	550	57 *(structural)* 54 *(hydraulic)*	5,810.4	121	8.40	--	5,785 [e/] (Main gate) 5,765 [e/] (Lower drain)	Constructed .... 1979 Outlet, u/s face & rt abutment modified .... 1984 Crest monuments installed .... 1993 Outlet modified 1997	Widespread sloughing, sliding, and seepage on right abutment. Riprap on u/s face may be undersized. No erosion protection along spillway.	Dam slopes are 2:1 to 5:1 u/s and 2.5:1 d/s. The spillway can pass the PMP flood. The drain bed dewaters sediment trapped below the outlet works inlet. Outlet conduit consists of 18" ϕ RCP. A rapid-drawdown failure of the u/s face occurred in 1983.
	Spillway Crest	80	--	--	5,803.9	73.7	6.02	3,500				
C-1	Dam Crest	25+	270	16 *(structural)* 15 *(hydraulic)*	5,829.8	13.1	2.66	--	5822.6 [a/]	Constructed .... 1952 Raised & modified 1972	Significant seepage passes through or beneath dam. A gully is headcutting up the spillway. Riprap on u/s face is small. Undercutting of concrete slab in spillway. Water leakage around gate valve leaf when closed.	Dam slopes are 2:1 u/s and 2.5:1 d/s, but are irregular. Spillway is concrete lined. The spillway can pass less than 10% of the PMP flood. The South Interceptor Ditch limits inflows. Outlet conduit consists of corrugated metal pipe.
	Spillway Crest	30	--	--	5,826.1	5.28	1.54	1,750				
C-2	Dam Crest	25+	1,180	43 *(structural)* 35.5 *(hydraulic)*	5,775.3	188	14.2	--	5,745.0 [f/]	Constructed .... 1979 Crest monuments installed 1993	No erosion protection along spillway. No toe drain present in embankment. Riprap on u/s face may be undersized. Outlet works has downstream valve only; conduit is pressurized.	Dam slopes are 2:1 u/s and 2.5:1 to 4.5:1 d/s. The spillway can pass about 80% of the PMP flood. The South Interceptor Ditch limits inflows. Outlet conduit consists of 18" ϕ RCP.
	Spillway Crest	190	--	--	5,765.3	70.0	8.90	19,100				
Landfill Pond	Dam Crest	20+	430	45 *(structural)* 35 *(hydraulic)*	5926.3	40.7	3.88	--	5907.3 [g/] Outlet is non-functional	Constructed .... 1974 Crest monuments installed 1993	Outlet works is inoperable due to bent valve stem. Wave erosion is present along waterline at upstream face.	Spillway flows through a 8'W by 5.75' H concrete box culvert. Outlet consists of 10" ϕ DI pipe.
	Spillway Crest	10	--	--	5921.0	23.1	2.80	120				

a/ Source: Merrick, 1992. *Detention Pond Capacity Study*. Drawings 39873-0001 to 39873-0022, updated May 1997.

b/ Source: Pond A-3 as-built drawings 27038-1 to 27038-10 prepared by Nelson, Haley, Patterson & Quirk, Inc., Greeley, Colorado, dated March 1974.

c/ Source: A-4 Dam Outlet Modifications as-built drawings 51420-0001 to 51420-0011 prepared by Wright Water Engineers, Denver, Colorado dated September 1996.

d/ Source: Liquid Waste Control and Miscellaneous Improvements as-built drawings 24961-1 to 24961-17 prepared by Ken R. White Company, Denver, Colorado, dated February 1972.

e/ Source: B-5 Dam Outlet Modifications as-built drawings 51420-0021 to 51420-0030 prepared by Wright Water Engineers, Denver, Colorado dated February 1998.

f/ Source: Surface Water Control C-2 Dam as -built drawings 27165-201 to 27165-244 dated November 1980.

g/ Source: Sanitary Landfill Renovations original issue (Revision 0) drawings 27318-1 to 27318-6 dated September 1974.

2/0

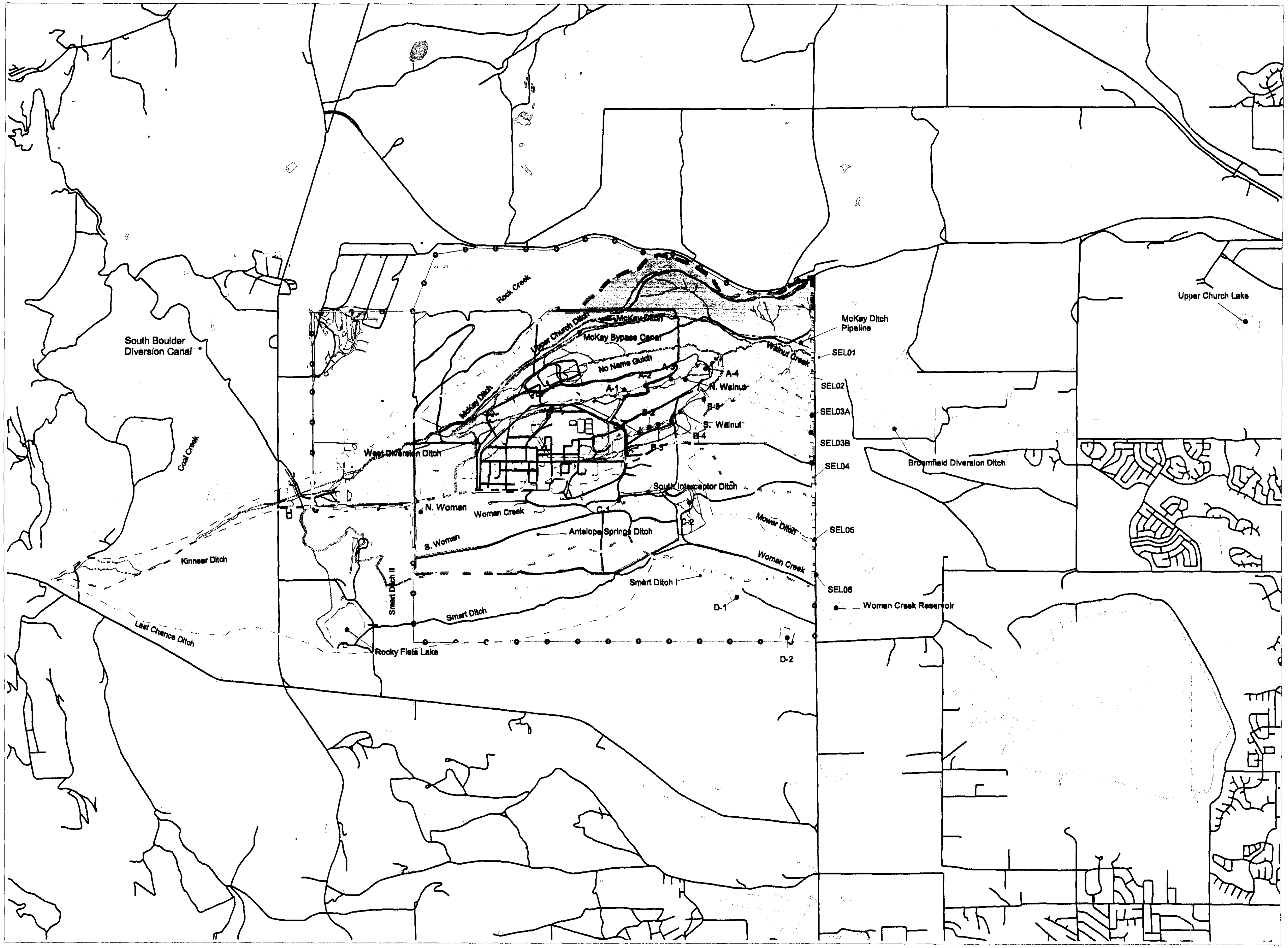

Figure B-02
LCDB Project Boundary and Drainage Features

Legend

- Lakes/Ponds/Solar Ponds
- Streams, ditches, or other drainage features
- Erosion Modeling Boundary
- Sub-Basin Drainage Boundary

Areas of Sub-basins (Acres)

Sub-basin	Acres
SEL01	2369
SEL02	21
SEL03A	58
SEL03B	117
SEL04	194
SEL05	175
SEL06	2870

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Drainage Basin data - Approved by Win Chromec (RMRS, 303-966-4535)

N

2000 0 2000 4000 Feet

1 : 48190
1" = 4098'

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

Prepared by:
PARSONS
Parsons, Inc.
1700 Broadway, Suite 900
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303-831-8100

Feg 5, 2002

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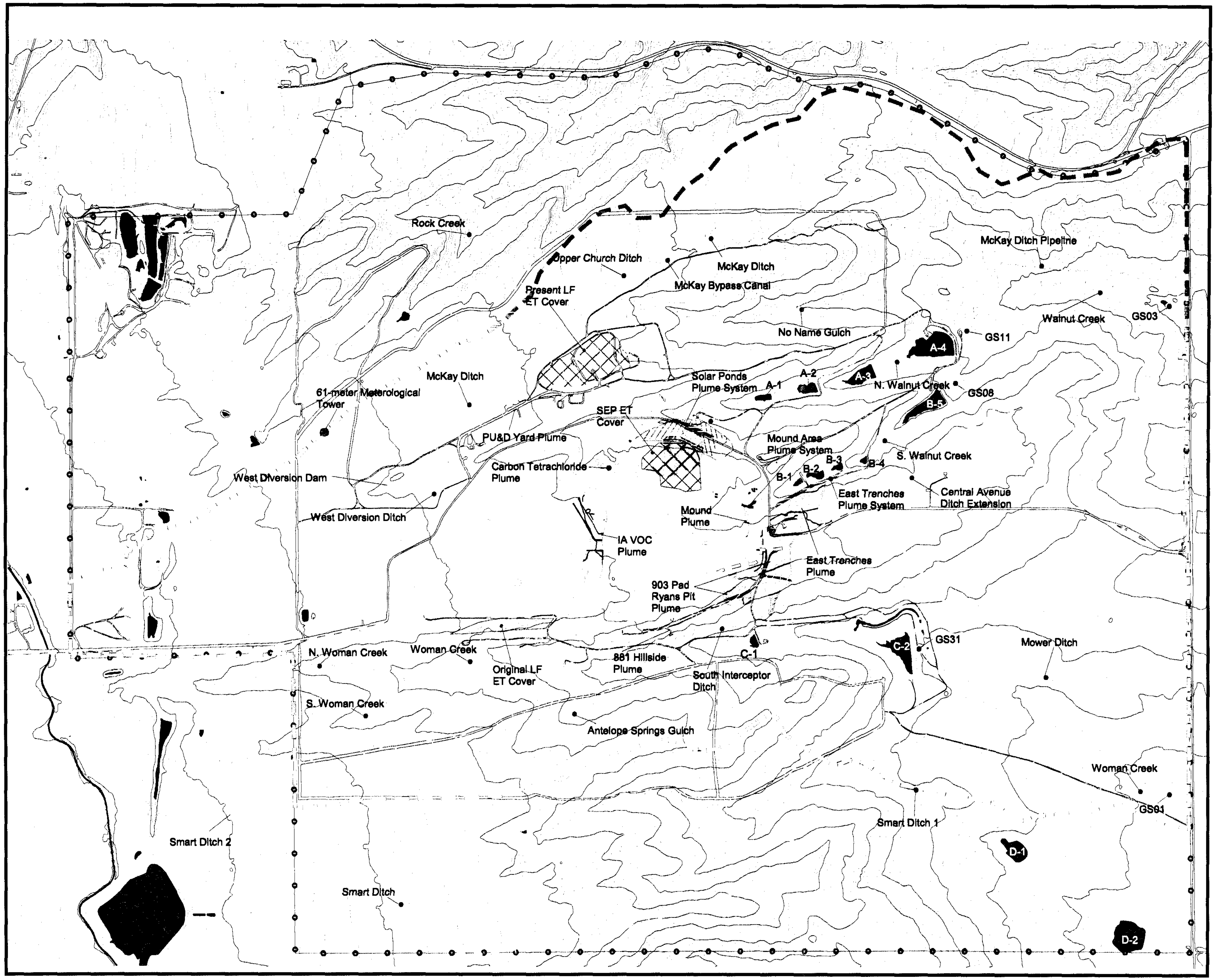

Figure B-03

Anticipated Conditions After Active Remediation

Legend

- Lakes/Ponds
- Groundwater Plume System
- Solar Pond ITS/French Drain
- Streams, ditches, or other drainage features
- Sub-Basin Drainage Boundary
- Groundwater Plume equal to or greater than Tier I
- Groundwater Plume equal to or greater than Tier II
- ET Cover
- Surface water monitoring Point of Compliance
- 10' Contour
- 50' Contour

Note: Tier I/II groundwater plumes do not include uranium plume.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source Kaiser-Hill

N

Scale

2000 0 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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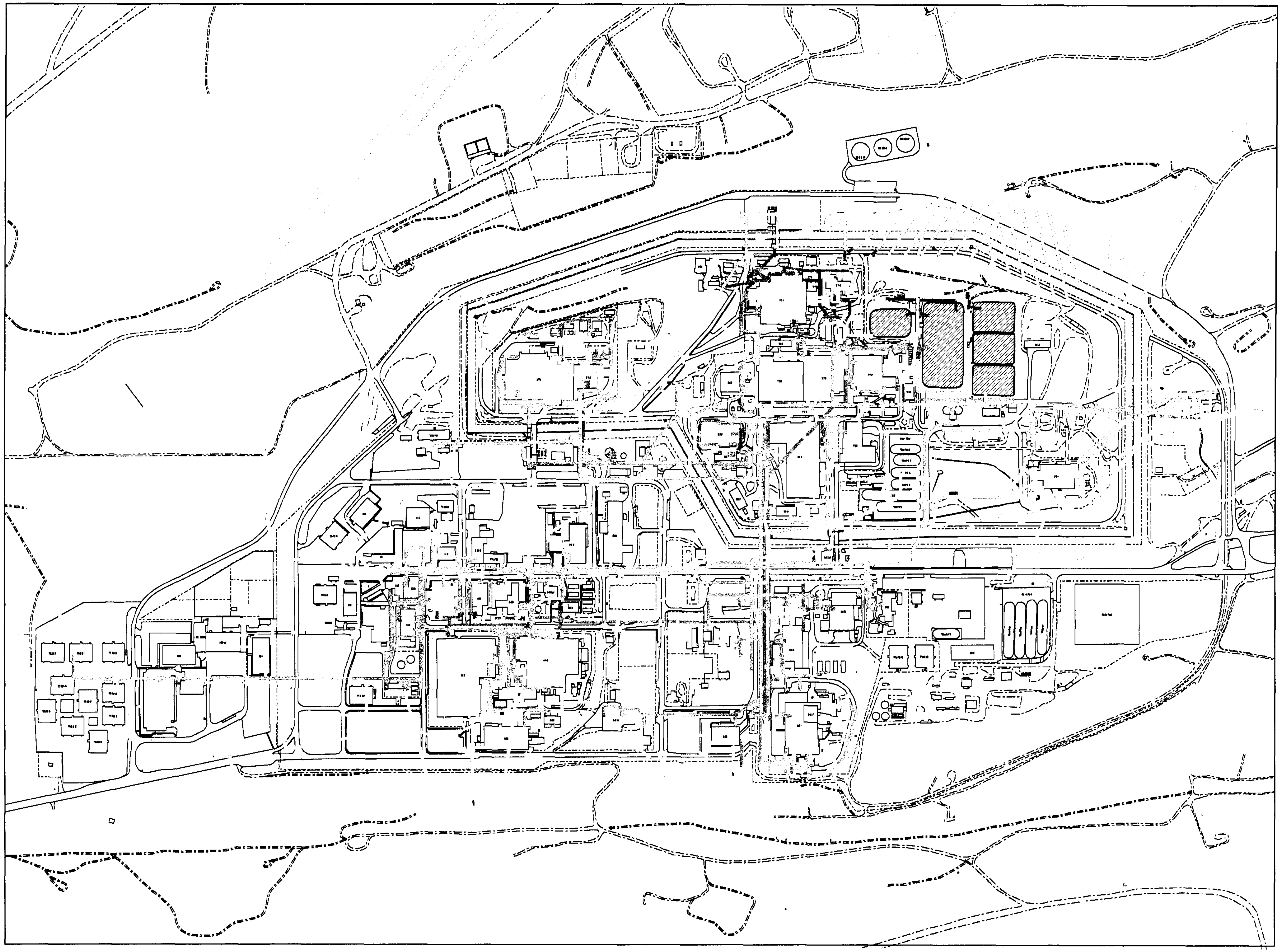
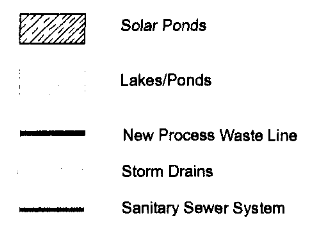


Figure B-04

Locations of Process Waste Lines, Sanitary Sewers and Storm Drains

Legend



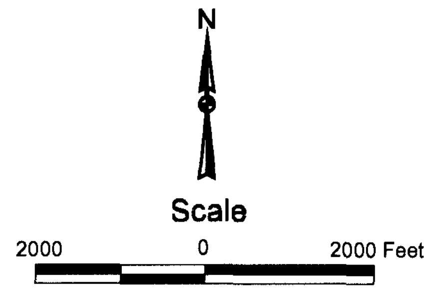
Data Source:

The utilities (above and underground) information was supplied by EG&G Facilities Department in DXF format, Aug 1993. The GIS department created ARC coverages (data layers from the DXF files and converted the data from Rocky Flats Coordinate system to State Plane Coordinate system.

Utility data as presented in the Industrial Characterization And Remediation Strategy (RMRS, 1999b, Figure 9).

Note: This data HAS NOT BEEN edited or coded with attribute information).

Buildings, fences, hydrology, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas Digitized from orthophotographs, 1/95



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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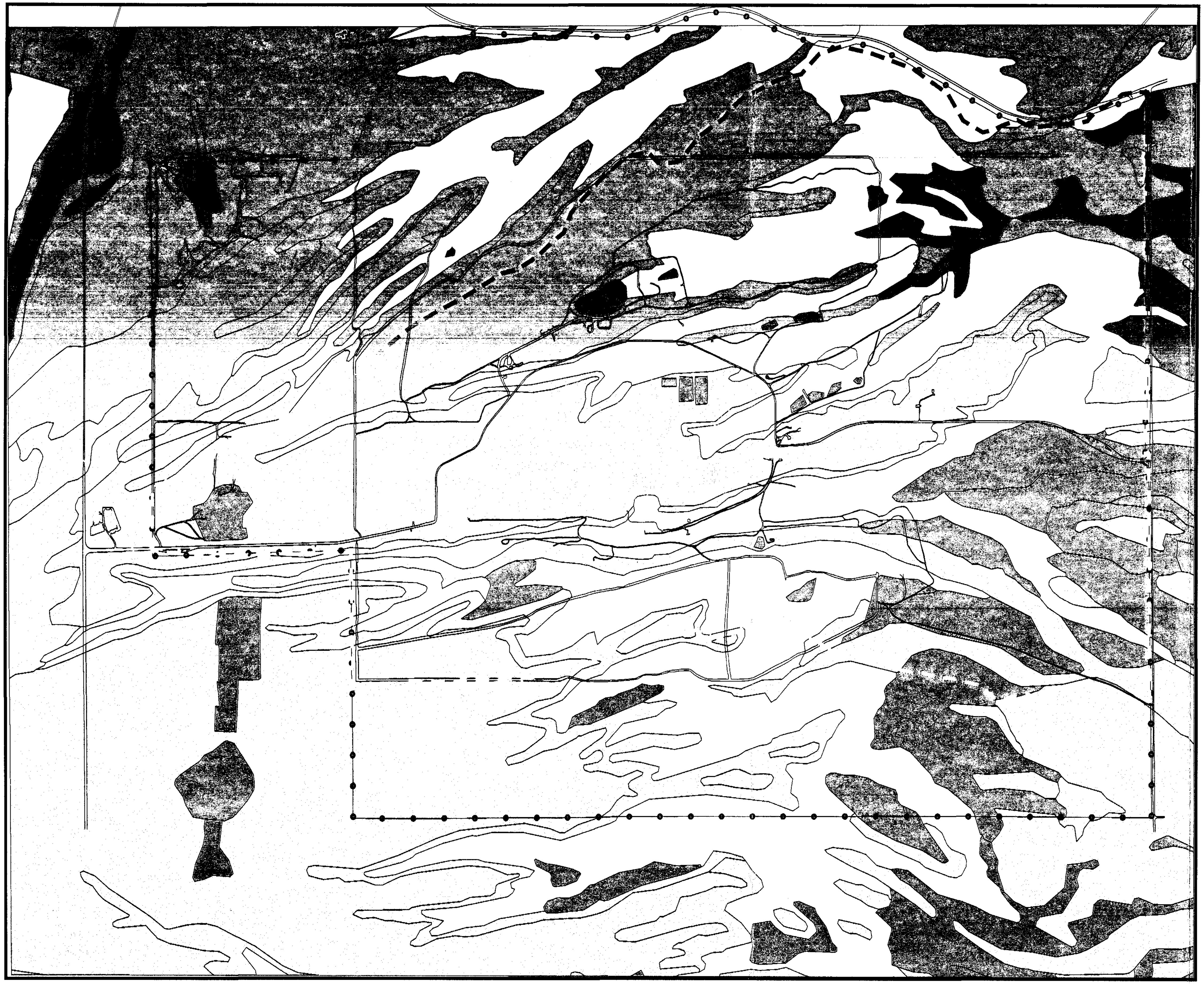

Figure B-05
Soil Infiltration Map
Legend

- High Infiltration
- Medium Infiltration
- Low Infiltration

Standard Map Features
- Building Outlines
- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source NRCS, SSURGO Digital soils

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Scale
2000 0 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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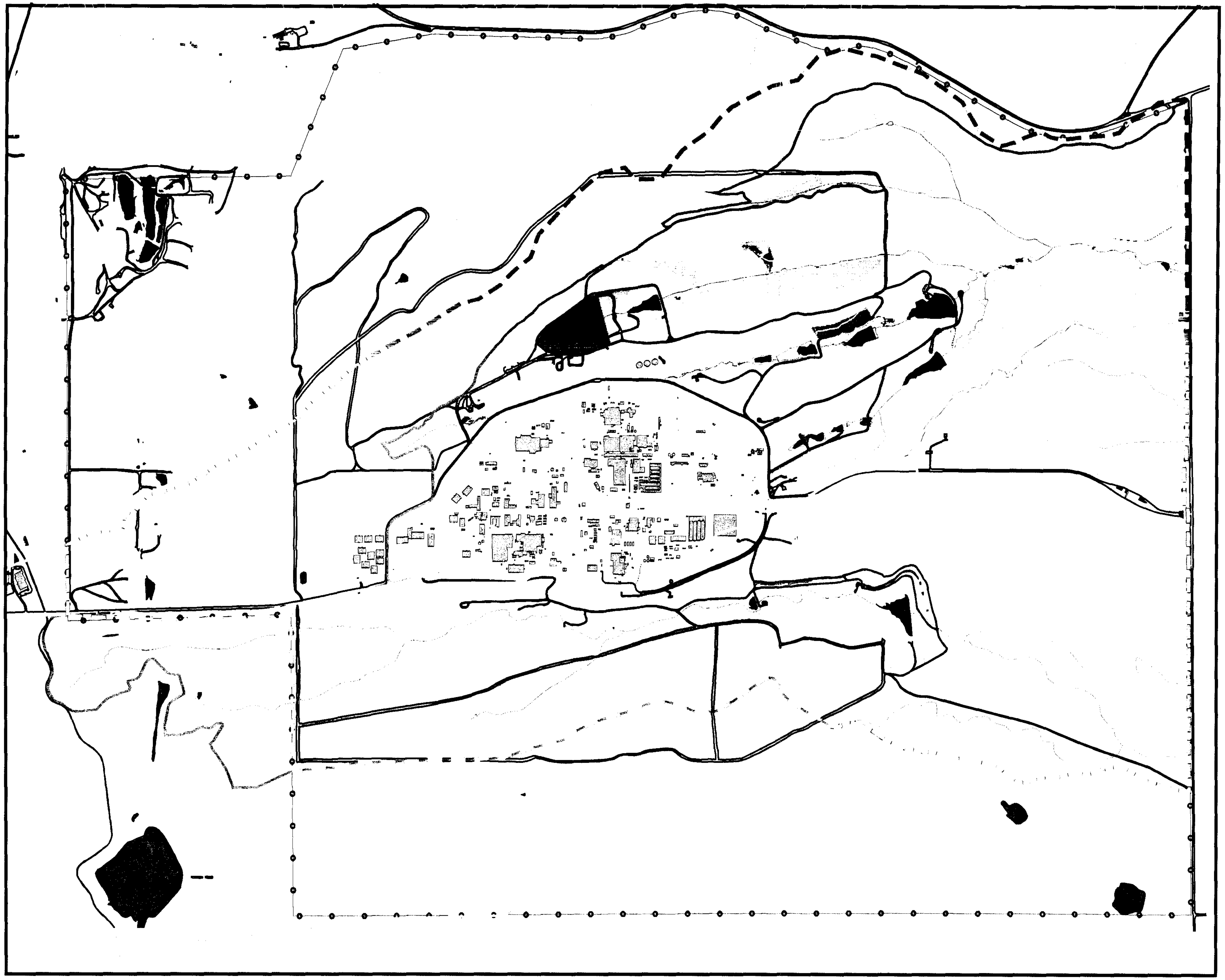

Figure B-06

Predicted 100-Year Average Erosion Map

Legend

- >0.400 Kg/m2 (0.737 Lbs/yd2) Deposition
- 0.200 Kg/m2 (0.369 Lbs/yd2) Deposition
- 0.020 Kg/m2 (0.037 Lbs/yd2) Deposition
- No Deposition or Detachment
- 0.010 Kg/m2 (0.018 Lbs/yd2) Detachment
- 0.025 Kg/m2 (0.046 Lbs/yd2) Detachment
- 0.050 Kg/m2 (0.092 Lbs/yd2) Detachment
- 0.100 Kg/m2 (0.184 Lbs/yd2) Detachment
- 0.150 Kg/m2 (0.276 Lbs/yd2) Detachment
- 0.200 Kg/m2 (0.369 Lbs/yd2) Detachment
- 0.250 Kg/m2 (0.461 Lbs/yd2) Detachment
- 0.300 Kg/m2 (0.553 Lbs/yd2) Detachment
- 0.350 Kg/m2 (0.645 Lbs/yd2) Detachment
- Buildings
- Lakes/Ponds
- Streams, ditches, or other drainage features
- 50' Contour
- Sub-Basin Drainage Boundary
- Erosion Modeling Boundary

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas Digitized from orthophotographs, 1/95 Erosion data from Report on Soil Erosion and Surface Water Sediment Transport Modeling for the Actinide Migration Evaluations at the Rocky Flats Environmental Technology Site (Kaiser-Hill, 2000a).

N

Scale

2000 0 2000 Feet

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Colorado Central Zone
Datum: NAD27

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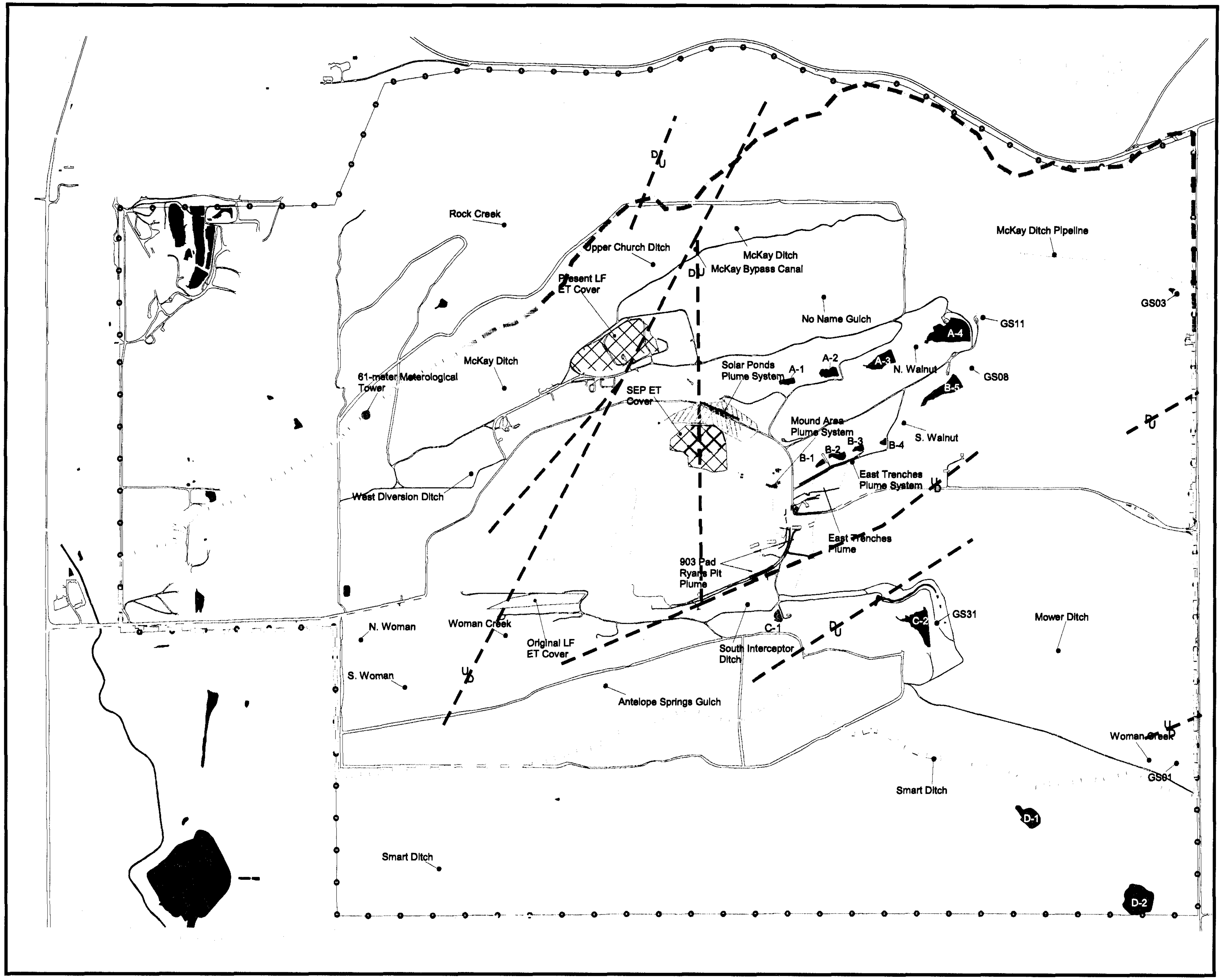
Figure B-08
Inferred Fault Locations



Legend

- Inferred Fault
- U/D Fault Direction
- Lakes/Ponds
- Groundwater Plume System
- Solar Pond ITS/French Drain
- Streams, ditches, or other drainage features
- Sub-Basin Drainage Boundary
- Groundwater Plume equal to or greater than Tier I
- Groundwater Plume equal to or greater than Tier II
- ET Cover
- Surface water monitoring Point of Compliance

Note: Tier I/II groundwater plumes do not include uranium plume.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Inferred fault data from site-wide Geologic Characterization Report (EG&G 1995a)

N

Scale

2000 0 2000 Feet

State Plane Coordinate Projection
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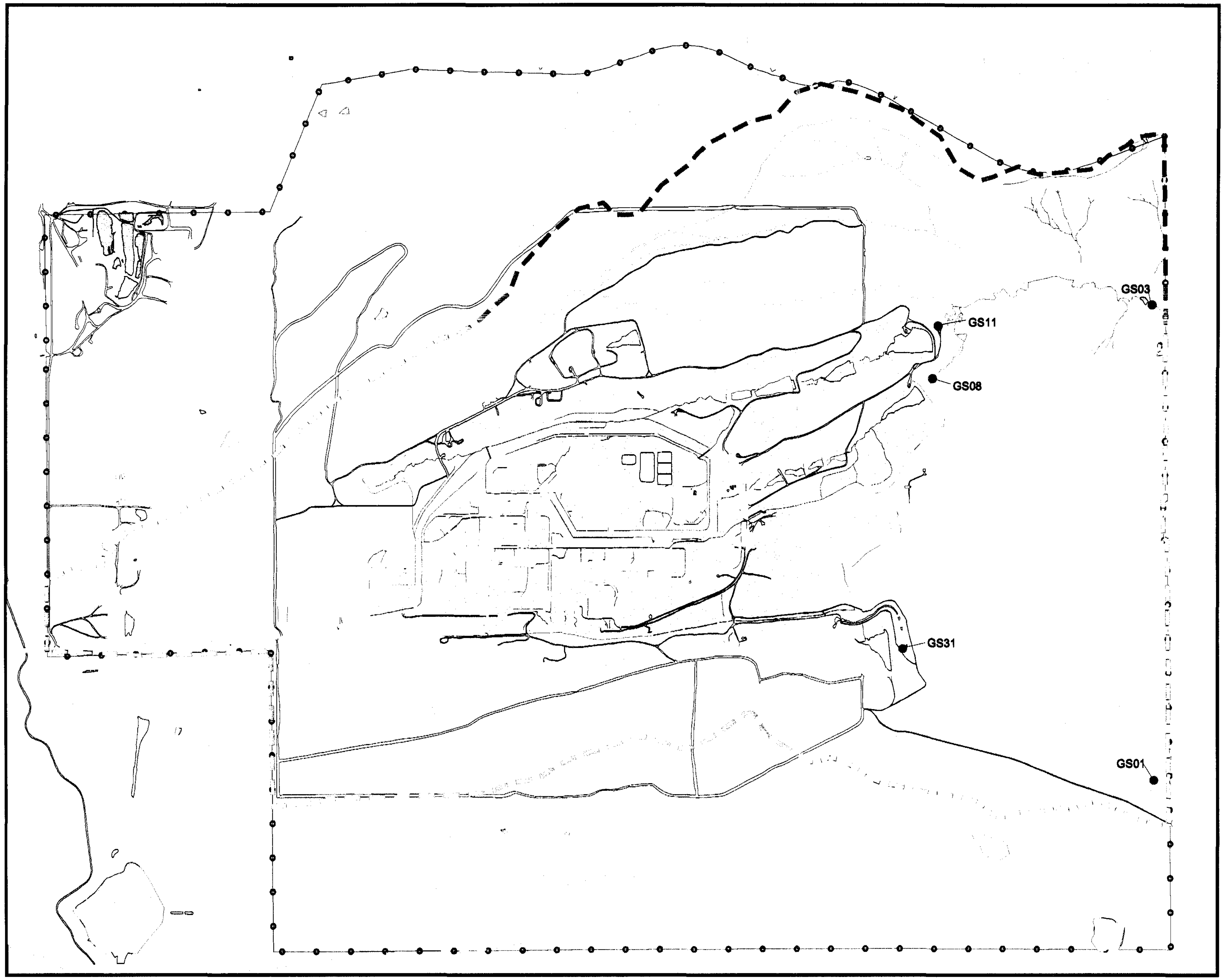

Figure B-9

Location of Surface Water Use Classifications

Legend

Segment 4a
Segment 4b
Segment 5
Lakes/Ponds/Solar Ponds
Streams, ditches, or other drainage features
Sub-Basin Drainage Boundary

Standard Map Features

Road
RFETS Boundary
Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95

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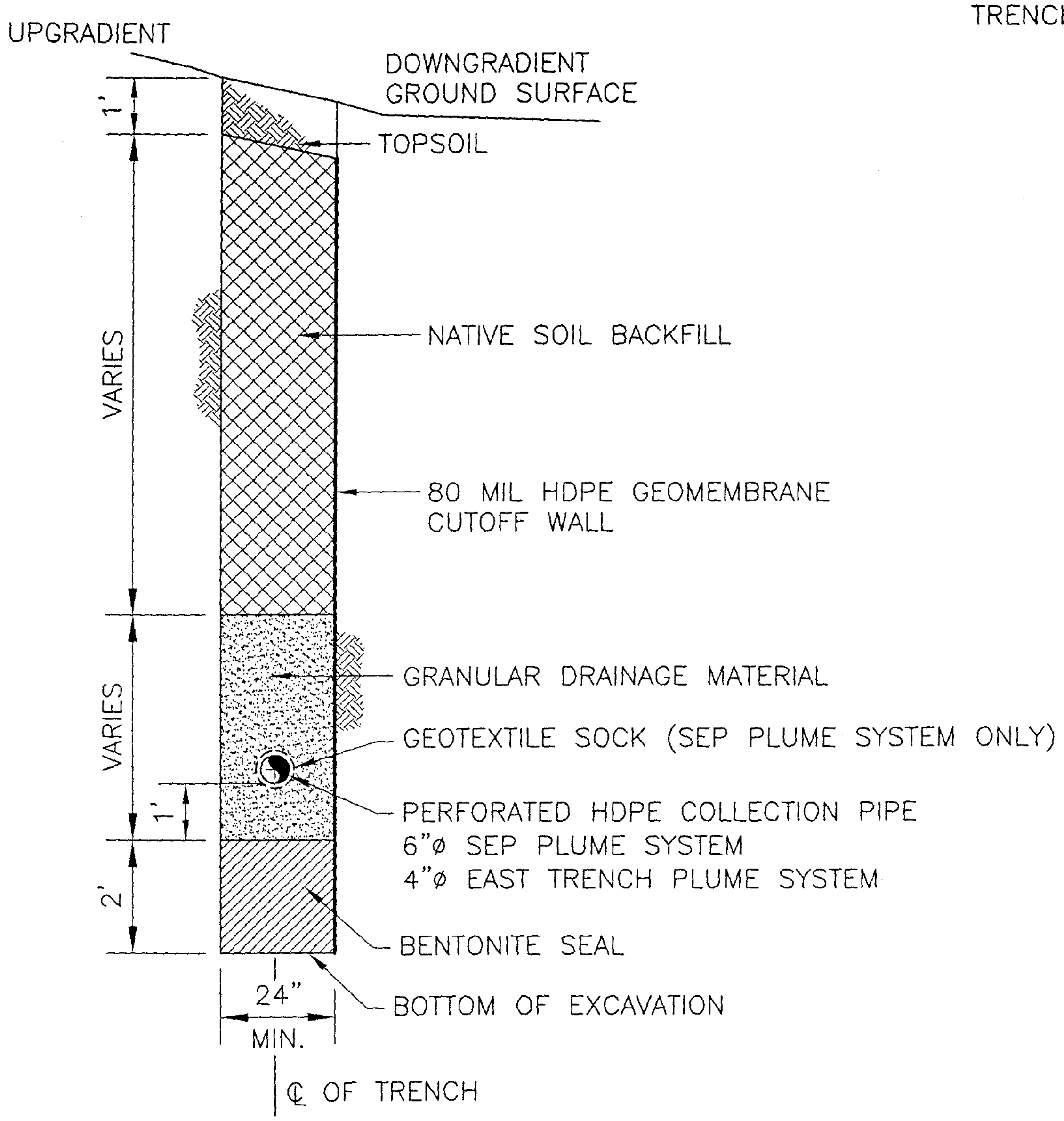
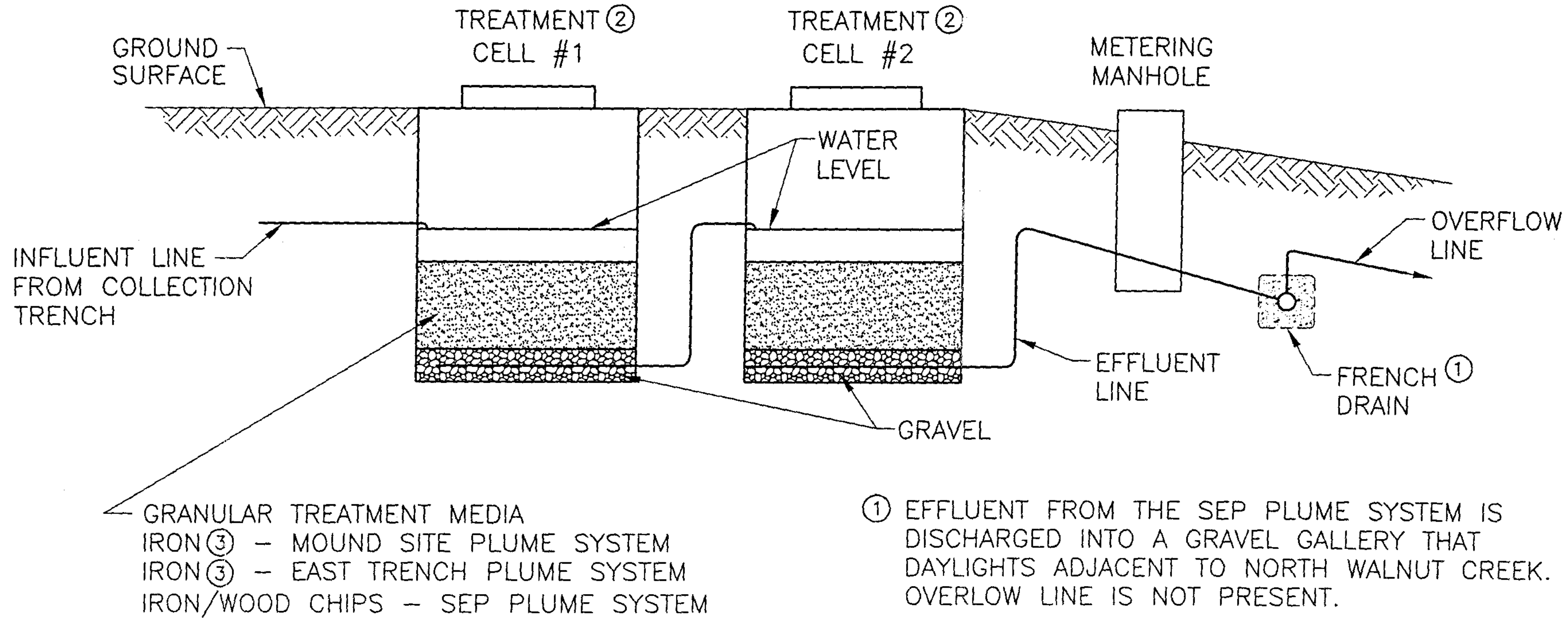


TYPICAL GROUNDWATER COLLECTION TRENCH CROSS SECTION

N.T.S.



① EFFLUENT FROM THE SEP PLUME SYSTEM IS DISCHARGED INTO A GRAVEL GALLERY THAT DAYLIGHTS ADJACENT TO NORTH WALNUT CREEK. OVERLOW LINE IS NOT PRESENT.

② TREATMENT CELL #1 AND #2 ARE CONTAINED WITHIN A SINGLE CHAMBER FOR THE SEP PLUME SYSTEM.

③ UPPER ONE FOOT OF TREATMENT MEDIA IS A MIXTURE OF IRON AND GRAVEL.

TREATMENT CELL

N.T.S.

FIGURE B-11

Schematic Design Details for Groundwater Plume Systems

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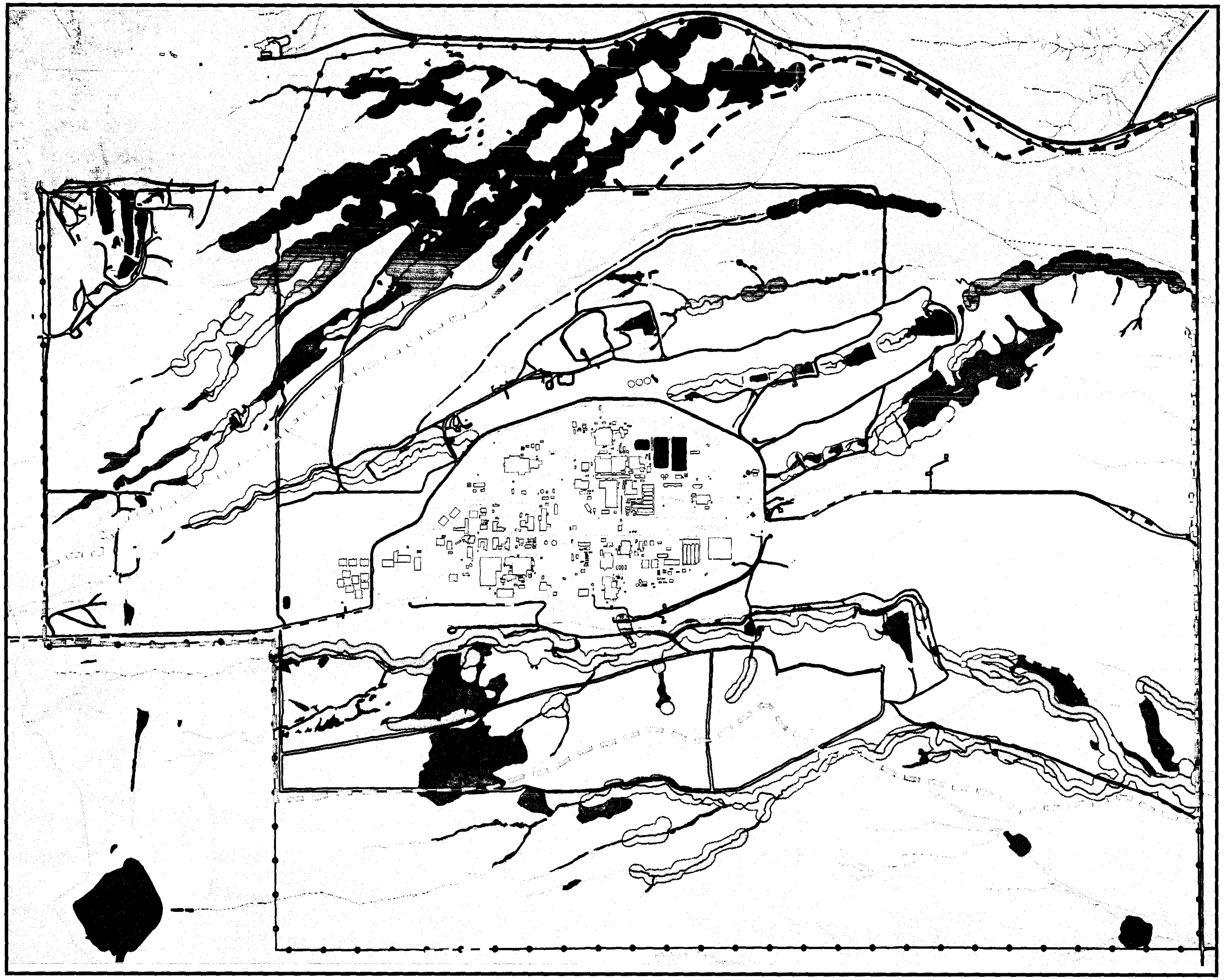

Figure B-12

Preble's Meadow Jumping Mouse Habitat

Legend

- Protection Area
- Contiguous Wetland
- Lakes/Ponds/Solar Ponds
- Streams, ditches, or other drainage features
- Sub-Basin Drainage Boundary

Definition of Protection Areas and Contiguous Wetlands are based on the requirements of the Preble's Meadow Jumping Mouse Protection Plan (DOE, 2000f). Designated Protection Areas and Contiguous Wetlands are subject to change. See Kaiser-Hill Ecology Group for latest map.

Note: Contiguous wetlands are not jurisdictional wetlands. See Figure B-13 for location and listing of wetlands.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Habitat Maps from 1999 Annual Wildlife Report (Kaiser-Hill, August 2000) and Preble's Meadow Jumping Mouse Protection Plan (DOE, 2000f).

N

Scale
2000 0 2000 Feet

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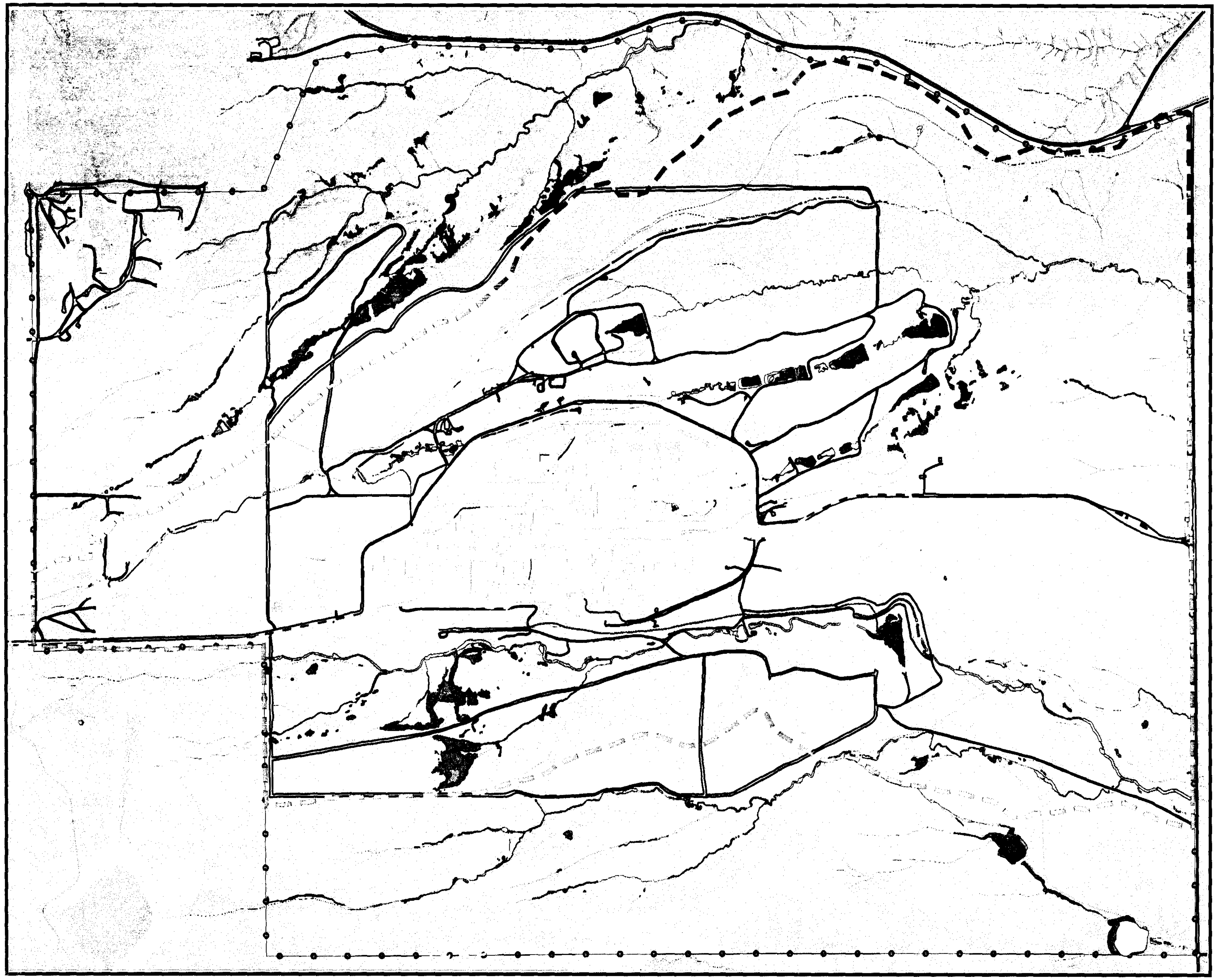

Figure B-13
Wetland Location Map
Based on 1994 Delineations

Legend

Wetland Types

- L1UBH
- PABH
- PEMA
- PEMB
- PEMC
- PEMF
- PFOA
- PFOC
- PSSA
- PSSC
- PUBF
- PUBH
- PUSC
- R4SBC
- R4SBG
- R4SBJ
- Streams, ditches, or other drainage features
- Palustrine
- Sub_Basin Drainage Boundary

Wetlands shown on this map may not be jurisdictional pending resoultion with EPA. See Kaiser-Hill Ecology Group for latest map.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures form 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Wetland data summerized, compiled, and compiled by the U.S. Army Corps of Engineers, 1994.
Source Kaiser-Hill

N

Scale

2000 0 2000 Feet

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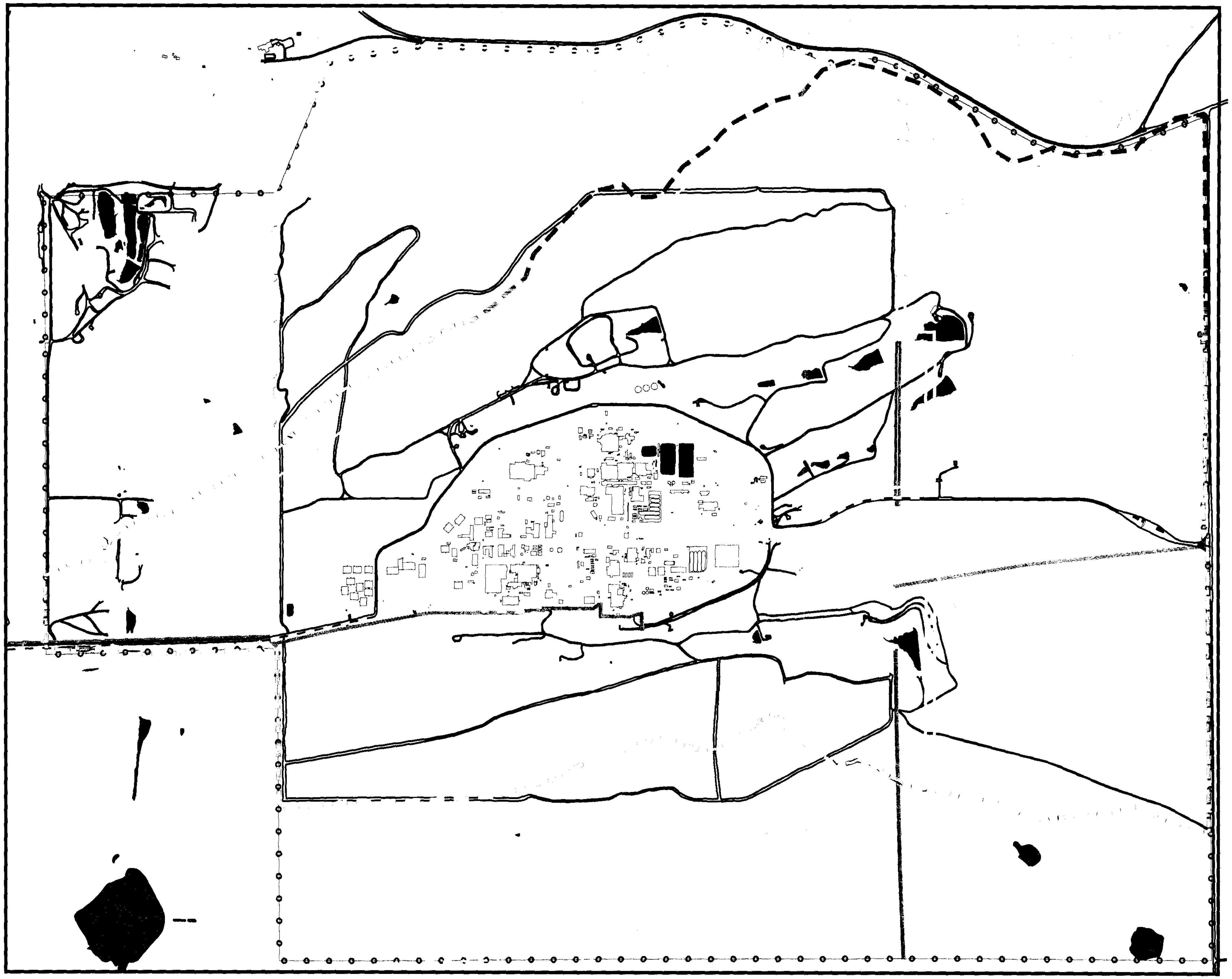

Figure B-14

Utility and Easement Location Map

Legend

- Gas Utility Easement
- Electirc Utility Easement
- Unknown Easement
- Lake/Ponds/Solar Ponds
- Streams, ditches, or other drainage features
- Sub-Basin Boundary

Note: All easements not shown. See Appendix B, Section 2.8.2.4 for complete listing of easements.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source Kaiser-Hill

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Scale

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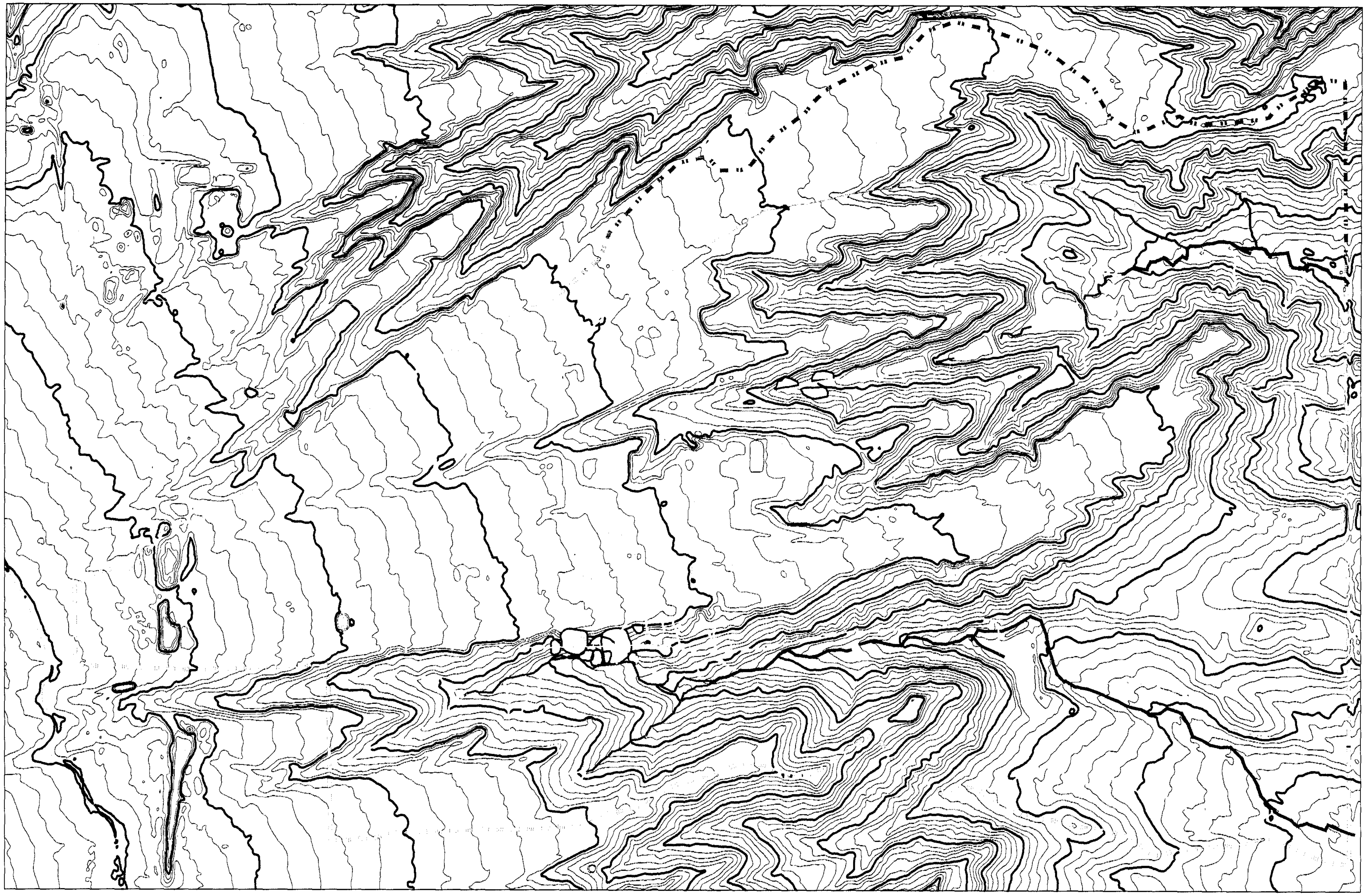

Figure G-2

Location Map of Geomorphic Features

Legend

Geomorphic Features	Geomorphic Features
Earth flow	1st Order Stream
Older slide	2nd Order Stream
Overlap	3rd Order Stream
Possible earthflow	4th Order Stream
Multiple slides	Canal/ditch
Slide	Erosion rill
Slump	Runoff/gully

Standard Map Features

Land Configuration Design Basis Project Boundary

10' Contour

50' Contour

Data Source:

Buildings, fences, hydrography, roads and other structures form 1994 aerial fly-over data captured by EG&G RSI, Las Vegas.

Digitized from orthophotographs, 1/95

Scale

0.5 0 Miles

1 : 22000

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Composite View

Image 1

Image 2

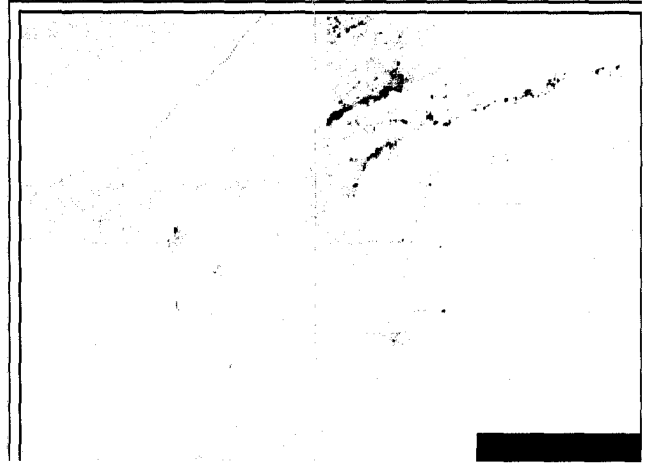

Image 3

FIGURE G-3
Principal Component Analysis Product

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December 07, 2001

Drawing Name: Tab 2, App G.2, Fig 4-3, PCA.tif

310

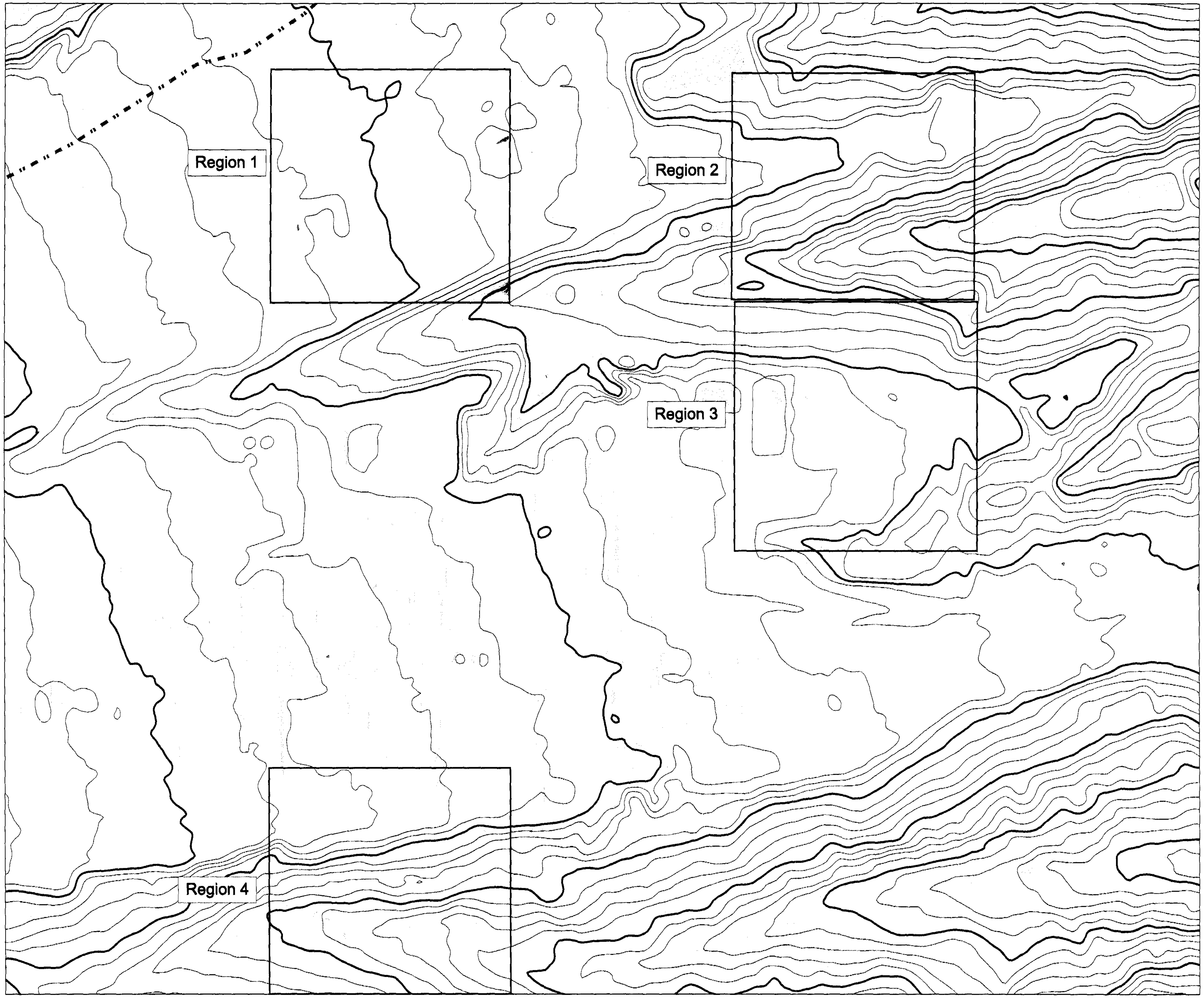

Figure G-4

Elevation Changes for Selected Areas 1951 - 1994

Elevation Decrease (ft) — Elevation Increase (ft)

30 15 0 15 30

Standard Map Features

1994 Contour Intervals

- 2' Contour
- 10' Contour
- 50' Contour
- Land Configuration Design Basis Project Boundary

Data Source:

1994 aerial fly-over data captured by EG&G RSI, Las Vegas. Digitized from orthophotographs, 1/95

1951 Topographic contours from pre-construction surveys by The Austin Company.

Scale

1000 0 1000 Feet

1 : 8000

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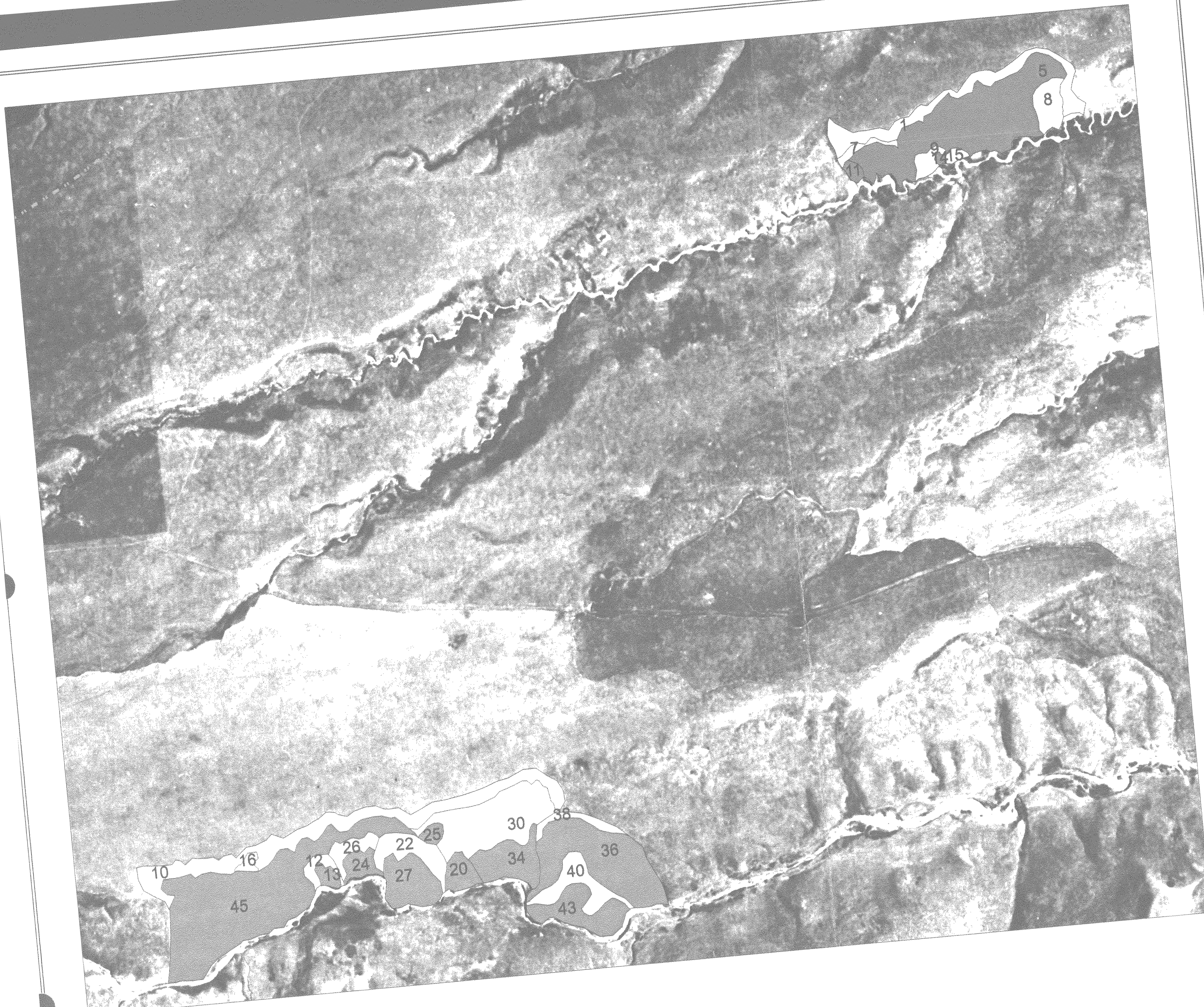


Figure G-7

1937 Mass Movement Delineation

Legend

Head

Scar

Toe

Standard Map Features

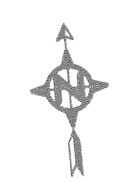
Land Configuration Design Basis Project Boundary

Data Source:

1937 aerial fly-over data

captured by American Reprographics

Digitized from photographs, 7/01



Scale

1000 0 1000 Feet

1 : 8000

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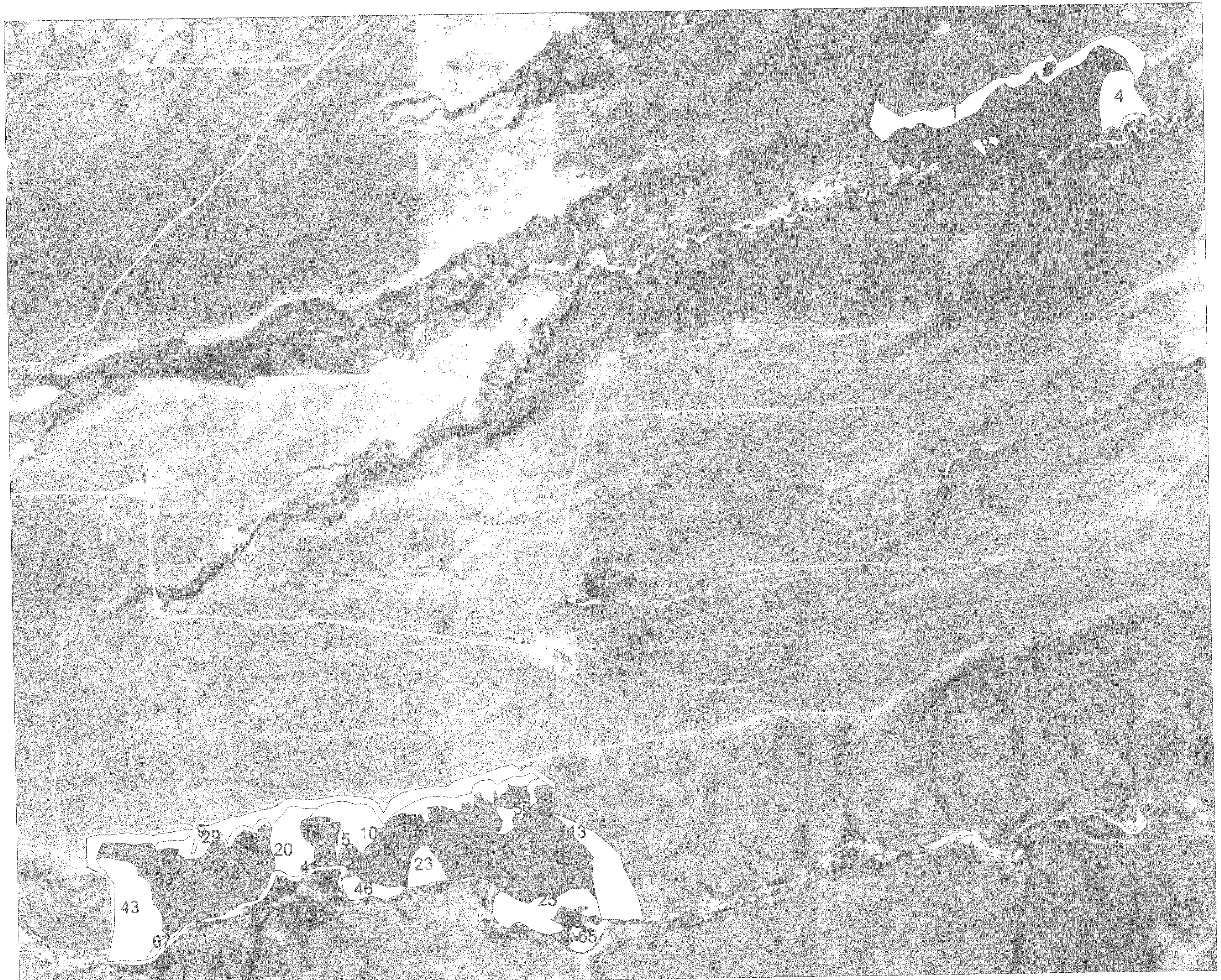

Figure G-8

1951 Mass Movement Delineation

Legend

Head

Scar

Toe

Standard Map Features

Land Configuration Design Basis Project Boundary

Data Source:

1951 aerial fly-over data

captured by American Reprographics.

Digitized from photographs, 6/01

Scale

1000 0 1000 Feet

1 : 8000

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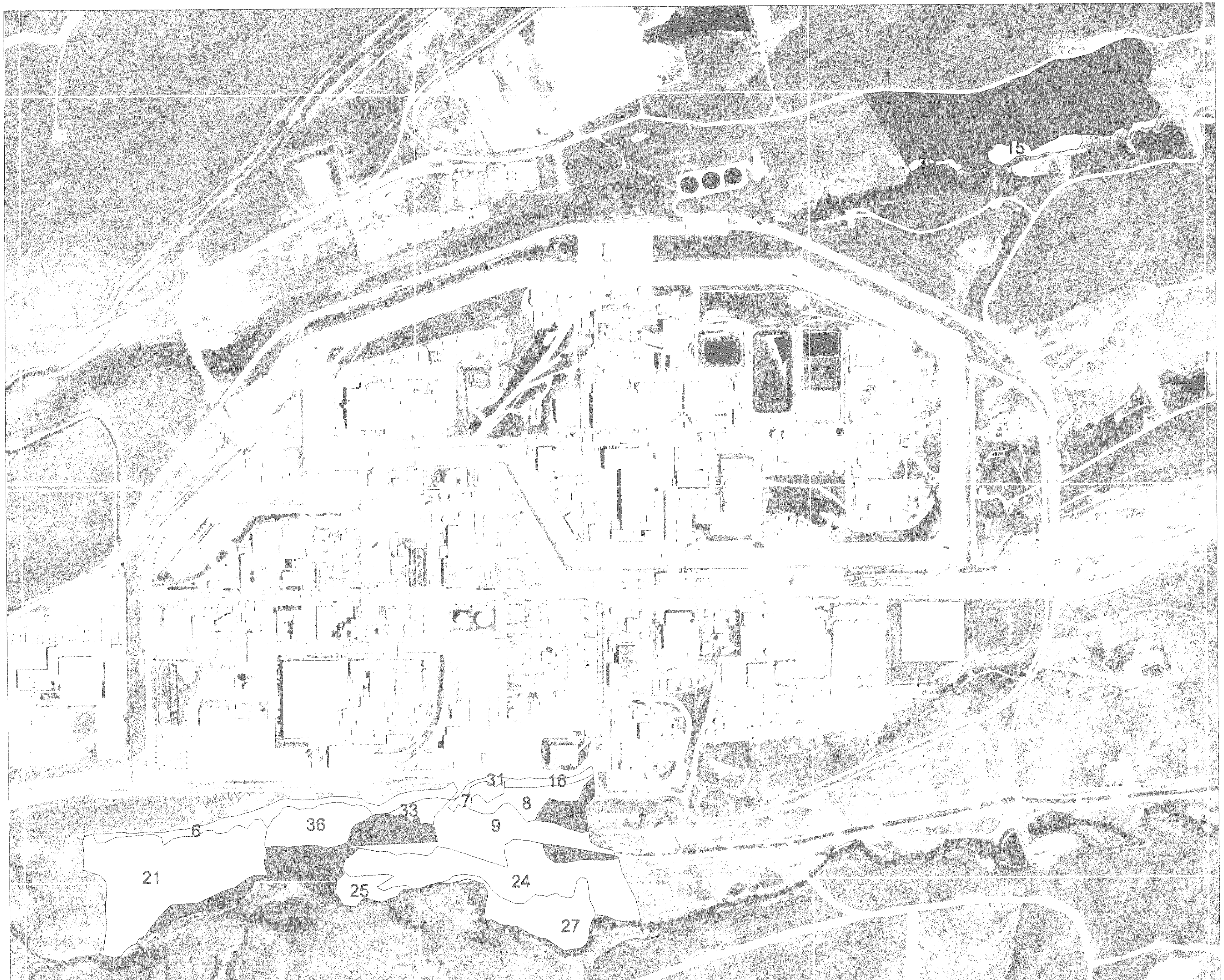


Figure G-9

1994 Mass Movement Delineation

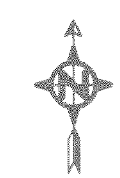
Legend

Head
Scar
Toe
Altered Area

Standard Map Features

Land Configuration Design Basis Project Boundary

Data Source:
1994 aerial fly-over data
captured by EG&G RSI, Las Vegas.
Digitized from orthophotographs, 1/95



Scale

1000 0 1000 Feet

1 : 8000

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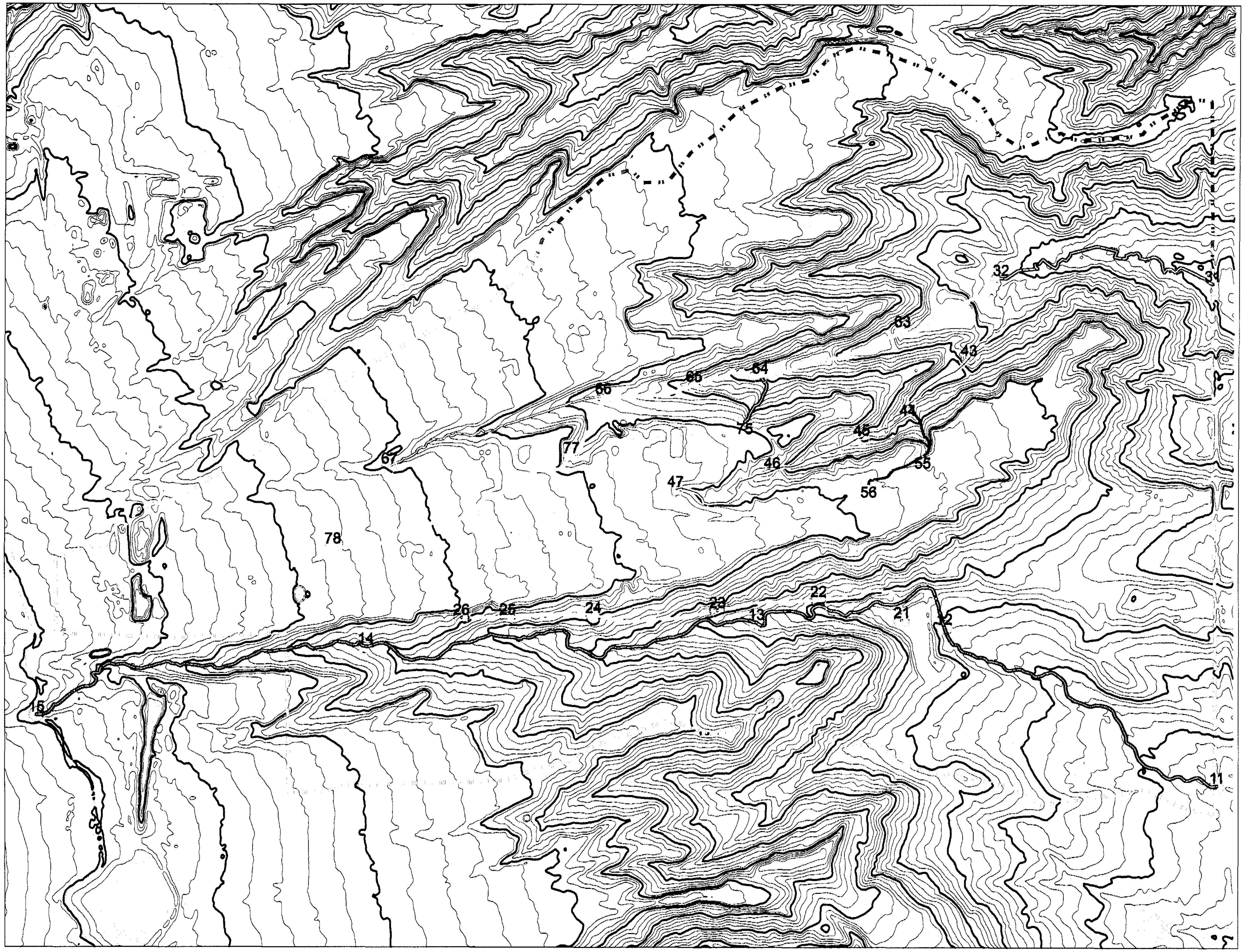

Figure G-12

Stream Channel Profile Location Map

Legend

- ⊙ Reach Terminous Points
- 15 Reach Label
- Woman Creek
- Walnut Creek
- North Walnut Creek
- North Walnut Gully
- North Walnut IA Tributary
- South Walnut Creek
- South Walnut Gully
- South Interceptor Ditch

Standard Map Features

- 2' Contour
- 10' Contour
- 50' Contour
- Land Configuration Design Basis Project Boundary

Data Source:

Buildings, fences, hydrography, roads and other structures form 1994 aerial fly-over data captured by EG&G RSI, Las Vegas.

Digitized from orthophotographs, 1/95

Scale

2000 0 2000 Feet

1 : 22000

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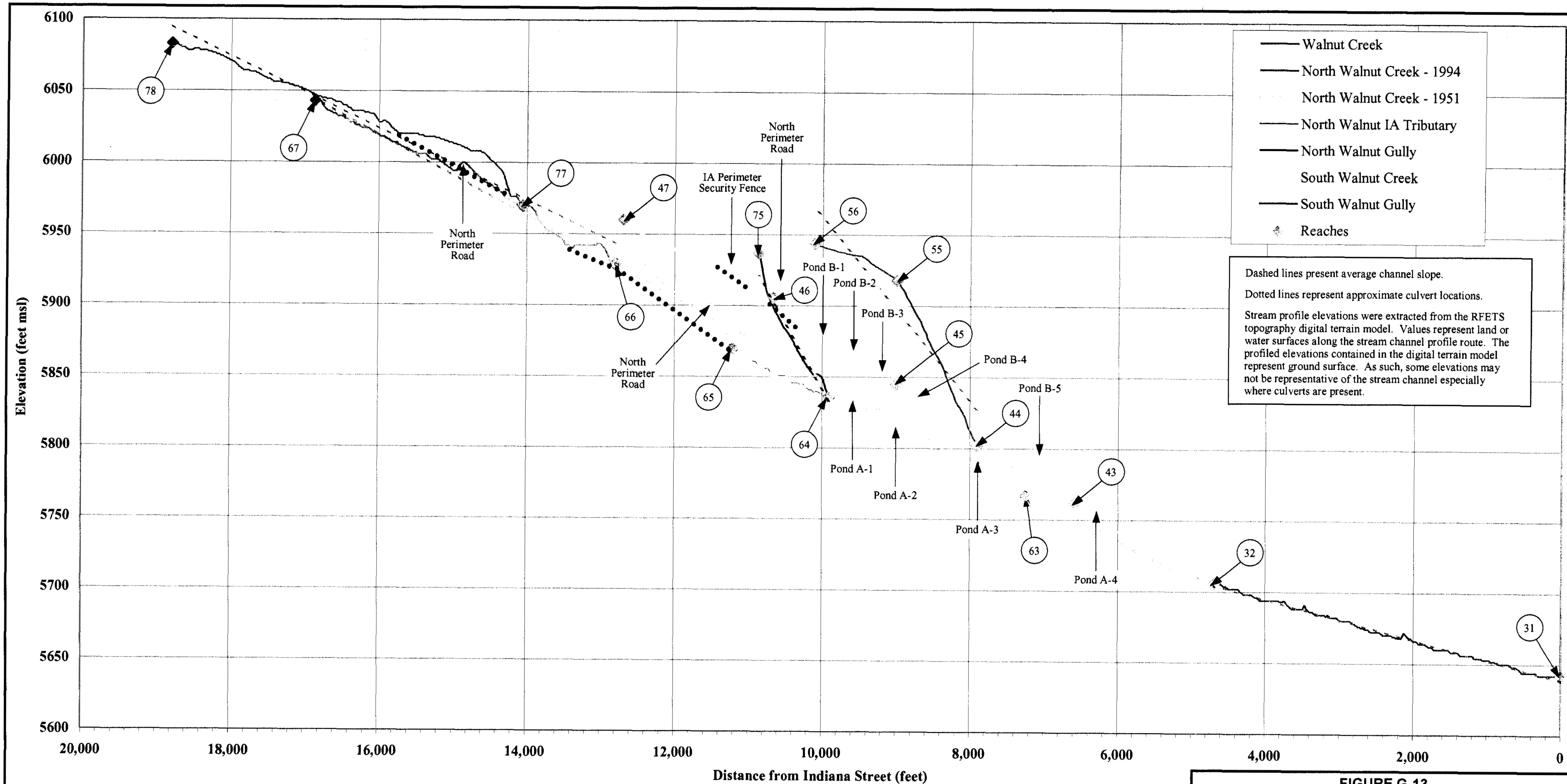

Walnut Creek

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 31 to 32	64	4679	1.4%
Average	**64**	**4679**	**1.4%**

North Walnut Creek

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 32 to 63	60	2563	2.4%
Reach 63 to 64	70	2668	2.6%
Reach 64 to 65	34	1301	2.6%
Reach 65 to 66	58	1590	3.7%
Reach 66 to 67	114	4063	2.8%
Average	**337**	**12186**	**2.8%**

North Walnut IA Tributary

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 66 to 77	41	1248	3.3%
Reach 77 to 78	113	4745	2.4%
Average	**154**	**5993**	**2.6%**

North Walnut Gully

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 64 to 75	101	952	10.6%
Average	**101**	**952**	**10.6%**

South Walnut Creek

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 32 to 43	56	1903	2.9%
Reach 43 to 44	40	1324	3.0%
Reach 44 to 45	43	1096	3.9%
Reach 45 to 46	61	1653	3.7%
Reach 46 to 47	54	2035	2.6%
Average	**254**	**8011**	**3.2%**

South Walnut Gully

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 44 to 55	115	1084	10.6%
Reach 55 to 56	26	1107	2.4%
Average	**142**	**2190**	**6.5%**

FIGURE G-13

Walnut Creek Stream Channel Profiles

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Rocky Flats Environmental Technology Site
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February 19, 2002

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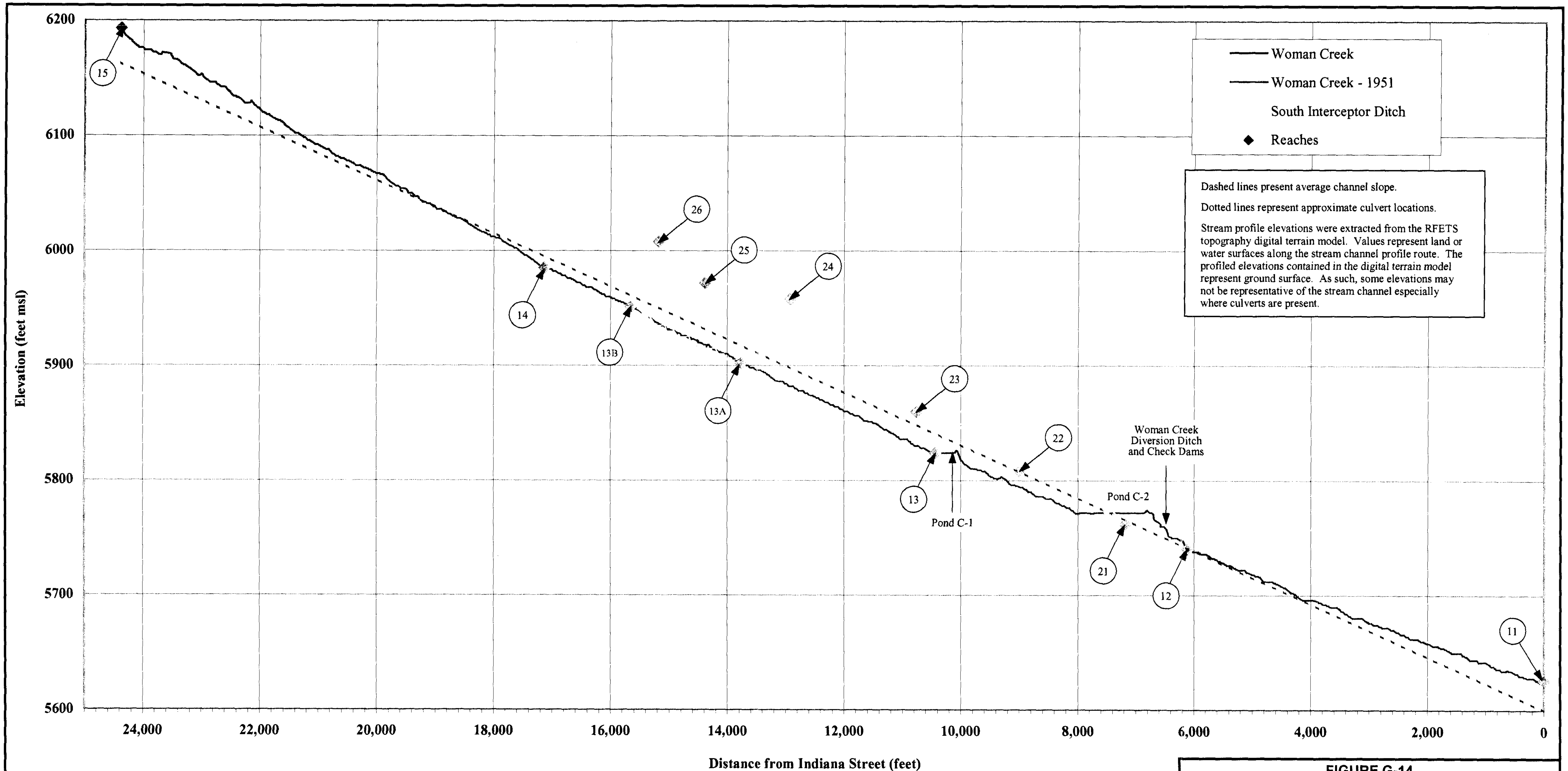

Woman Creek

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 11 to 12	115	6114	1.9%
Reach 12 to 13	83	4327	1.9%
Reach 13 to 14	161	6699	2.4%
Reach 14 to 15	208	7241	2.9%
Average	567	24381	2.3%

South Interceptor Ditch

Segment	Vert Rise (feet)	Horz Run (feet)	Slope
Reach 21 to 22	46	1809	2.5%
Reach 22 to 23	53	1766	3.0%
Reach 23 to 24	98	2157	4.5%
Reach 24 to 25	14	1473	0.9%
Reach 25 to 26	36	793	4.5%
Average	246	7999	3.1%

FIGURE G-14

Woman Creek and SID Stream Channel Profiles

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis Project

Prepared By: **Parsons Infrastructure and Technology Group, Inc.**
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PARSONS

February 19, 2002

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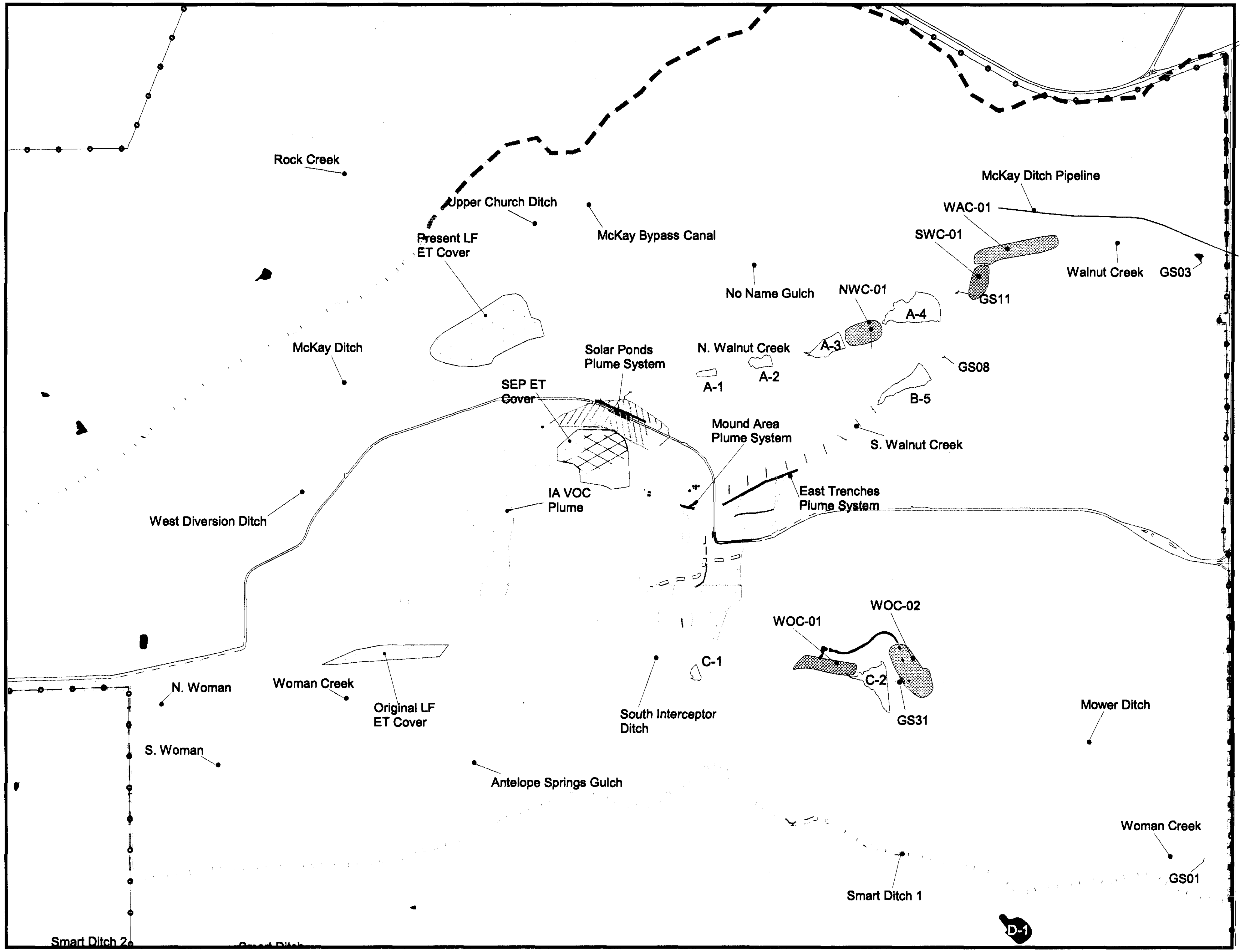

Figure A-01

Scenario 1
Flow-Through Detention Ponds and Wetlands
Legend

- Lakes/Ponds
- Groundwater Plume System
- Solar Pond ITS/French Drain
- Streams, ditches, or other drainage features
- Sub-Basin Drainage Boundary
- Groundwater Plume equal to or greater than Tier I
- Groundwater Plume equal to or greater than Tier II
- ET Cover
- Surface water monitoring Point of Compliance
- New/Enlarged Wetland
- Wetland Pond/Marsh System
- Passive Flow-Through Detention Ponds
- Check Dam

Note: IA Vegetated area not shown for clarity. Tier I/II groundwater plumes do not include uranium plume.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source NRCS, SSURGO Digital soils

N

Scale

2000 0 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Land Configuration Design Basis

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Feb 5, 2002

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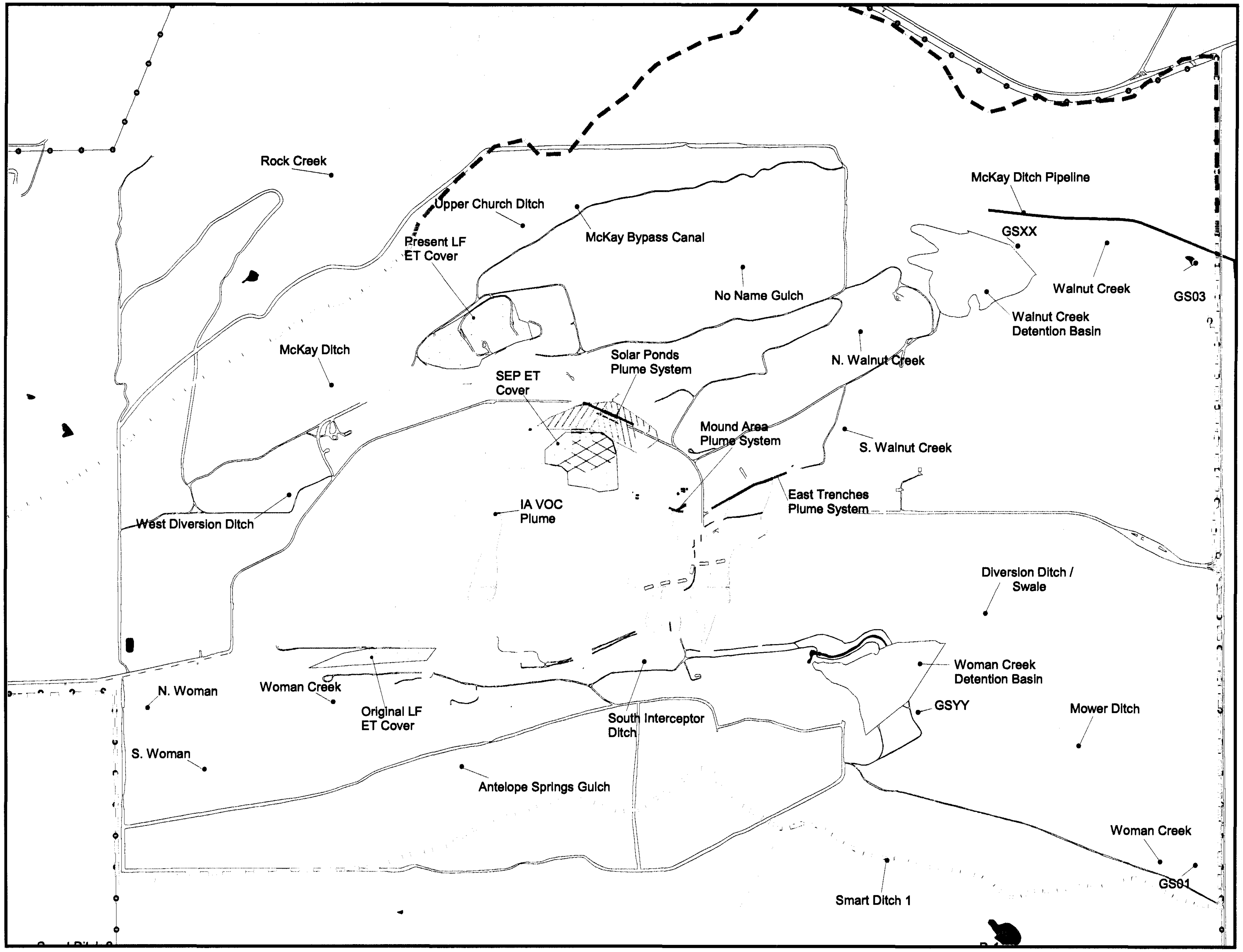

Figure A-05

Scenario 2
Batch Release Detention Basins

Legend

- Lakes/Ponds
- Groundwater Plume System
- Solar Pond ITS/French Drain
- Streams, ditches, or other drainage features
- Sub-Basin Drainage Boundary
- Groundwater Plume equal to or greater than Tier I
- Groundwater Plume equal to or greater than Tier II
- ET Cover
- Surface water monitoring Point of Compliance
- Detention Basin

Note: IA Vegetated area not shown for clarity. Tier I/II groundwater plumes do not include uranium plume.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source NRCS, SSURGO Digital soils

N

Scale

2000 0 2000 Feet

State Plane Coordinate Projection
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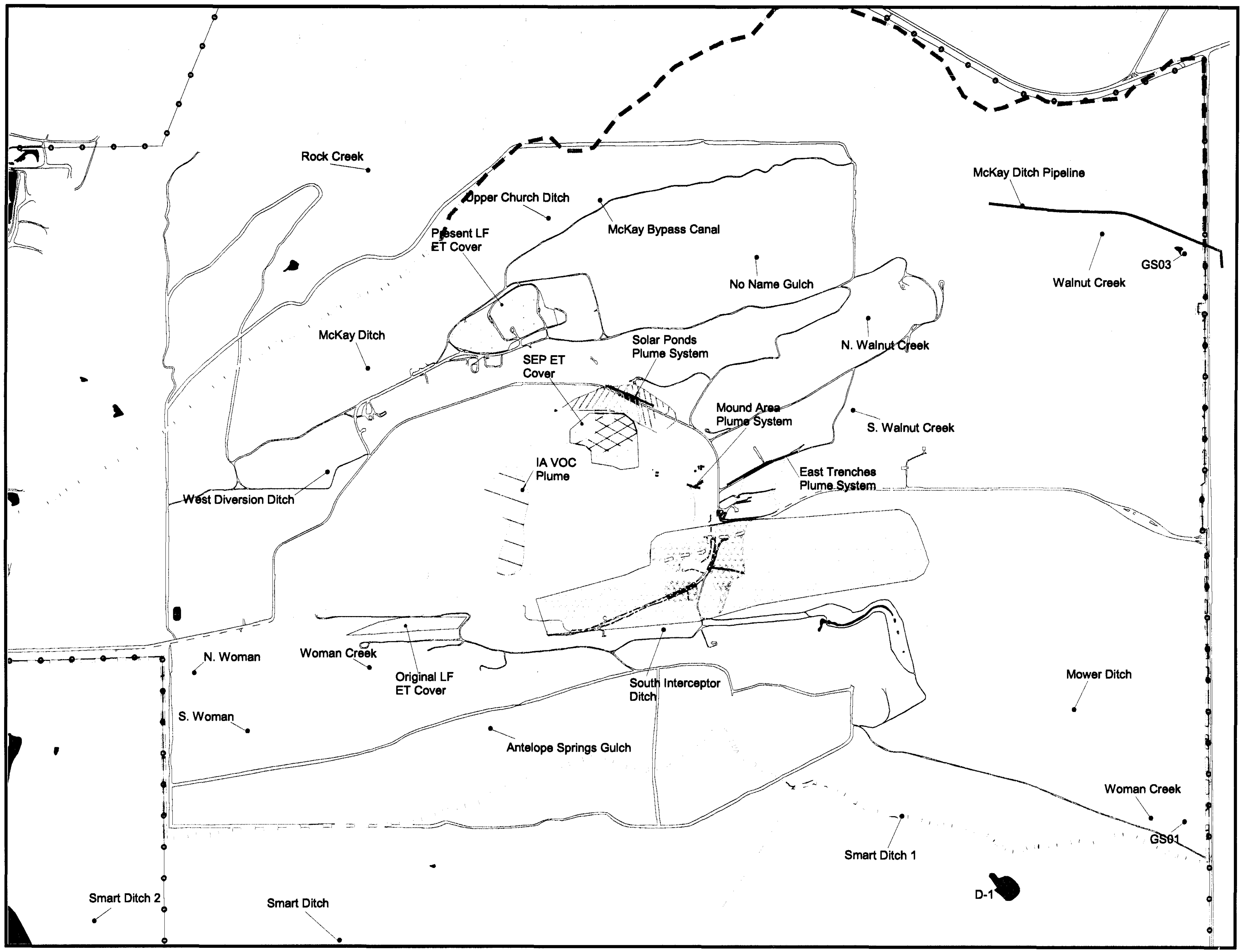

Figure A-09

Scenario 3
Source Isolation
Legend

- Lakes/Ponds
- Groundwater Plume System
- Solar Pond ITS/French Drain
- Streams, ditches, or other drainage features
- Sub-Basin Drainage Boundary
- Groundwater Plume equal to or greater than Tier I
- Groundwater Plume equal to or greater than Tier II
- ET Cover
- Surface water monitoring Point of Compliance
- Graded and Revegetated Area
- Diversion Ditch
- Positive Drainage & ET Provisions

Note: IA Vegetated area not shown for clarity. Tier I/II groundwater plumes do not include uranium plume.

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source NRCS, SSURGO Digital soils

N

Scale
2000 0 2000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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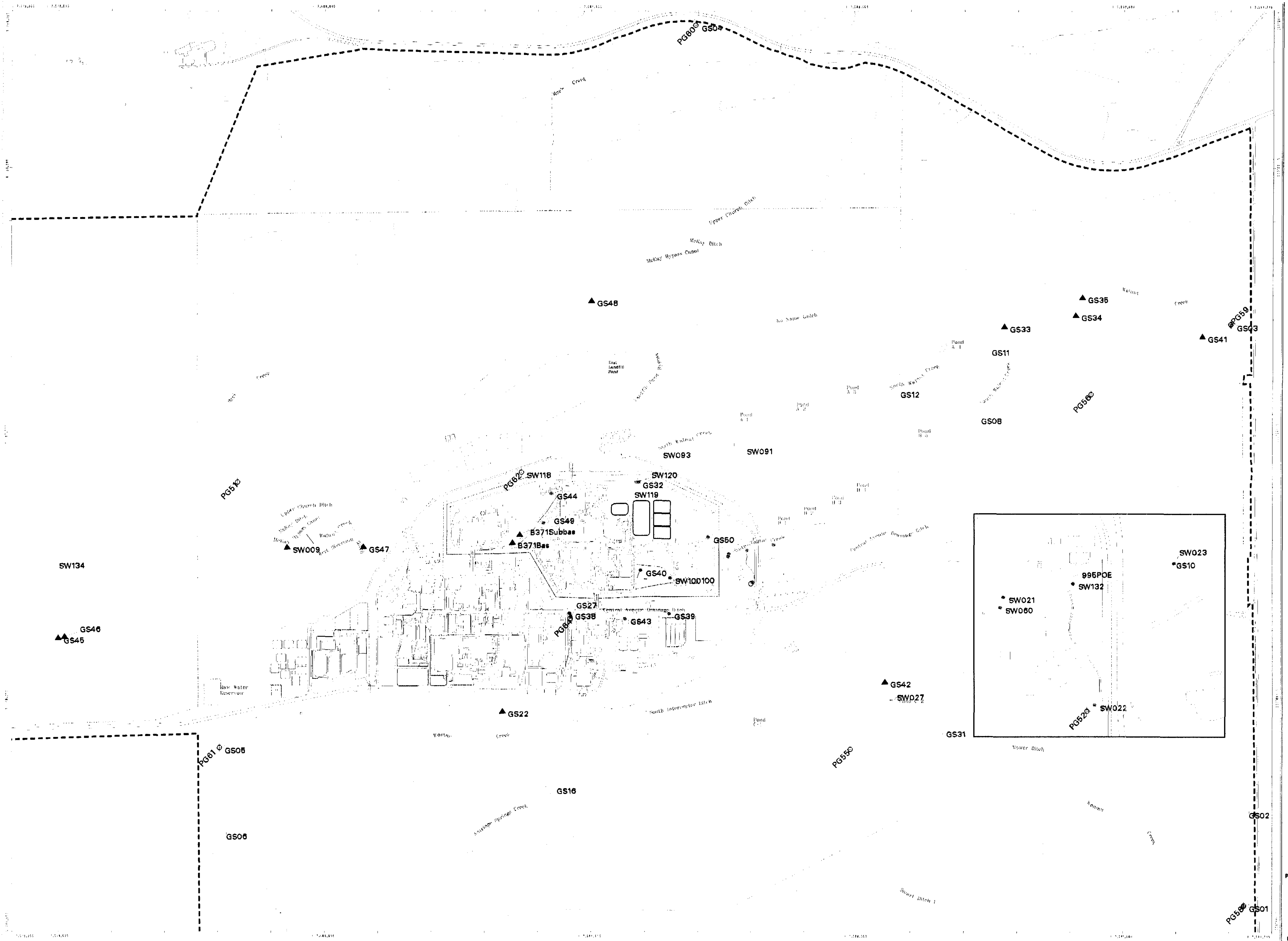

Figure 1

Automated Surface Water Monitoring Locations and Precipitation Gages for FY 2001

EXPLANATION

- Precipitation Gage

Monitoring Location Objective*

- Buffer Zone Hydrologic
- New Source Detection
- Point of Compliance
- Point of Evaluation
- Source Location
- Ad Hoc
- Performance
- IDLH**

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Rocky Flats boundary
- Paved roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

NOTE:

Scale = 1 : 17870
1 inch represents approximately 1489 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL COMPANY

MAP ID: 2k-0227

October 31, 2000

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Figure 3
LCDB Scenarios 0, 1 and 2
Erosion
100-Year Event (97.1mm)

EXPLANATION

- Erosion Model Boundary
- > 0.400 Kg/m2 (0.737 Lbs/yd2) Deposition
- 0.200 Kg/m2 (0.368 Lbs/yd2) Deposition
- 0.020 Kg/m2 (0.037 Lbs/yd2) Deposition
- No Deposition or Detachment
- 0.010 Kg/m2 (0.018 Lbs/yd2) Detachment
- 0.025 Kg/m2 (0.046 Lbs/yd2) Detachment
- 0.050 Kg/m2 (0.092 Lbs/yd2) Detachment
- 0.100 Kg/m2 (0.184 Lbs/yd2) Detachment
- 0.150 Kg/m2 (0.276 Lbs/yd2) Detachment
- 0.200 Kg/m2 (0.360 Lbs/yd2) Detachment
- 0.250 Kg/m2 (0.461 Lbs/yd2) Detachment
- 0.300 Kg/m2 (0.553 Lbs/yd2) Detachment
- 0.350 Kg/m2 (0.645 Lbs/yd2) Detachment
- Road Detachment
- Area not modeled
- Wetland

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Topographic Contour (5-Foot)

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 18360
1 inch represents approximately 1513 feet

250 0 500 1000 ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site
GIS Dept. 303-966-7707

MAP ID: 02-0168/all_erosion_con1.aml

December 27, 2001

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Figure 4
LCDB Scenario 3
Erosion
100-Year Event (97.1mm)

EXPLANATION

- Erosion Model Boundary
- > 0.400 Kg/m2 (0.737 Lbs/yd2) Deposition
- 0.200 Kg/m2 (0.369 Lbs/yd2) Deposition
- 0.020 Kg/m2 (0.037 Lbs/yd2) Deposition
- No Deposition or Detachment
- 0.010 Kg/m2 (0.018 Lbs/yd2) Detachment
- 0.025 Kg/m2 (0.046 Lbs/yd2) Detachment
- 0.050 Kg/m2 (0.092 Lbs/yd2) Detachment
- 0.100 Kg/m2 (0.184 Lbs/yd2) Detachment
- 0.150 Kg/m2 (0.276 Lbs/yd2) Detachment
- 0.200 Kg/m2 (0.369 Lbs/yd2) Detachment
- 0.250 Kg/m2 (0.461 Lbs/yd2) Detachment
- 0.300 Kg/m2 (0.553 Lbs/yd2) Detachment
- 0.350 Kg/m2 (0.645 Lbs/yd2) Detachment
- Road Detachment
- Area not modeled
- Wetland

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Topographic Contour (5-Foot)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 10360
1 inch represents approximately 1613 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

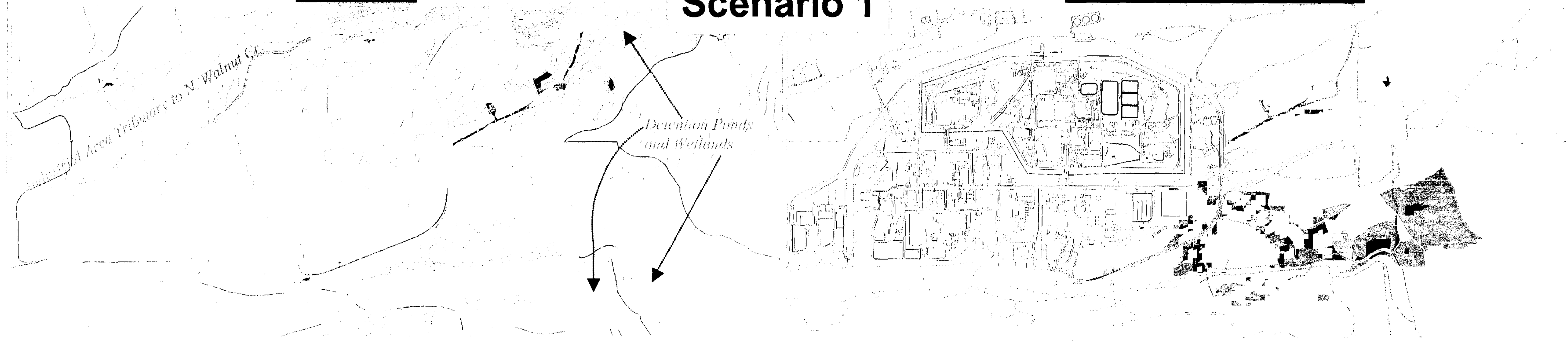
MAP ID: 02-0159/all_erosion_scn3.aml

December 26, 2001

NT Svr d:/projects/fy2002/02-0159/all erosion scn3.aml

Figure 5.
Comparison of Estimated Erosion and Pu-239,240 Mobility Grids for LCDB Scenarios 1 and 3 - 100-Year, 6-Hour Storm (97.1mm)

Erosion **Scenario 1** **Pu-239,240 Mobility**



Existing Industrial Area tributary to North Walnut Creek

Existing land surface grade in eastern SID watershed

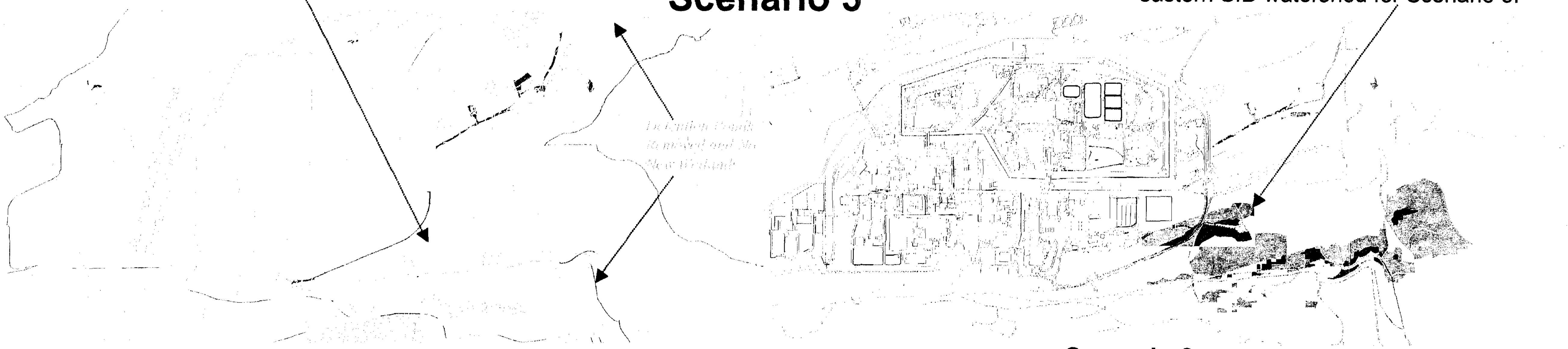
Detention ponds and wetlands used to promote actinide settling, reduce actinide mobility

Scenario 1 Features

Note: Eastern SID erosion lower for Scenario 3.

Scenario 3

Note: Reduced actinide mobility in eastern SID watershed for Scenario 3.



Reconfigured Industrial Area tributary to North Walnut Creek

Reduced slope of land surface in eastern SID watershed, which also reduces surface soil actinide concentrations

No wetlands or detention ponds.

Scenario 3 Features

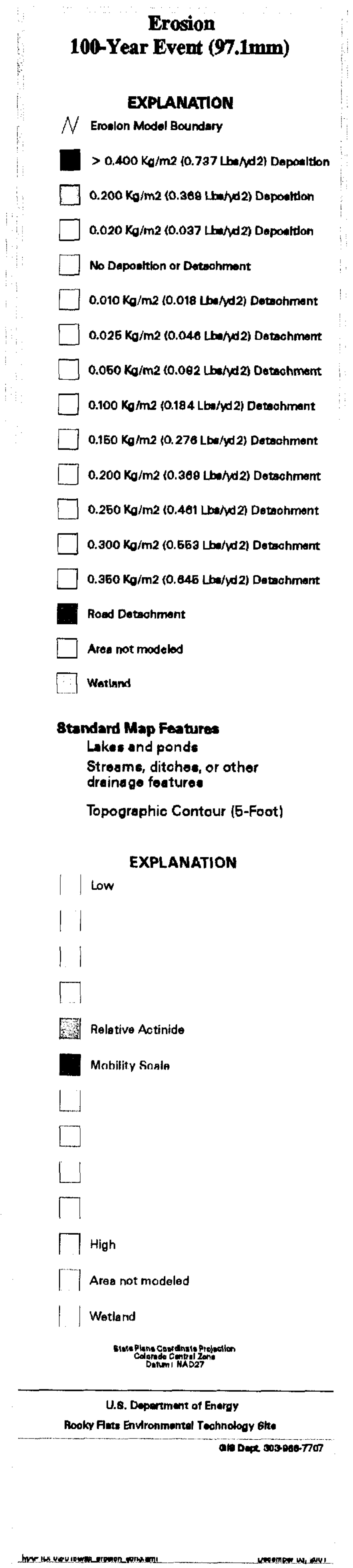


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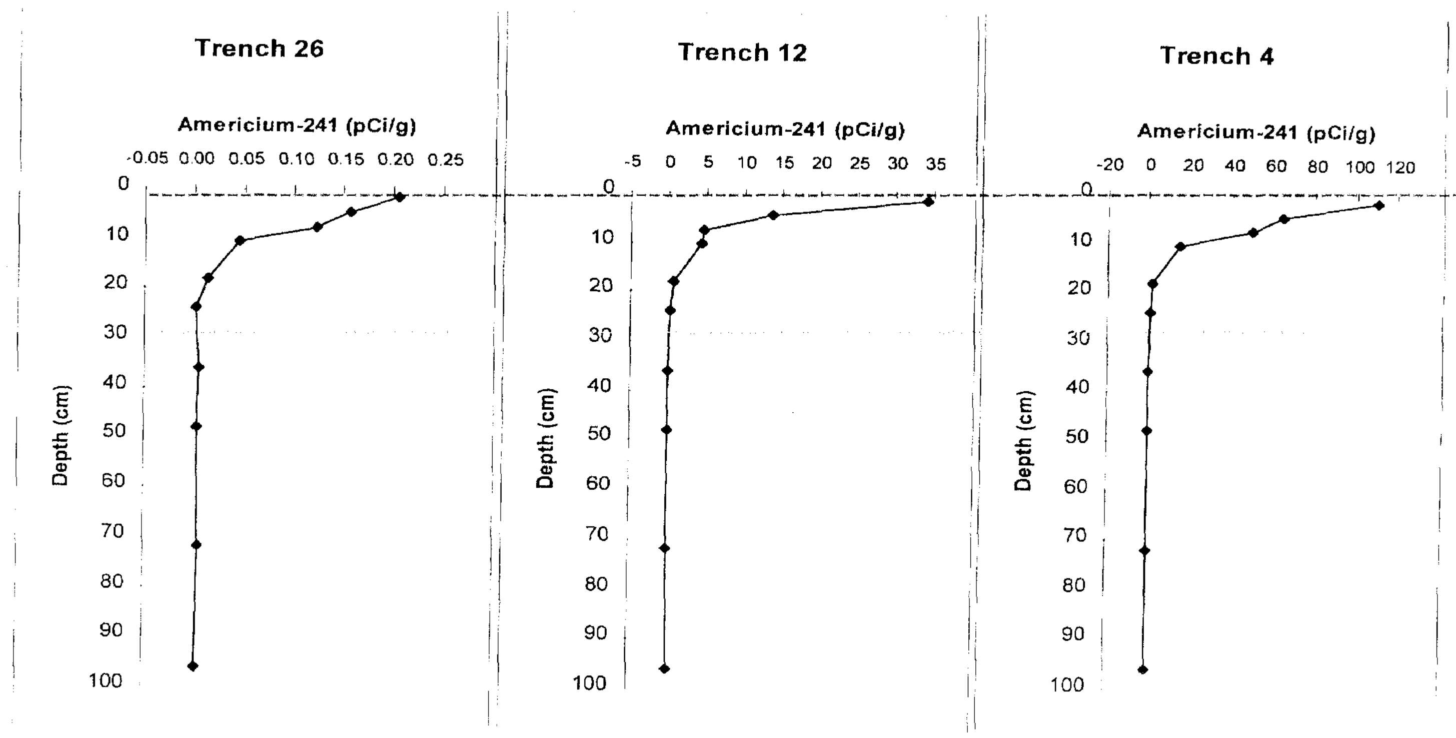
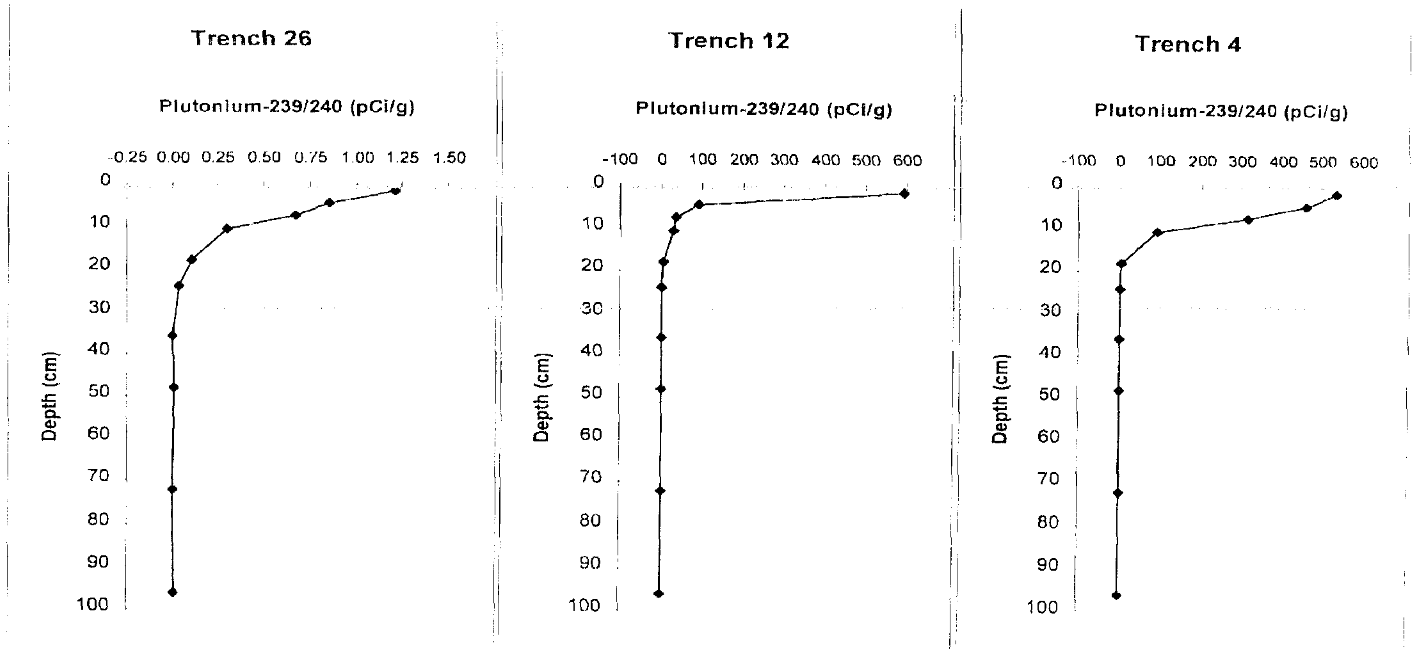
Figure 6. Soil Actinide Concentrations with Depth for Rocky Flats Environmental Technology Site Soil and Conversion to Estimated Tilled (Homogenized) Soil Actinide Concentrations.

Depth Distribution of Americium-241 in Soils Near the 903 Pad



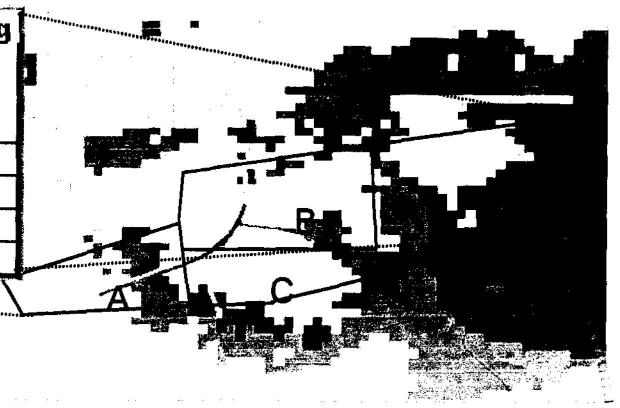
Depth Distribution of Plutonium-239/240 in Soils Near the 903 Pad



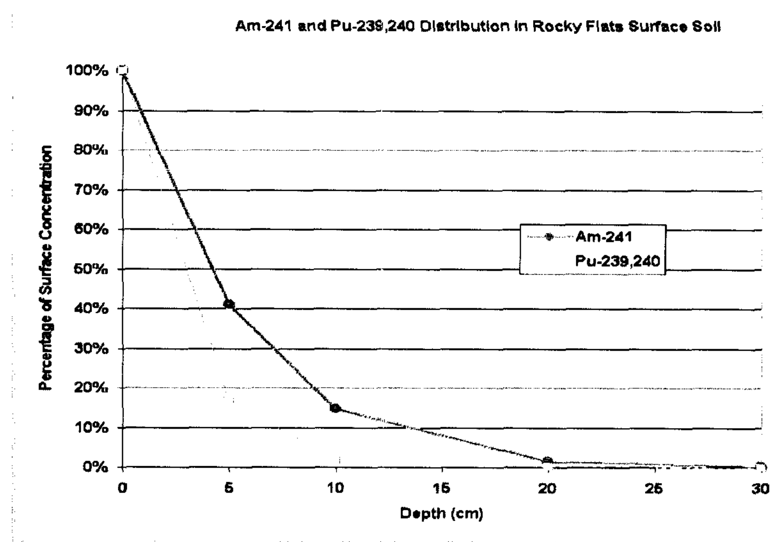
Source: RF/RMRS-97-074.UN *Summary of Existing Data on Actinide Migration at the Rocky Flats Environmental Technology Site*

Data Source: Litaor et al, 1994 and DOE, 1995.

Sector	Average Existing Pu-239,240 Soil Concentration (pCi/g)	Average Existing Am-241 Soil Concentration (pCi/g)
A	0.51	0.1
B	27.5	4.46
C	9.28	1.28
D	7.99	1.12



Measured distribution of actinides with depth is applied to modified Kriged grid of surface-soil concentration to estimate activity of soil homogenized to a depth of 30 cm. Sectors A, B, C, and D were selected by grouping areas with similar actinide concentrations (by eye).



Homogenized Pu-239,240 Surface-Soil Concentration Grid

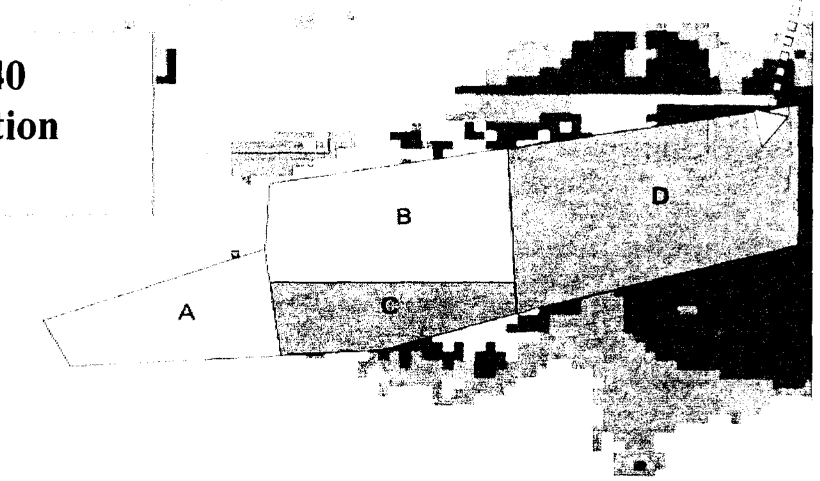


Figure 7. Actinide Isoplot Comparison for Remediated Conditions and Hypothetical Graded SID Watershed Land Surface Woman Creek Scenario 3

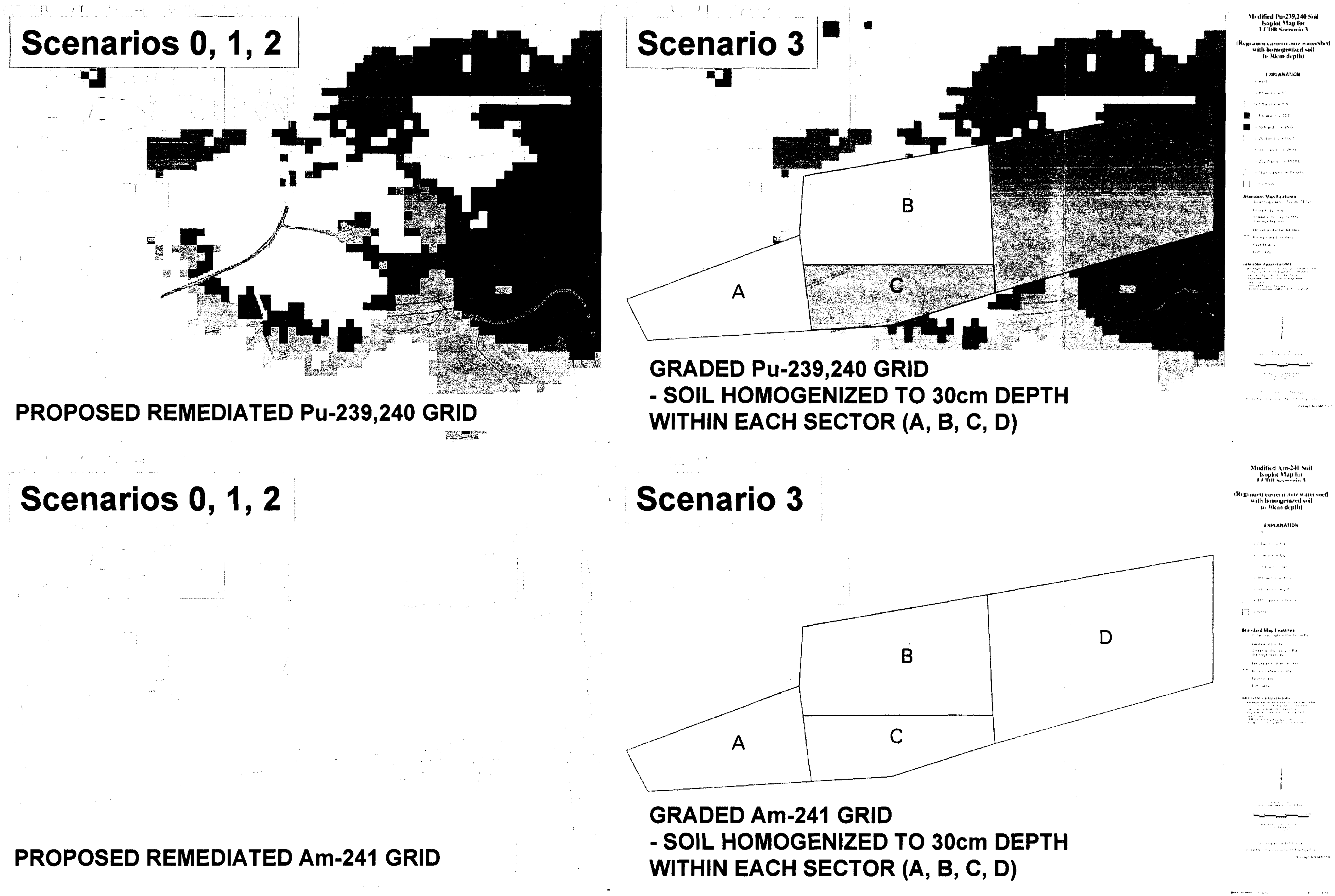
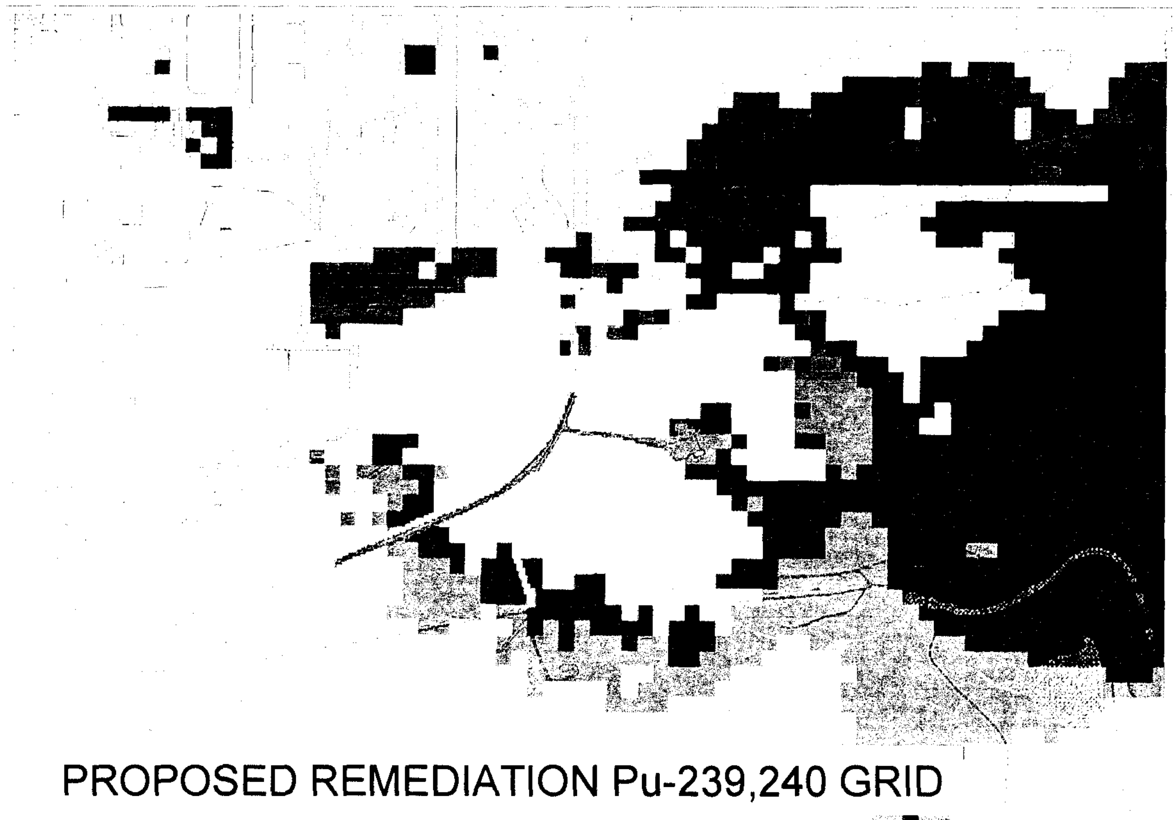
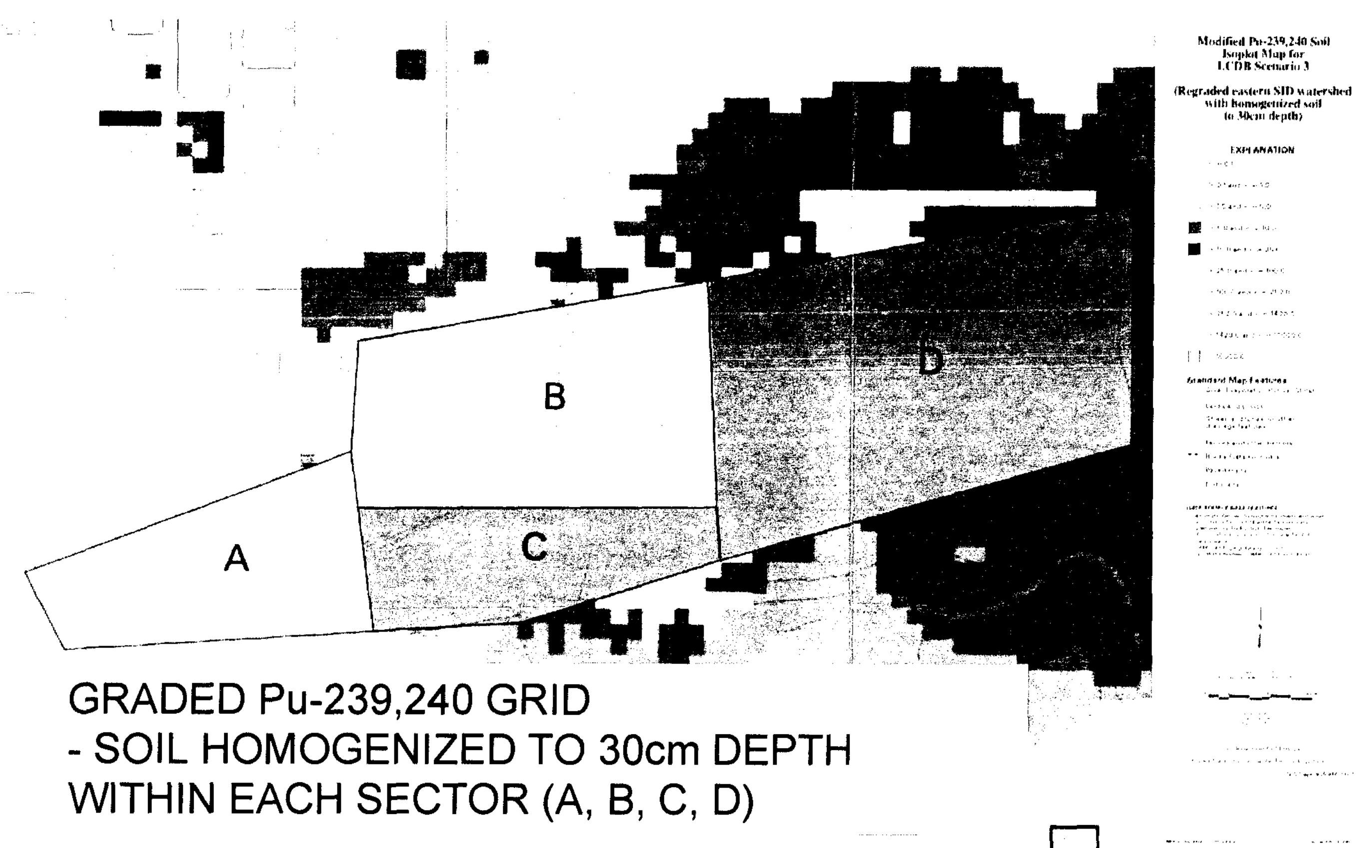


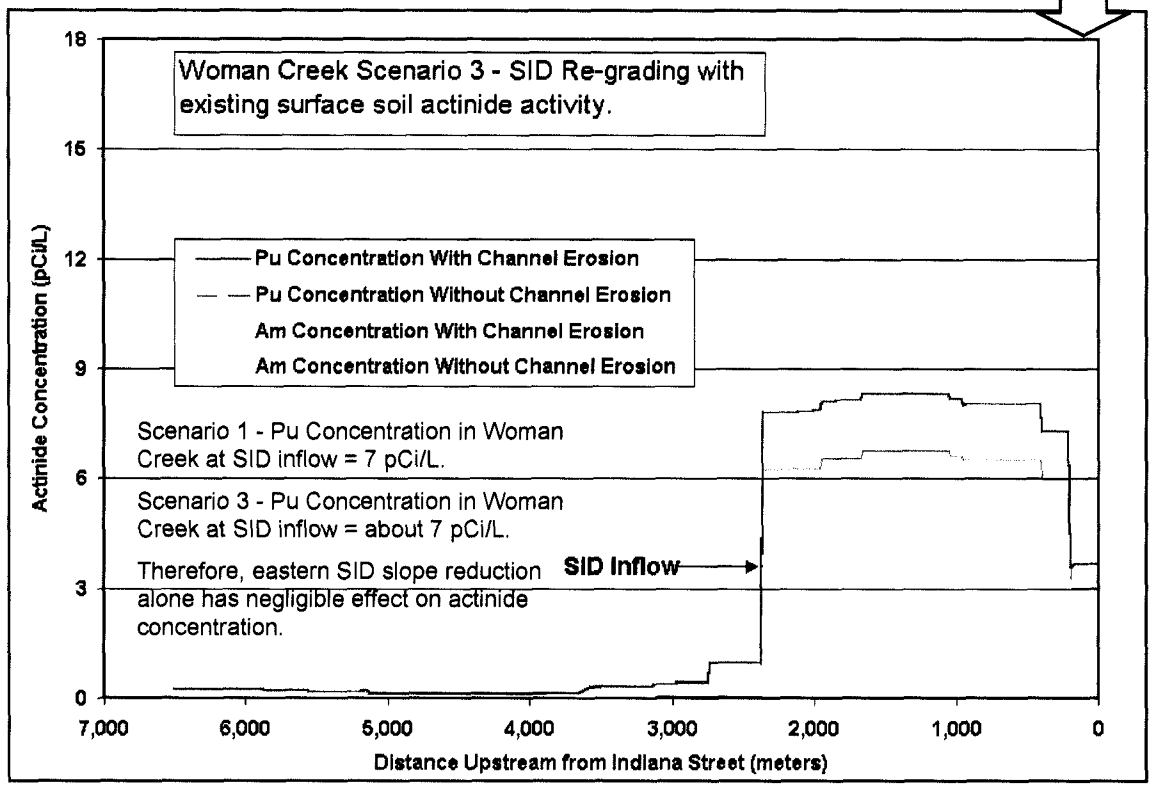
Figure 8. Comparison of Model-Predicted Surface-Water Actinide Concentrations for Proposed Remediated Soil Conditions and a Hypothetical Graded SID Watershed Land Surface - Woman Creek Scenario 3.

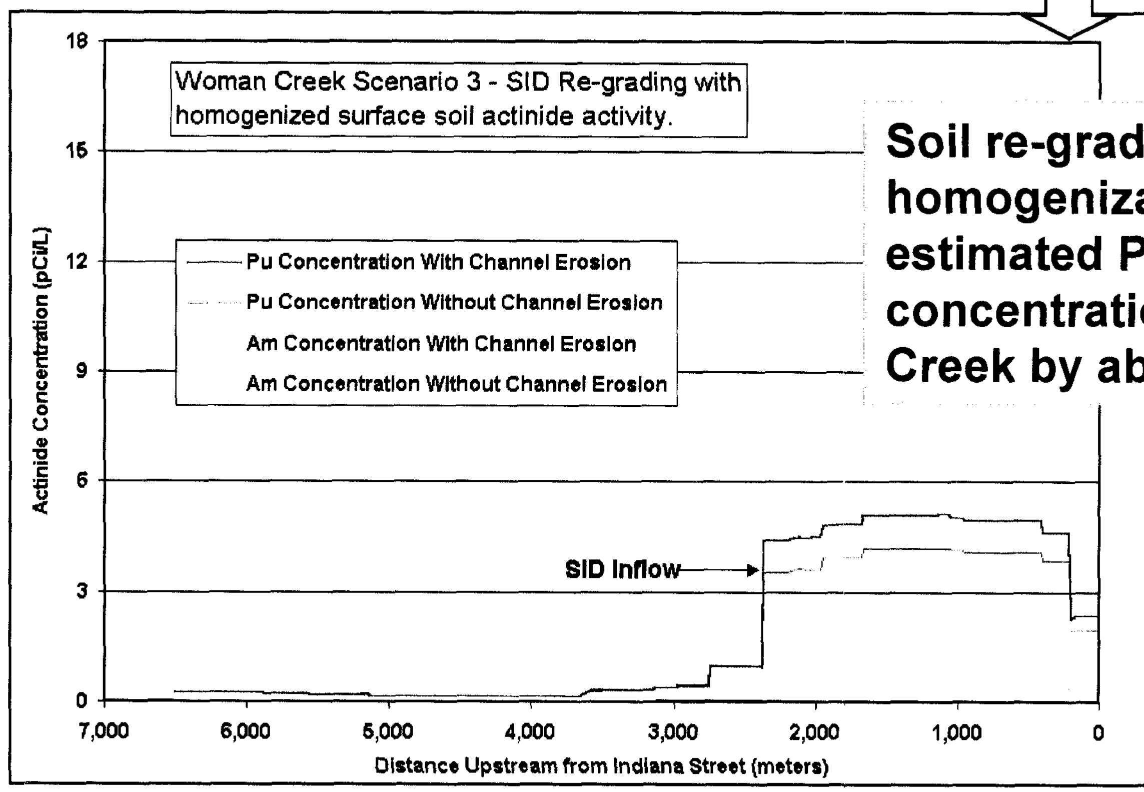


PROPOSED REMEDIATION Pu-239,240 GRID



GRADED Pu-239,240 GRID
- SOIL HOMOGENIZED TO 30cm DEPTH
WITHIN EACH SECTOR (A, B, C, D)

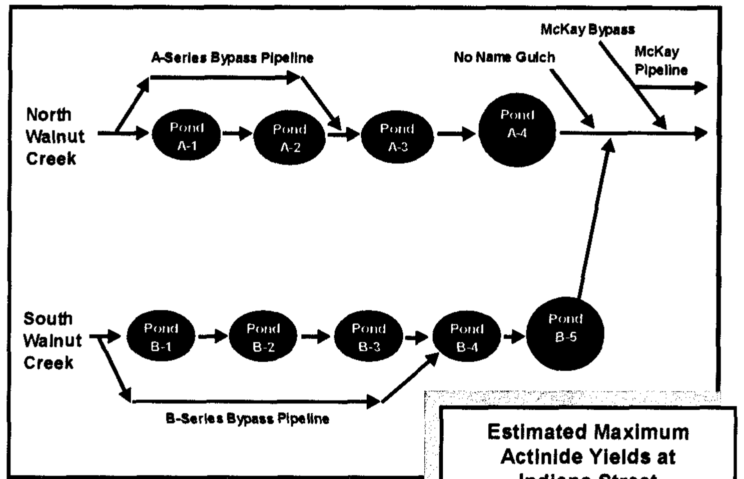


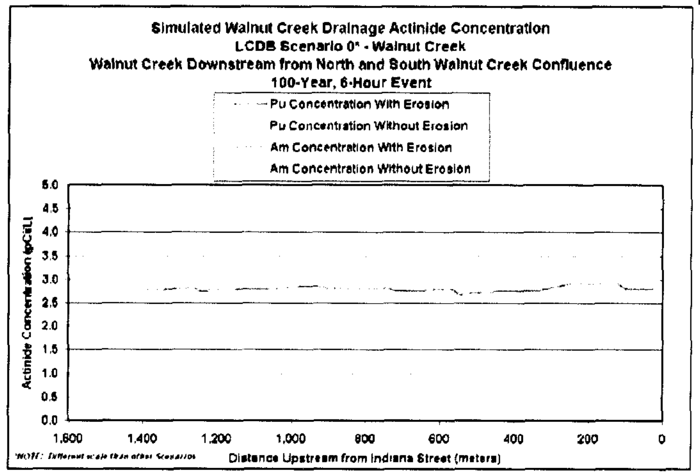


Soil re-grading and homogenization reduces estimated Pu-239,240 concentrations in Woman Creek by about 30 %.

Figure 9. Walnut Creek LCDB Scenarios
Model-Predicted Pu and Am Surface Water Concentrations in Lower Walnut Creek - 100-Year, 6-Hour Storm (97.1 mm)

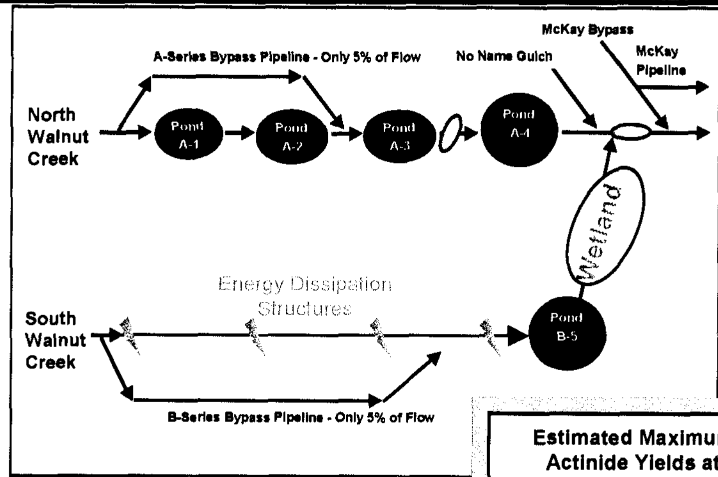
Scenario 0 - Reclaimed Industrial Area

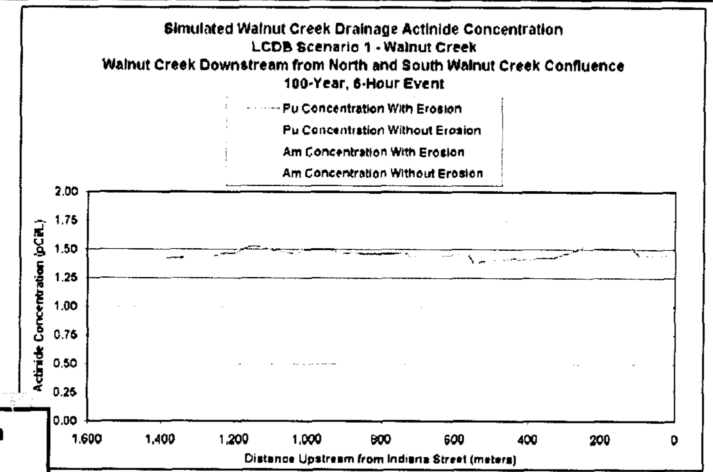




Estimated Maximum Actinide Yields at Indiana Street
Pu = 4.55E+08 pCi
Am = 1.31E+08 pCi

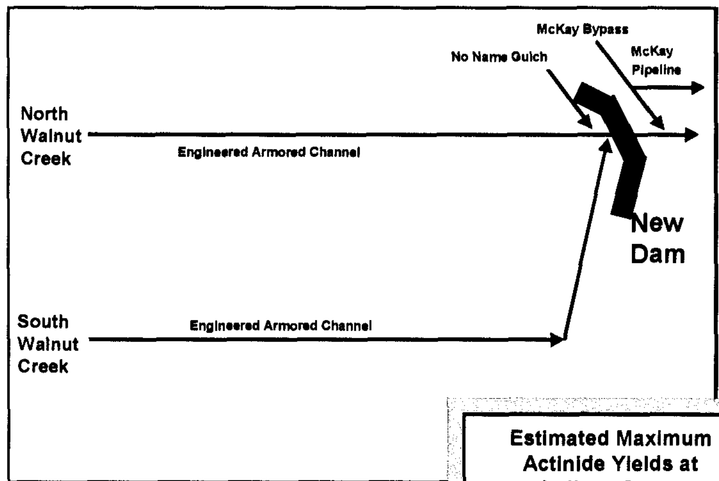
Scenario 1
Reclaimed IA, Wetlands, and Energy Dissipation Structures, No Upper B-Series Ponds

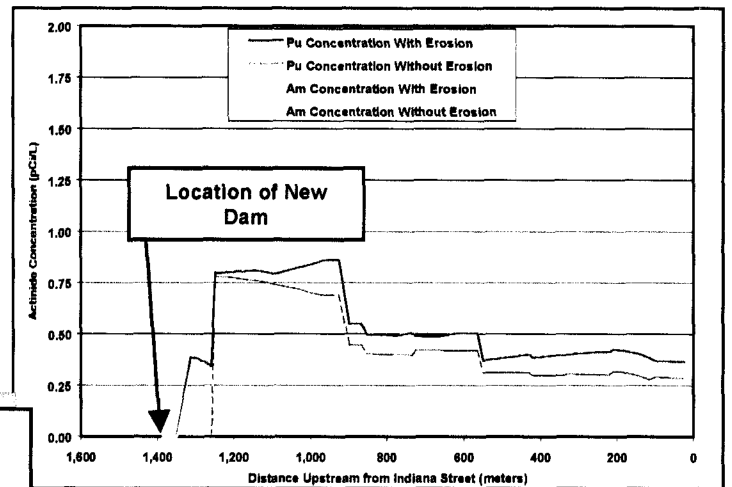




Estimated Maximum Actinide Yields at Indiana Street
Pu = 2.86E+08 pCi
Am = 8.47E+07 pCi

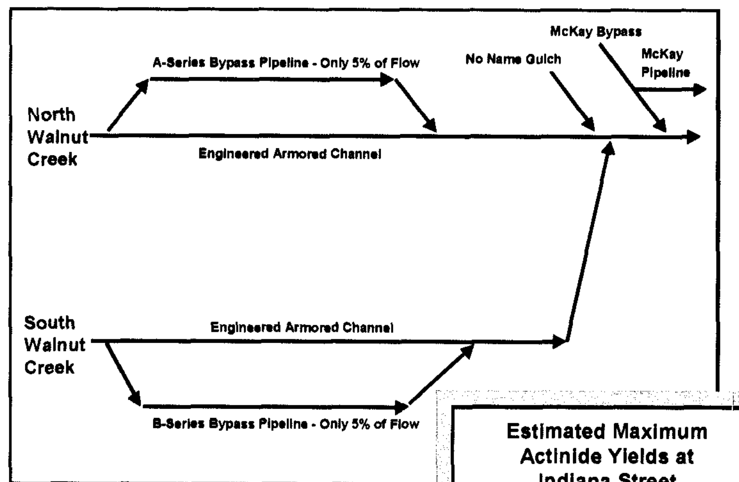
Scenario 2 - New Dam at Confluence of North Walnut Creek and South Walnut Creek

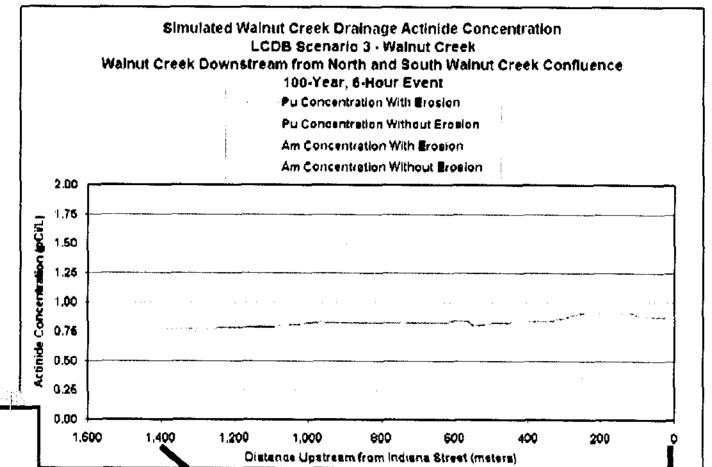




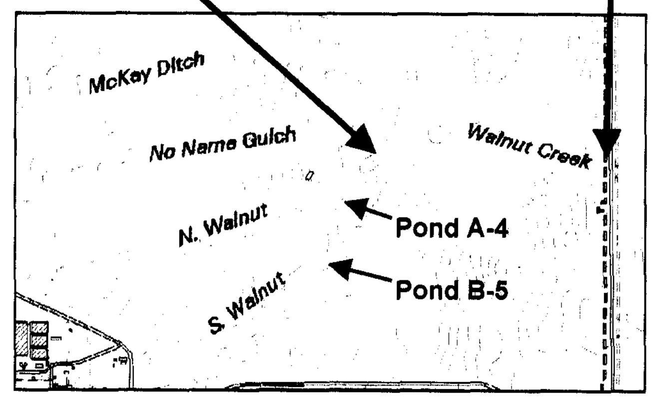
Estimated Maximum Actinide Yields at Indiana Street
Pu = 1.26E+07 pCi
Am = 3.68E+06 pCi

Scenario 3 - Re-Contoured IA, IA Runoff Re-Routed, No Detention Ponds





Estimated Maximum Actinide Yields at Indiana Street
Pu = 1.57E+08 pCi
Am = 1.59E+07 pCi



Lower Walnut Creek Location Reference

Figure 10. Walnut Creek LCDB Scenarios 1 and 3
Model-Predicted Pu and Am Surface Water Concentrations in Walnut Creek - 100-Year, 6-Hour Storm (97.1 mm)

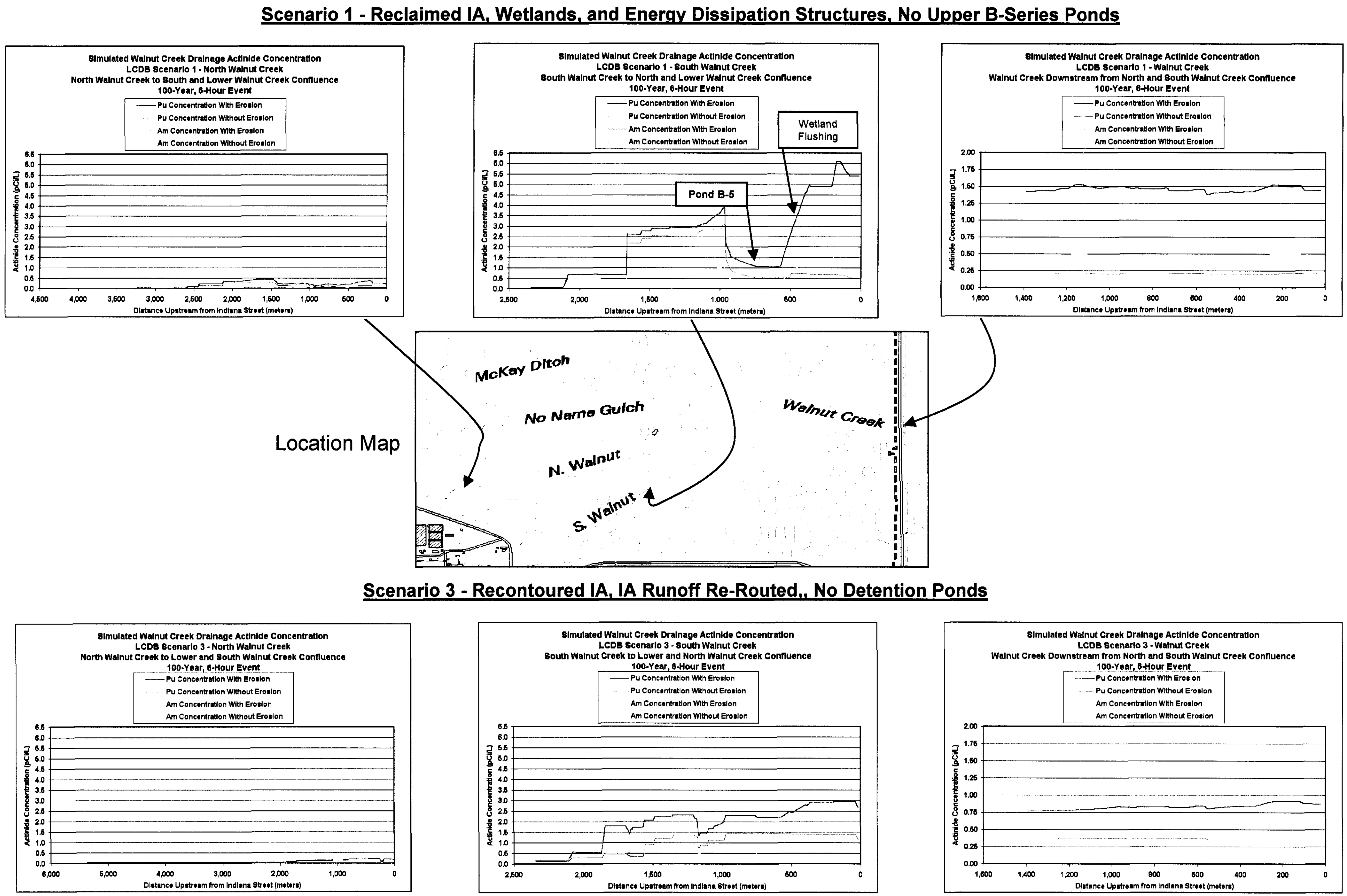
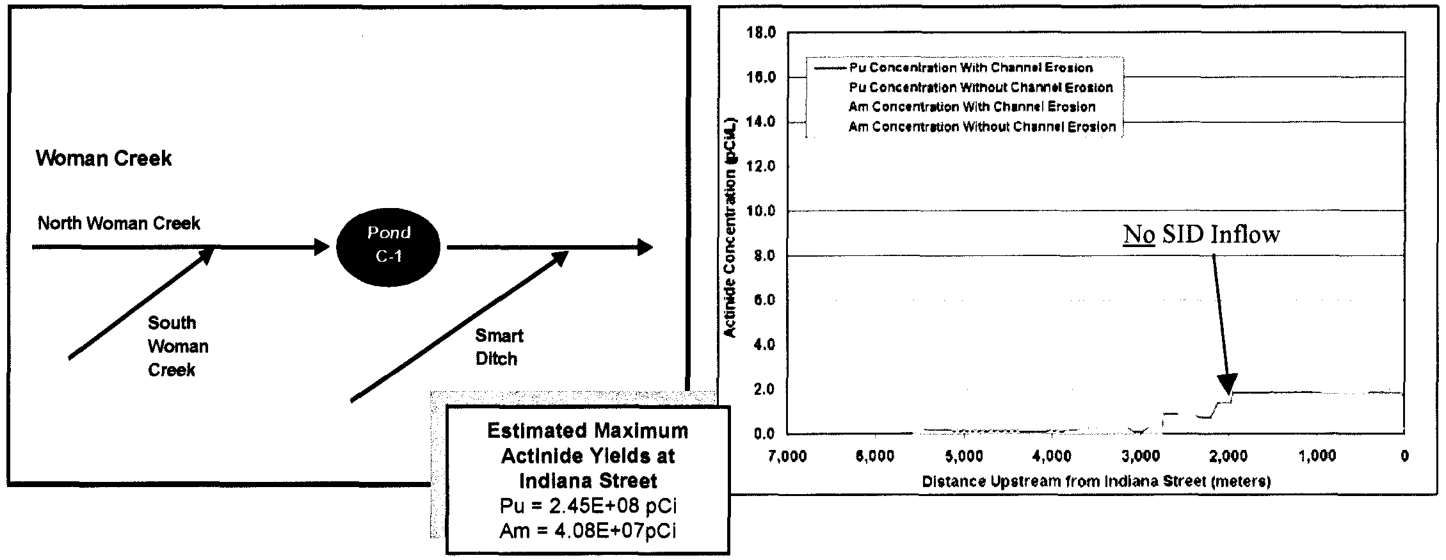
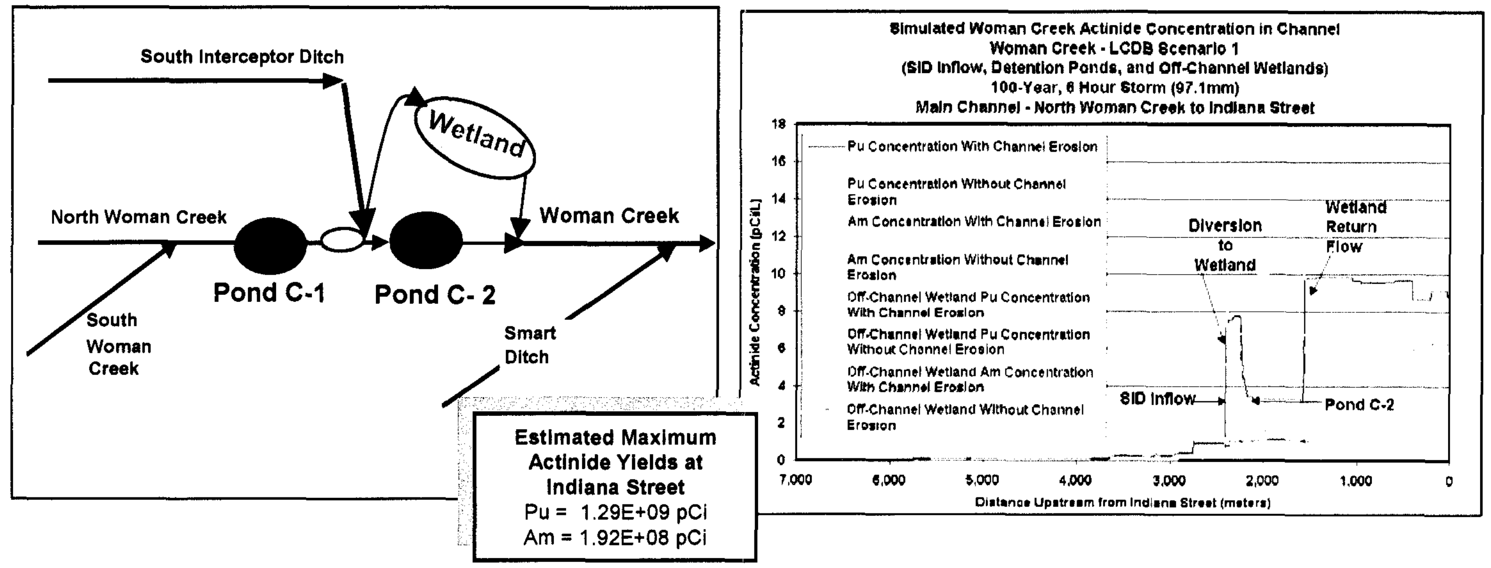


Figure 12. Woman Creek LCDB Scenarios
Model-Predicted Pu and Am Surface-Water Concentrations in Woman Creek - 100-Year, 6-Hour Storm (97.1 mm)

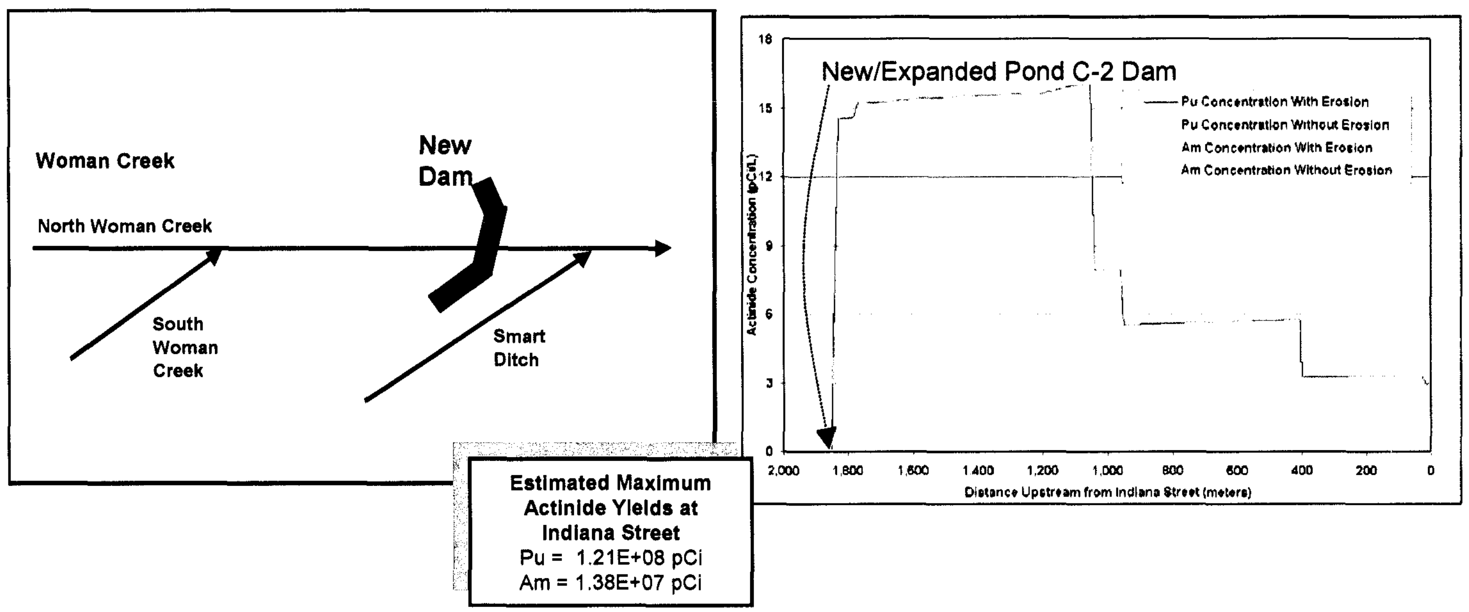
Scenario 0 - Reclaimed / Re-vegetated Industrial Area



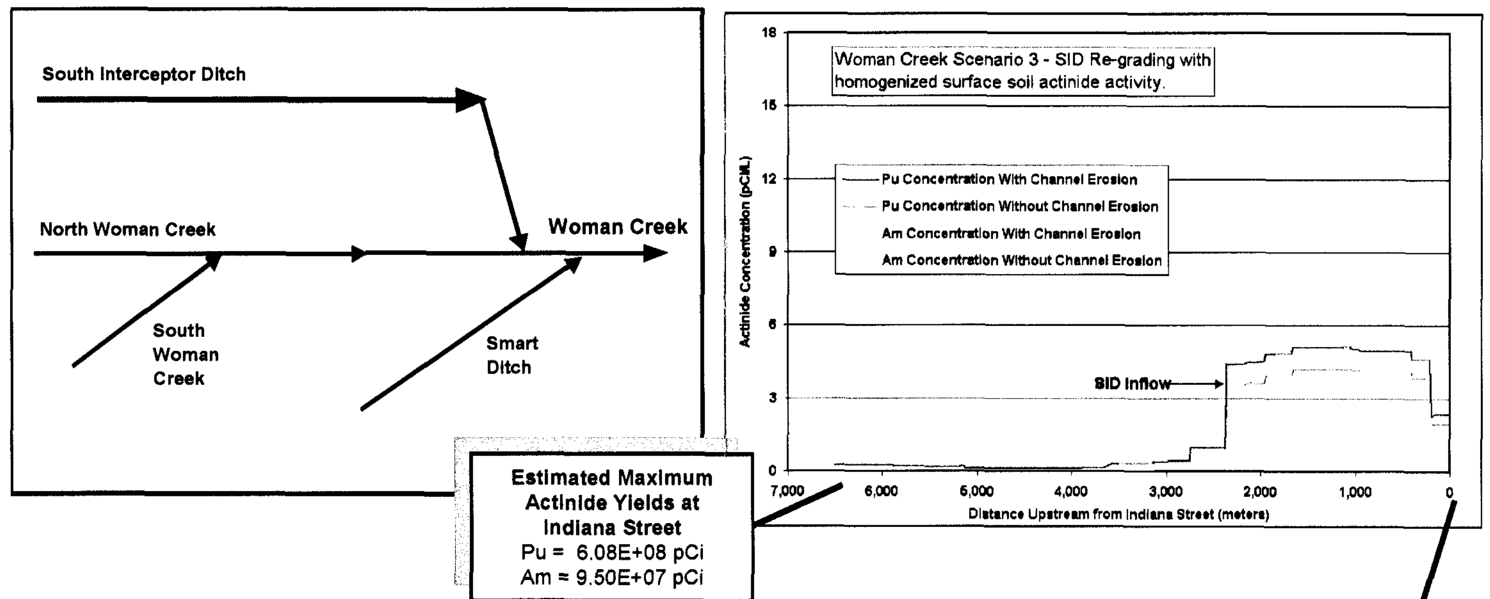
Scenario 1 - SID Routed to Woman Creek, Modified Ponds, and Off-Channel Wetlands

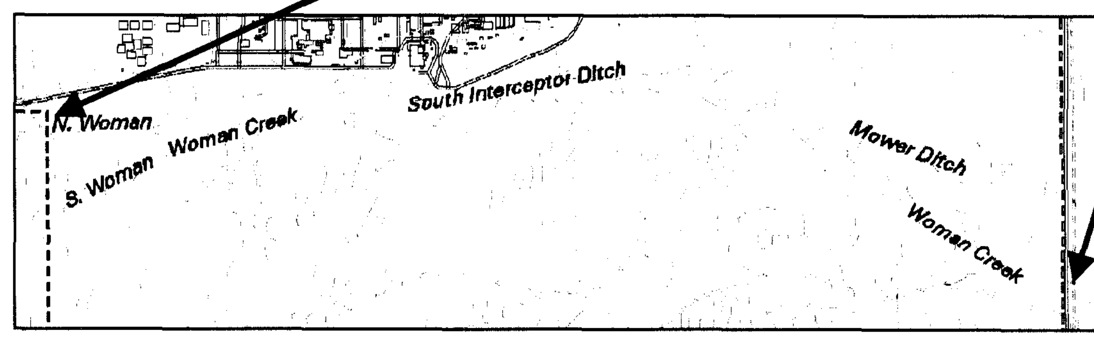


Scenario 2 - Hypothetical Expanded Pond C-2 Dam



Scenario 3 - Regraded SID Drainage Routed to Woman Creek, No Ponds





Woman Creek Location Reference

Figure B-1
LCDB Scenarios 0, 1 and 2
Pu-239,240 Mobility
100-Year Event (97.1mm)

EXPLANATION

Low

Relative Actinide
Mobility Scale

High

Area not modeled

Wetland

Standard Map Features

Solar Evaporation Ponds (SEPs)

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Rocky Flats boundary

Paved roads

Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

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December 27, 2001

Figure B-2
LCDB Scenarios 0, 1 and 2
Am-241 Mobility
100-Year Event (97.1mm)

Figure B-3
LCDB Scenario 3
Pu-239,240 Mobility
100-Year Event (97.1mm)

EXPLANATION

Low

Relative Actinide

Mobility Scale

High

Area not modeled

Wetland

Standard Map Features

Solar Evaporation Ponds (SEPs)

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Rocky Flats boundary

Paved roads

Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95

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December 26, 2001

Figure B-4
LCDB Scenario 3
Am-241 Mobility
100-Year Event (97.1mm)

EXPLANATION

Low

Relative Actinide

Mobility Scale

High

Area not modeled

Wetland

Standard Map Features

Solar Evaporation Ponds (SEPs)

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Rocky Flats boundary

Paved roads

Dirt roads

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1/95

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GIS Dept. 303-966-7707

December 26, 2001

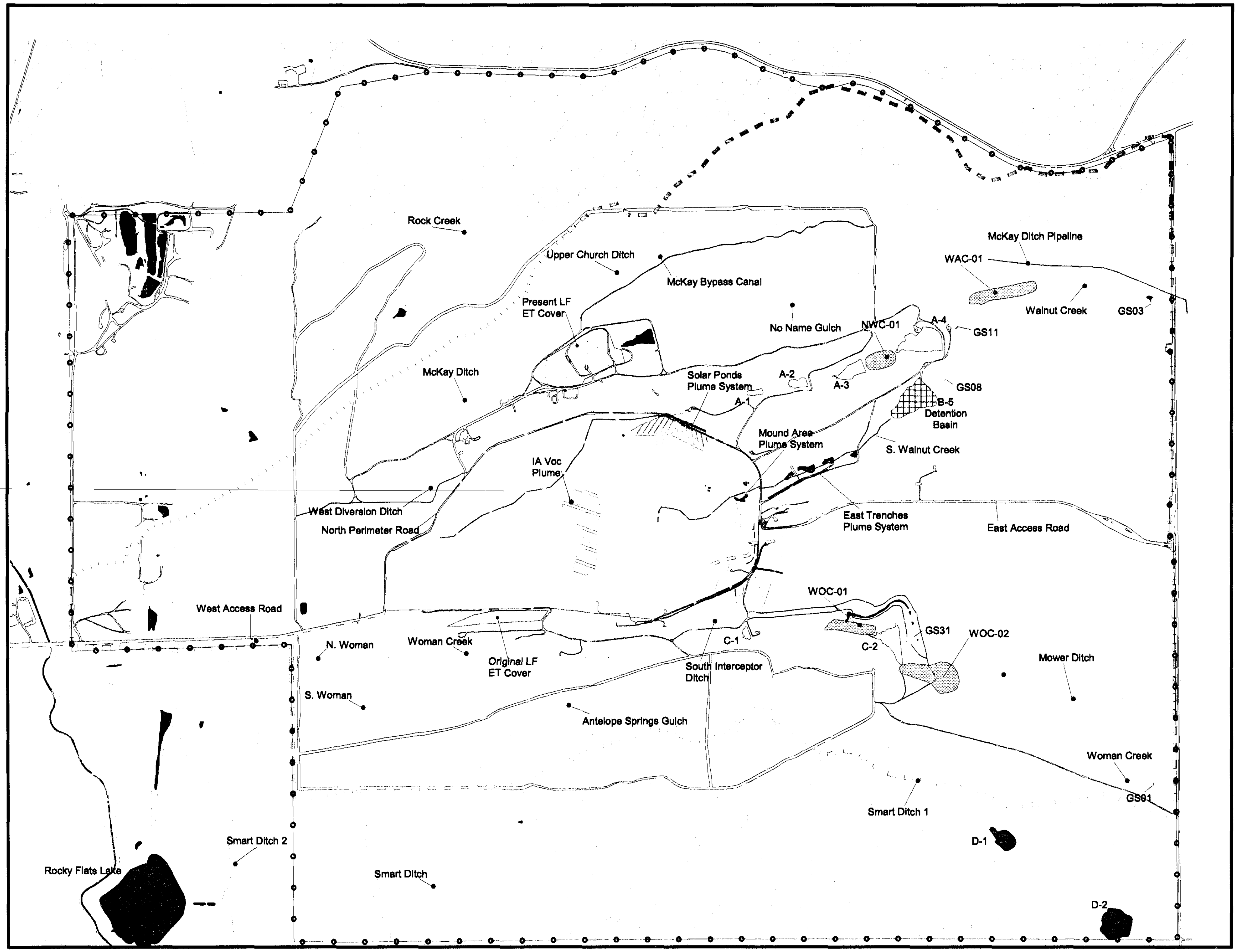


Figure C-1

Potential Location of Initial Conceptual Design Components

Legend

- Lakes/Ponds
- 50' Contours
- Sub-Basin Drainage Boundary
- Diversion Ditch
- Streams, ditches, or other drainage features
- Enhanced Engineered Drainage Channel
- Groundwater Plume equal to or greater than Tier I
- Groundwater Plume equal to or greater than Tier II
- Groundwater Plume System
- Solar Pond ITS/French Drain (Active)
- Solar Pond ITS (Inactive)
- Positive Drainage and ET Provisions
- Revegetation
- Detention Basin
- ET Cover
- New/Enlarged Wetland
- Wetland Pond/Marsh System
- Passive Flow-Through Detention Pond
- Surface water monitoring Point of Compliance

Note: IA Vegetated area not shown for clarity. Tier I/II groundwater plumes do not include uranium plume. See design drawing package 51649 for additional details for Solar Pond Plume System

Standard Map Features

- Road
- RFETS Boundary
- Land Configuration Design Basis Project Boundary

Data Source:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas
Digitized from orthophotographs, 1/95
Source NRCS, SSURGO Digital soils

N

Scale

1000 0 1000 2000 3000 4000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site
Land Configuration Design Basis

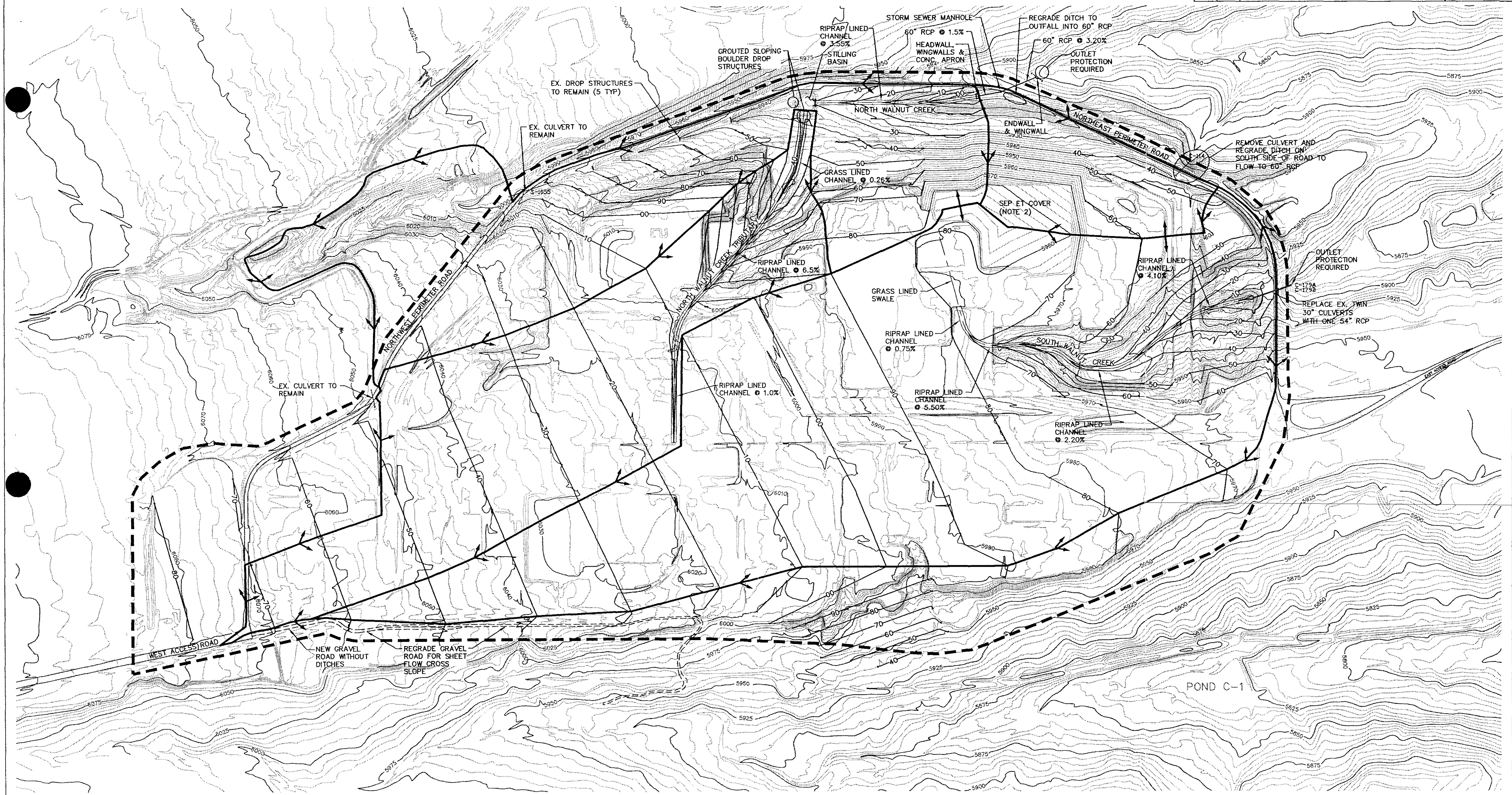
Prepared by:

PARSONS

Parsons, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290
303-831-8100

Feb 5, 2002

042



LEGEND

— — —	STUDY LIMITS
	EXISTING INTERMEDIATE CONTOURS
—5000—	EXISTING INDEX CONTOURS
	PAVED PERIMETER ROAD
- - -	UNPAVED ROAD
C-114	EXISTING CULVERTS
—70—	PROPOSED INDEX CONTOURS
	PROPOSED EDGE OF CHANNEL
— - —	PROPOSED CHANNEL OR SWALE CENTERLINE
←	PROPOSED DRAINAGE DIVIDES
—<	PROPOSED CULVERT

NOTES

1. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.
2. SEP ET COVER: HOLD.

0' 150' 300' 600'
ORIGINAL SCALE: 1"=300'

DRAWINGS ARE NOT FOR CONSTRUCTION

ISSUE	DESCRIPTION
0	ORIGINAL ISSUE/CONCEPTUAL DESIGN

KEYWORDS: 1.LAND 2.CONFIG. 3.DRAINAGE 4.CONTOUR 5.CONCEPT

TOLERANCES: FRACT. ± ANGLE ± DEC. ± UNLESS NOTED OTHERWISE; REMOVE BURRS AND SHARP EDGES

DESIGN COMPANY: PARSONS I&T
DESIGNED BY: J. KAPINOS JMK
DRAWN BY: J. HARSCH JH
CHECKED BY: R. STEGEN RLS 01/23/02
INDEPENDENT VERIFIER
APPROVED BY
CLASSIFIER
ADDITIONAL APPROVALS

BLDG./FACILITY: SITE
ROOM/AREA: N/A
NEXT ASSEMBLY: N/A
GRID COORD./COL NO.: N/A
SCALE: 1"=300'

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

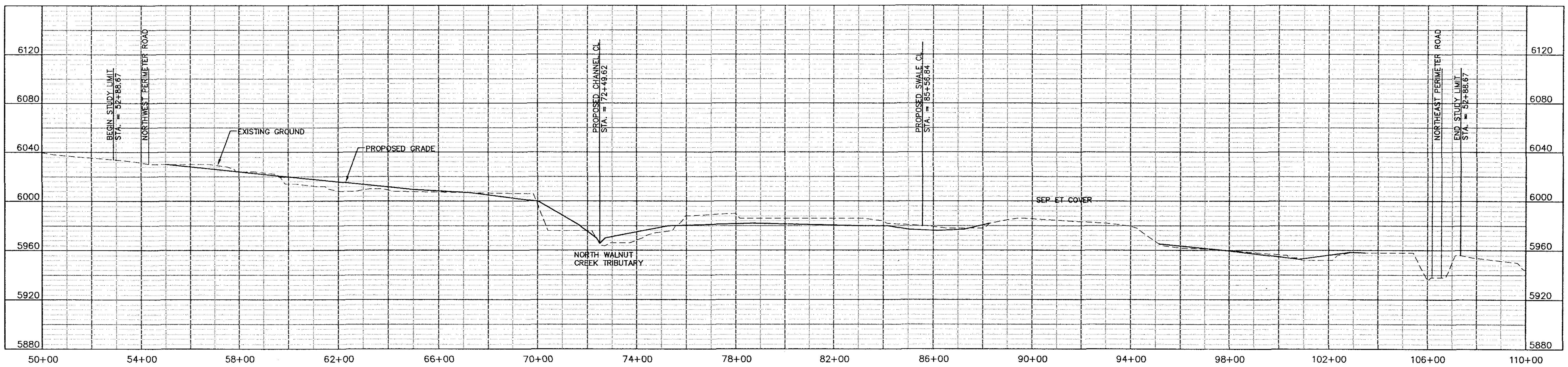
FIGURE E-01 PLAN VIEW
INITIAL AND PROPOSED TOPOGRAPHY

SIZE	DRAWING NUMBER	ISSUE
D	51754-C001	0

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL

587

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL



SECTION A - A'

0' 50' 100' 200' 400'
SCALE: HORIZONTAL 1"=200'
VERTICAL 1"=40'

LEGEND

Symbol	Description
— — — (heavy dashed)	STUDY LIMITS
········	EXISTING INTERMEDIATE CONTOURS
—— 6000 ——	EXISTING INDEX CONTOURS
————	PAVED PERIMETER ROAD
— — — —	UNPAVED ROAD
——< C-114	EXISTING CULVERTS
——70——	PROPOSED INDEX CONTOURS
————	PROPOSED EDGE OF CHANNEL
—— — ——	PROPOSED CHANNEL OR SWALE CENTERLINE
A A'	CROSS-SECTION LOCATION

NOTES

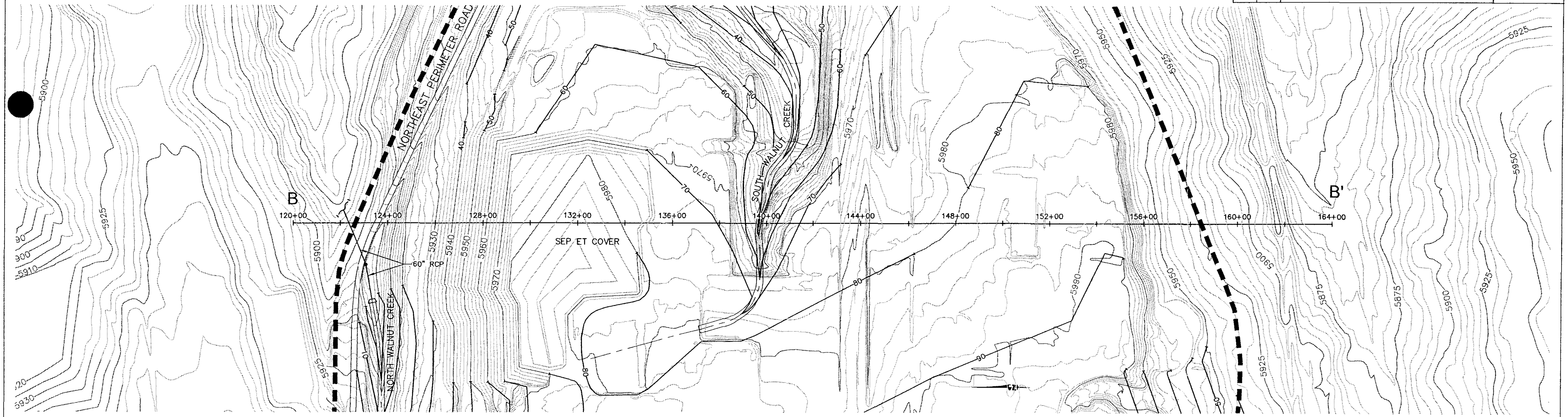
1. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.
2. SEP ET COVER: HOLD.

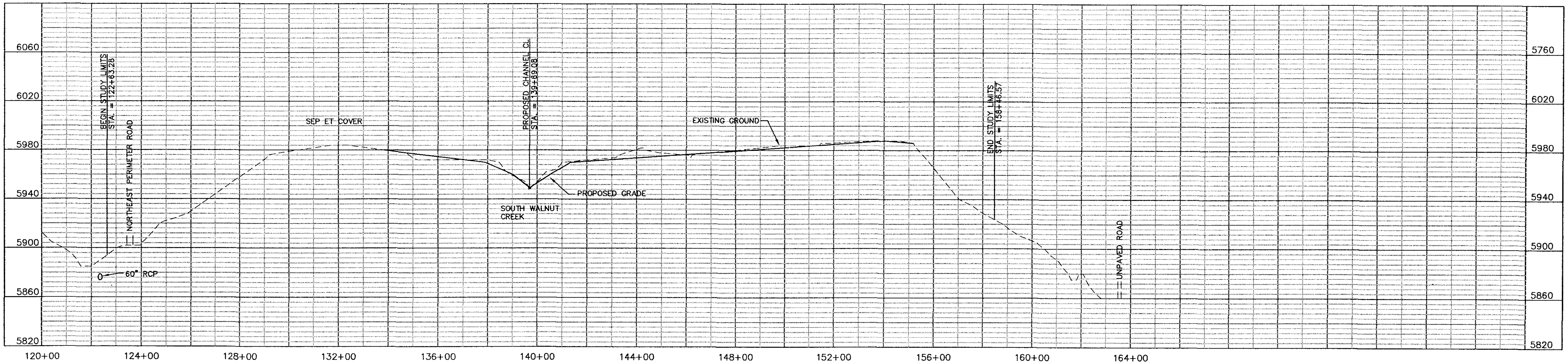
DRAWINGS ARE NOT FOR CONSTRUCTION

0 ISSUE	ORIGINAL ISSUE/CONCEPTUAL DESIGN DESCRIPTION		KH900286-003 PROJECT/WOF NO.
KEYWORDS	TOLERANCES FRACT. ± ANGLE ± DEC. ±	DESIGN COMPANY: PARSONS I&T	U.S. DEPARTMENT OF ENERGY ROCKY FLATS OFFICE GOLDEN, COLORADO
1.LAND		DESIGNED BY J. KAPINOS JMK	Rocky Flats Environmental Technology Site
2.CONFIG.		DRAWN BY J. HARSCH JLH	GOLDEN, COLORADO
3.DRAINAGE	UNLESS NOTED OTHERWISE	CHECKED BY R. STEGEN RLS 01/23/02	LAND CONFIGURATION DESIGN BASIS GRADING AND DRAINAGE CONCEPT
4.CONTOUR	REMOVE BURRS AND SHARP EDGES	INDEPENDENT VERIFIER	FIGURE E-02 PLAN AND PROFILE SECTION A-A'
5.CONCEPT		APPROVED BY	
BLDG./FACILITY SITE	NEXT ASSEMBLY N/A	CLASSIFIER	SIZE D
ROOM/AREA N/A	SCALE: AS SHOWN	ADDITIONAL APPROVALS	DRAWING NUMBER 51754-C002
GRID COORD./COL. NO. N/A			ISSUE 0

58?

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL





SECTION B - B'

0' 50' 100' 200' 400'
SCALE: HORIZONTAL 1"=200'
VERTICAL 1"=40'

LEGEND

- STUDY LIMITS
- EXISTING INTERMEDIATE CONTOURS
- EXISTING INDEX CONTOURS (6000)
- PAVED PERIMETER ROAD
- UNPAVED ROAD
- PROPOSED CULVERT
- PROPOSED INDEX CONTOURS (70)
- PROPOSED EDGE OF CHANNEL
- PROPOSED CHANNEL OR SWALE CENTERLINE
- B B' CROSS-SECTION LOCATION

NOTES

1. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.
2. SEP ET COVER: HOLD.

DRAWINGS ARE NOT FOR CONSTRUCTION

ISSUE	DESCRIPTION
0	ORIGINAL ISSUE/CONCEPTUAL DESIGN

KEYWORDS: 1.LAND, 2.CONFIG., 3.DRAINAGE, 4.CONTOUR, 5.CONCEPT

TOLERANCES: FRACT. ± ; ANGLE ± ; DEC. ; UNLESS NOTED OTHERWISE

REMOVE BURRS AND SHARP EDGES

BLDG./FACILITY: SITE
ROOM/AREA: N/A
GRID COORD./COL NO.: N/A
NEXT ASSEMBLY: N/A
SCALE: AS SHOWN

DESIGN COMPANY: PARSONS I&T
DESIGNED BY: J. KAPINOS JMK
DRAWN BY: J. HARSCH JLH
CHECKED BY: R. STEGEN RLS 01/23/02
INDEPENDENT VERIFIER
APPROVED BY
CLASSIFIER
ADDITIONAL APPROVALS

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

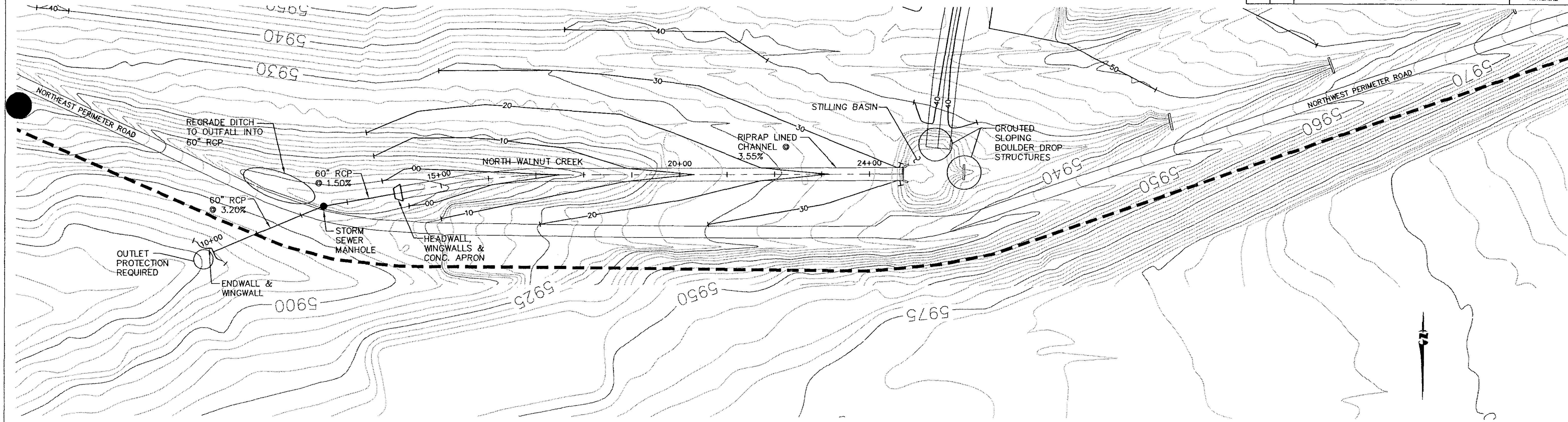
Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

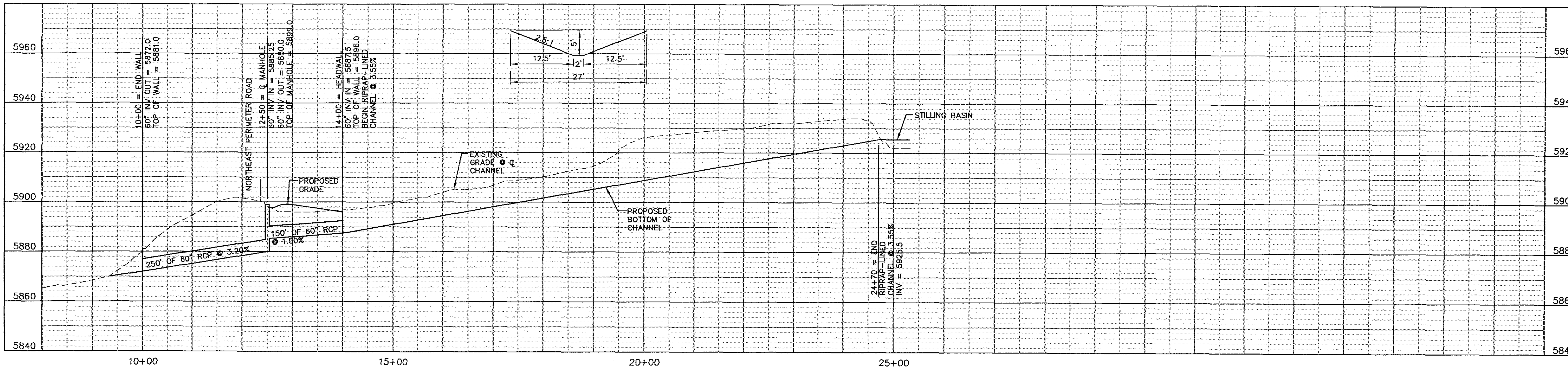
LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-03 PLAN AND PROFILE
SECTION B-B'

SIZE: D
DRAWING NUMBER: 51754-C003
ISSUE: 0

535





NORTH WALNUT CREEK PROPOSED CHANNEL

0' 25' 50' 100' 200'
SCALE: HORIZONTAL 1"=100'
VERTICAL 1"=20'

LEGEND

- STUDY LIMITS
- EXISTING INTERMEDIATE CONTOURS
- 6000 EXISTING INDEX CONTOURS
- PAVED ROADS
- UNPAVED ROAD
- 70 PROPOSED INDEX CONTOURS
- PROPOSED EDGE OF CHANNEL
- PROPOSED CHANNEL OR SWALE CENTERLINE
- PROPOSED CULVERT

NOTES

1. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.
2. SEP ET COVER: HOLD.

DRAWINGS ARE NOT FOR CONSTRUCTION

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL

ISSUE	DESCRIPTION
0	ORIGINAL ISSUE/CONCEPTUAL DESIGN

KEYWORDS: 1.LAND 2.CONFIG. 3.DRAINAGE 4.CONTOUR 5.CONCEPT

TOLERANCES: FRACT. ± ANGLE ± DEC.
UNLESS NOTED OTHERWISE
REMOVE BURRS AND SHARP EDGES

BLDG./FACILITY: SITE
ROOM/AREA: N/A
GRID COORD./COL NO.: N/A
NEXT ASSEMBLY: N/A
SCALE: AS SHOWN

DESIGN COMPANY: PARSONS I&T
DESIGNED BY: J. KAPINOS JMK
DRAWN BY: J. HARSCH JLH
CHECKED BY: R. STEGEN RLS 01/23/02
INDEPENDENT VERIFIER
APPROVED BY
CLASSIFIER
ADDITIONAL APPROVALS

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

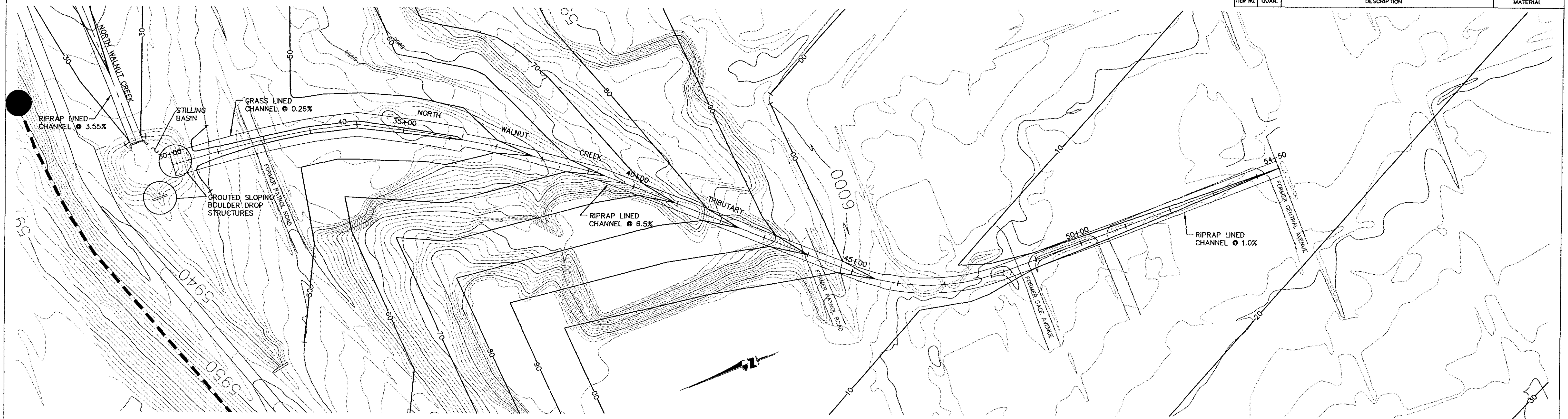
Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

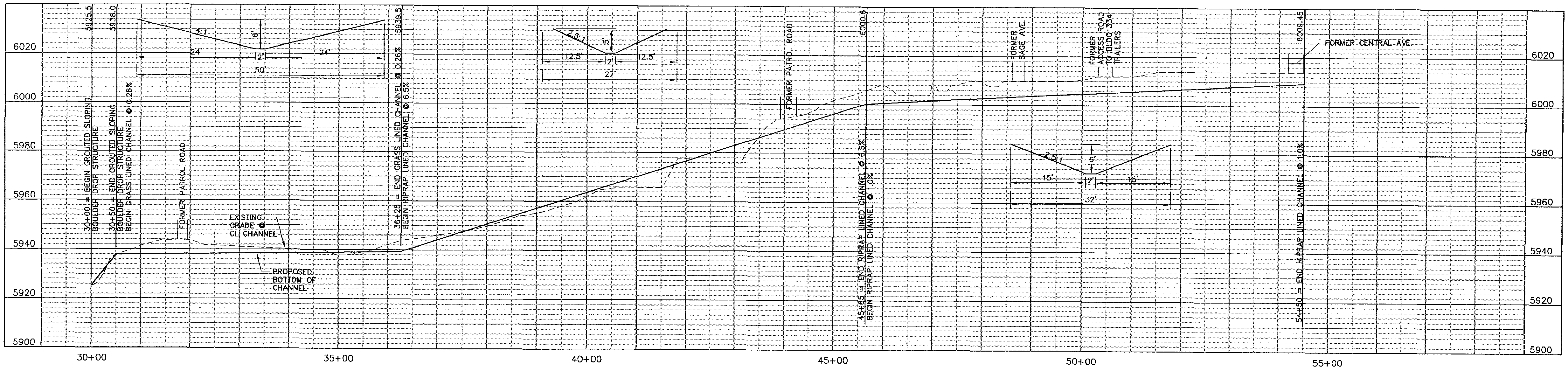
LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-04 PLAN AND PROFILE
NORTH WALNUT CREEK

SIZE	DRAWING NUMBER	ISSUE
D	51754-C004	0

536





NORTH WALNUT CREEK TRIBUTARY PROPOSED CHANNEL

0' 25' 50' 100' 200'
SCALE: HORIZONTAL 1"=100'
VERTICAL 1"=20'

LEGEND

- STUDY LIMITS
- EXISTING INTERMEDIATE CONTOURS
- EXISTING INDEX CONTOURS (6000)
- PAVED ROADS
- UNPAVED ROAD
- PROPOSED INDEX CONTOURS (70)
- PROPOSED EDGE OF CHANNEL
- PROPOSED CHANNEL OR SWALE CENTERLINE

NOTES

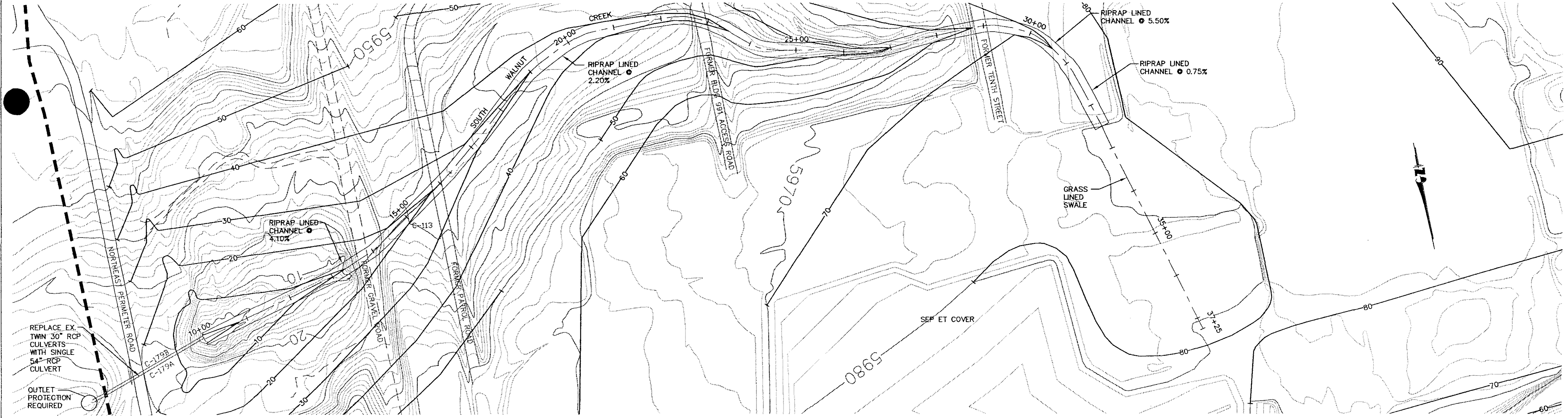
1. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.
2. SEP ET COVER: HOLD.

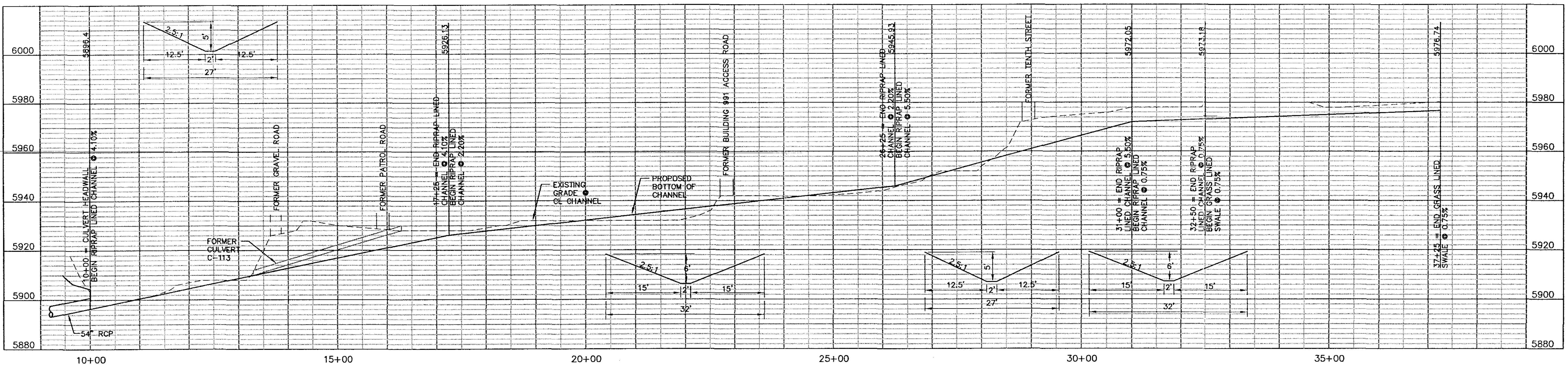
DRAWINGS ARE NOT FOR CONSTRUCTION

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL

0 (ISSUE)	ORIGINAL ISSUE/CONCEPTUAL DESIGN (DESCRIPTION)	KH900286-003 PROJECT/WCF NO.
KEYWORDS: 1.LAND 2.CONFIG. 3.DRAINAGE 4.CONTOUR 5.CONCEPT	TOLERANCES: FRACT. ± ANGLE ± DEC. UNLESS NOTED OTHERWISE; REMOVE BURRS AND SHARP EDGES	U.S. DEPARTMENT OF ENERGY, ROCKY FLATS OFFICE, GOLDEN, COLORADO
BLDG./FACILITY: SITE	DESIGN COMPANY: PARSONS I&T	Rocky Flats Environmental Technology Site, GOLDEN, COLORADO
ROOM/AREA: N/A	DESIGNED BY: J. KAPINOS JMK	LAND CONFIGURATION DESIGN BASIS GRADING AND DRAINAGE CONCEPT
GRID COORD./COL NO.: N/A	DRAWN BY: J. HARSCH JLH	FIGURE E-06 PLAN AND PROFILE NORTH WALNUT CREEK TRIBUTARY
NEXT ASSEMBLY: N/A	CHECKED BY: R. STEGEN RLS 01/23/02; INDEPENDENT VERIFIER; APPROVED BY; CLASSIFIER; ADDITIONAL APPROVALS	SIZE: D; DRAWING NUMBER: 51754-C005; ISSUE: 0
SCALE: AS SHOWN		

581





SOUTH WALNUT CREEK PROPOSED CHANNEL

0' 25' 50' 100' 200'
SCALE: HORIZONTAL 1"=100'
VERTICAL 1"=20'

LEGEND

- STUDY LIMITS
- EXISTING INTERMEDIATE CONTOURS
- 6000 — EXISTING INDEX CONTOURS
- PAVED ROADS
- UNPAVED ROAD
- 70 — PROPOSED INDEX CONTOURS
- PROPOSED EDGE OF CHANNEL
- PROPOSED CHANNEL OR SWALE CENTERLINE
- C-113 EXISTING CULVERTS

NOTES

1. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.
2. SEP ET COVER: HOLD.

DRAWINGS ARE NOT FOR CONSTRUCTION

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL

ISSUE	DESCRIPTION
0	ORIGINAL ISSUE/CONCEPTUAL DESIGN

KEYWORDS: 1.LAND 2.CONFIG. 3.DRAINAGE 4.CONTOUR 5.CONCEPT

BLDG./FACILITY: SITE
ROOM/AREA: N/A
GRID COORD./COL. NO.: N/A
TOLERANCES: FRACT. ± ANGLE ± DEC. ±
UNLESS NOTED OTHERWISE
REMOVE BURRS AND SHARP EDGES
NEXT ASSEMBLY: N/A
SCALE: AS SHOWN

DESIGN COMPANY: PARSONS I&T
DESIGNED BY: J. KAPINOS JMK
DRAWN BY: J. HARSCH JLH
CHECKED BY: R. STEGEN RLS 01/23/02
INDEPENDENT VERIFIER
APPROVED BY
CLASSIFIER
ADDITIONAL APPROVALS

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

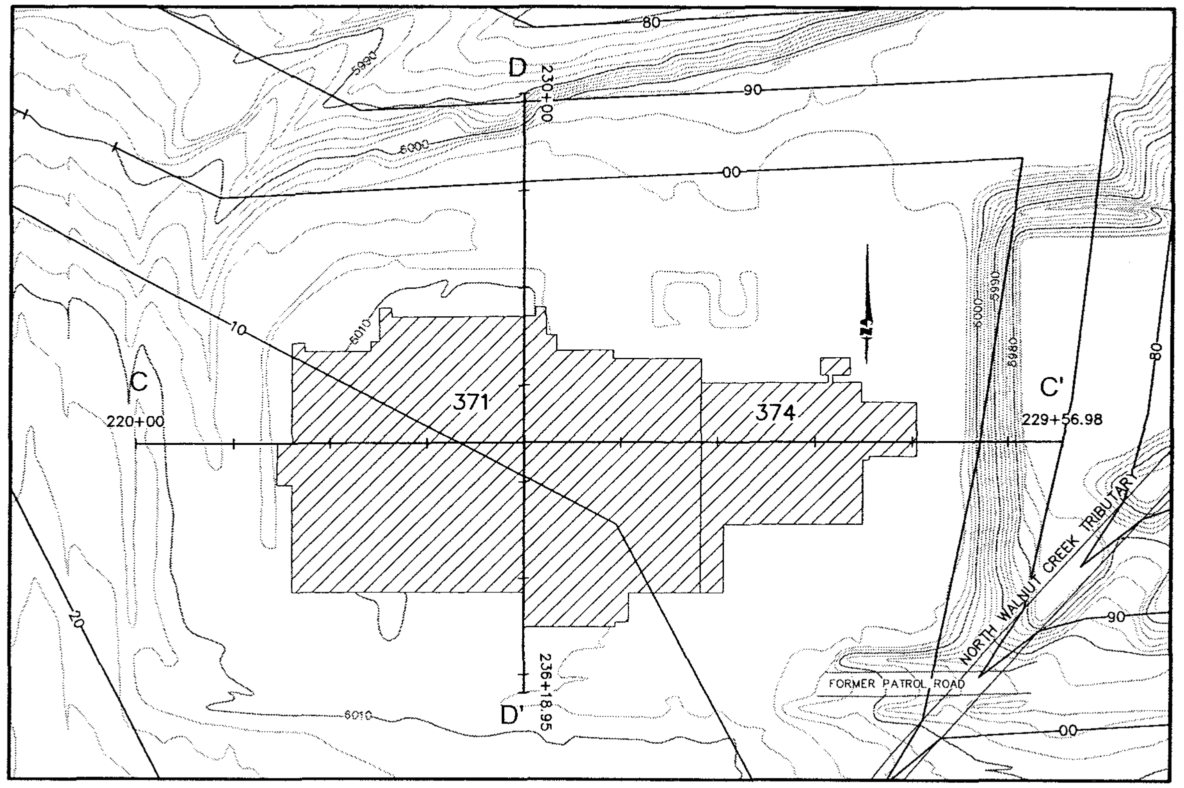
Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-06 PLAN AND PROFILE
SOUTH WALNUT CREEK

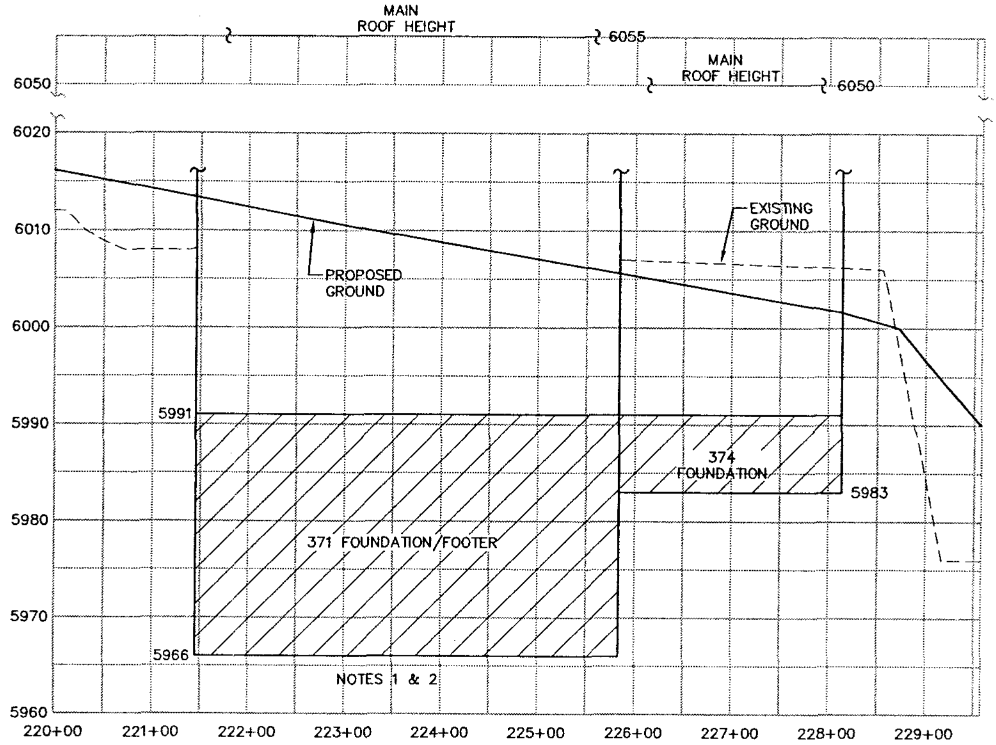
SIZE	DRAWING NUMBER	ISSUE
D	51754-C006	0

538



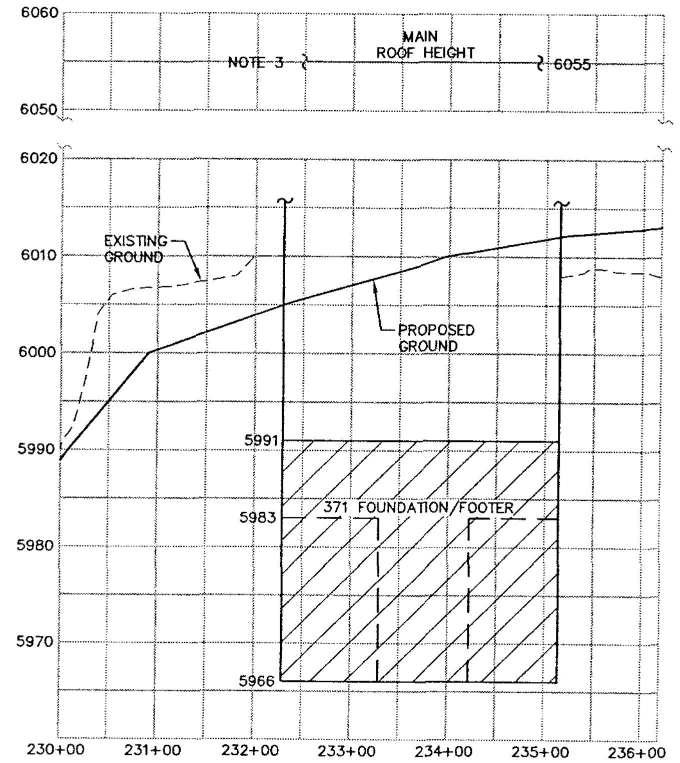
BUILDING 371 PLAN VIEW

0 25 50 100 200
SCALE: 1" = 100'



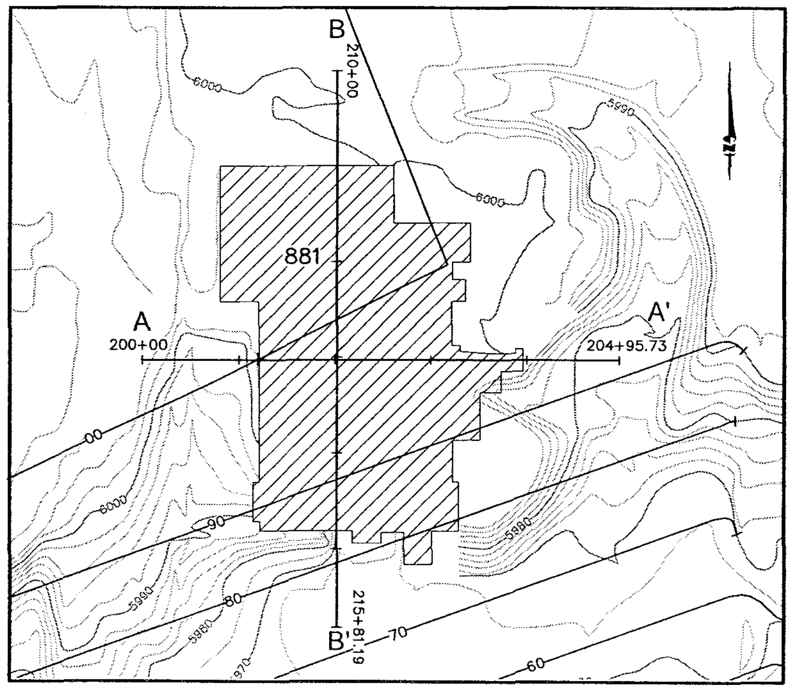
BUILDING 371/374, C-C' WEST - EAST

SCALE: HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



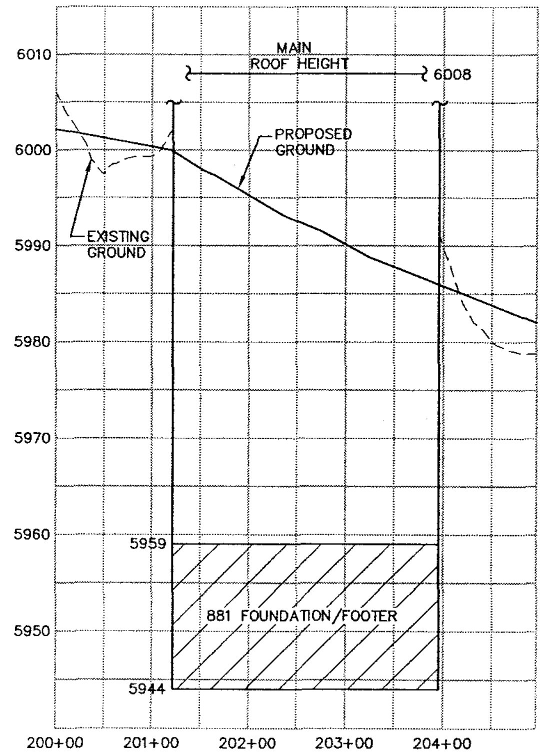
BUILDING 371, D-D' NORTH - SOUTH

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



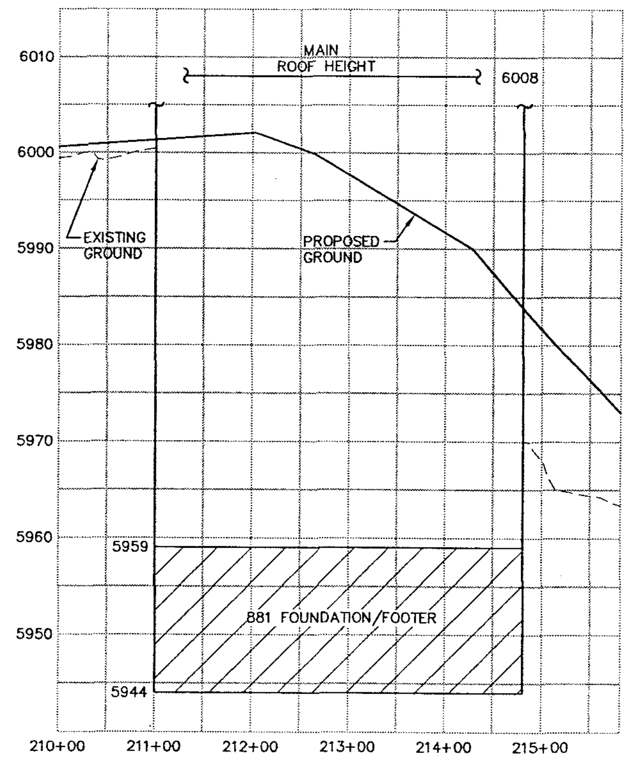
BUILDING 881 PLAN VIEW

0 25 50 100 200
SCALE: 1" = 100'



BUILDING 881, A-A' WEST - EAST

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



BUILDING 881, B-B' NORTH - SOUTH

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'

NOTES:

1. BUILDING CROSS-SECTIONS REPRESENT A SIMPLIFIED CONSERVATIVE ENVELOPE OF MAJOR SUBSURFACE BUILDING FOOTER/FOUNDATIONS AND DO NOT DEPICT ACTUAL LOCATIONS OF INDIVIDUAL STRUCTURAL COMPONENTS.

2. THE BASE OF THE CROSS HATCHED AREA REPRESENTS THE BOTTOM OF THE LOWEST ELEVATION OF THE BUILDING FOOTER/FOUNDATION. THE TOP OF THE CROSS HATCHED AREA REPRESENTS THE ELEVATION OF THE TOP OF THE LOWEST REMAINING BUILDING SLAB (TOP OF TUNNEL FOR TUNNELS) PLUS THREE FEET.

3. THE INDICATED BUILDING ROOF ELEVATION IS THE HIGHEST FINISHED BUILDING MAIN ROOF HEIGHT FOR THE STRUCTURE.

4. FOUNDATION/FOOTER INFORMATION IS APPROXIMATE FROM HYDROGEOLOGIC CHARACTERIZATION REPORT FOR RFETS, APRIL 1995.

5. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.

DRAWINGS ARE NOT FOR CONSTRUCTION

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL

0 ISSUE — ORIGINAL ISSUE/CONCEPTUAL DESIGN — DESCRIPTION

KEYWORDS: 1.LAND 2.CONFIG. 3.DRAINAGE 4.CONTOUR 5.CONCEPT

BLDG./FACILITY: SITE
RCOM/AREA: N/A
GRID COORD./COL NO.: N/A

TOLERANCES: FRACT. ± ANGLE ± DEC.
UNLESS NOTED OTHERWISE
REMOVE BURRS AND SHARP EDGES
NEXT ASSEMBLY: N/A
SCALE: AS SHOWN

DESIGN COMPANY: PARSONS I&T
DESIGNED BY: J. KAPINOS JMK
DRAWN BY: J. HARSCH JLH
CHECKED BY: R. STEGEN RLS 01/23/02
INDEPENDENT VERIFIER
APPROVED BY
CLASSIFIER
ADDITIONAL APPROVALS

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

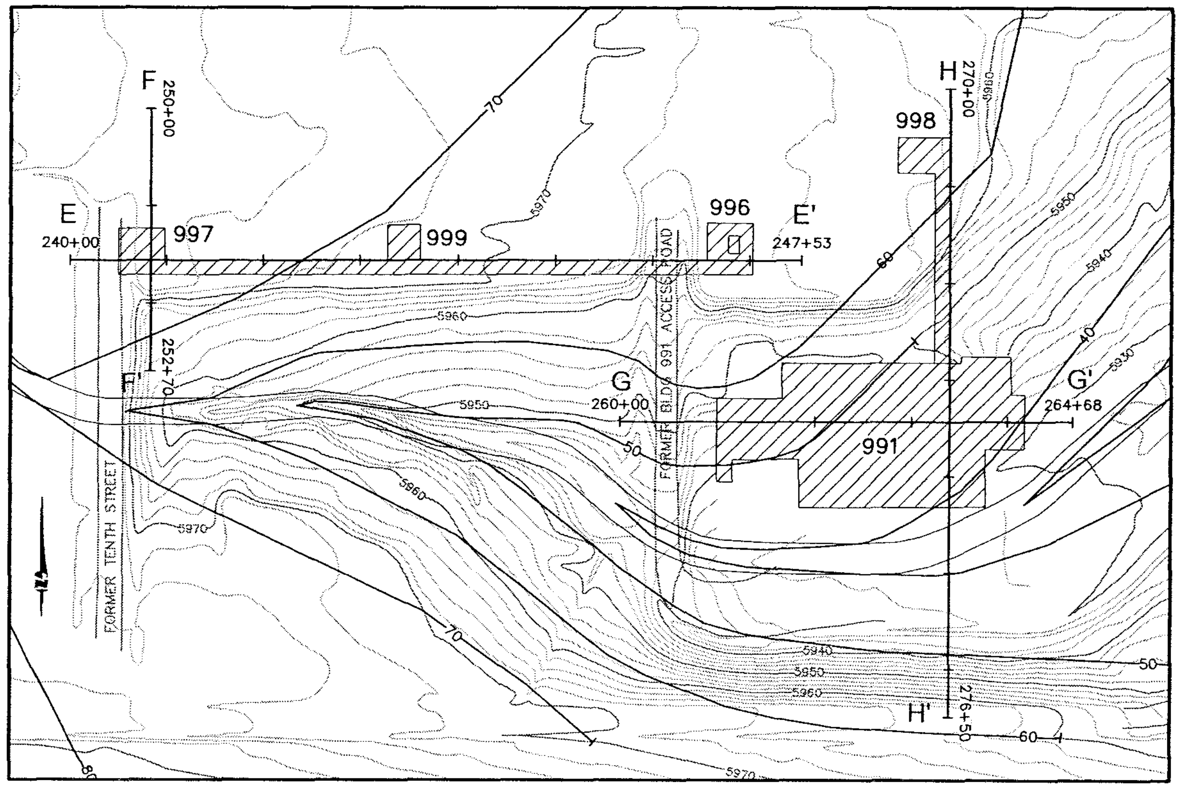
Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-07 PLAN AND PROFILE
BUILDINGS 371 AND 881 SECTIONS

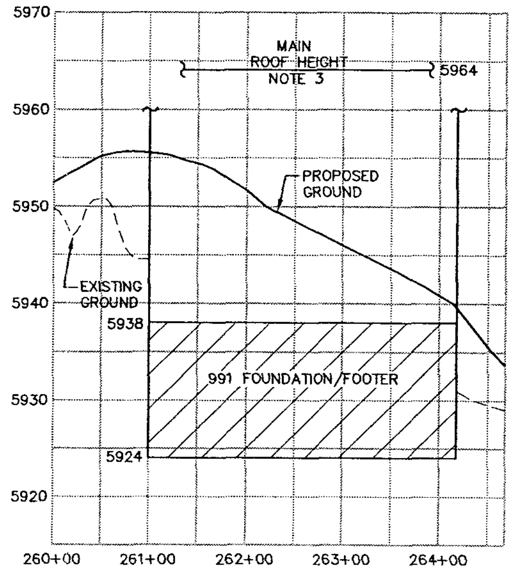
SIZE: D DRAWING NUMBER: 51754-C007 ISSUE: 0

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL



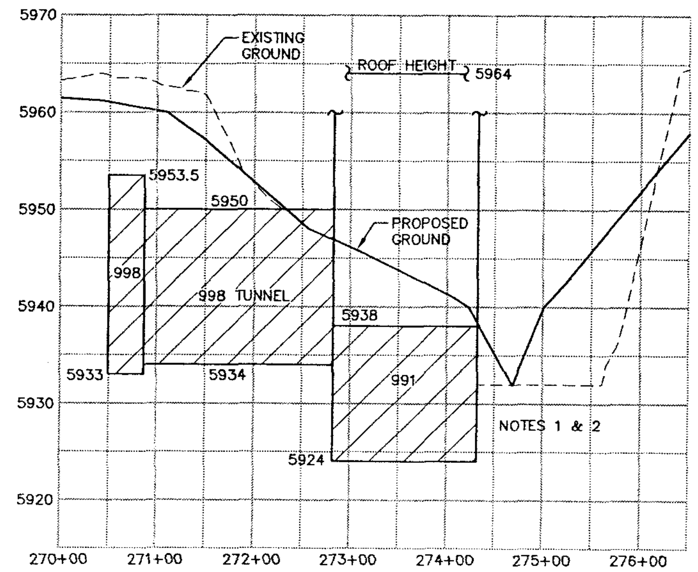
BUILDING 991 AND TUNNELS PLAN VIEW

0 25 50 100 200
SCALE: 1" = 100'



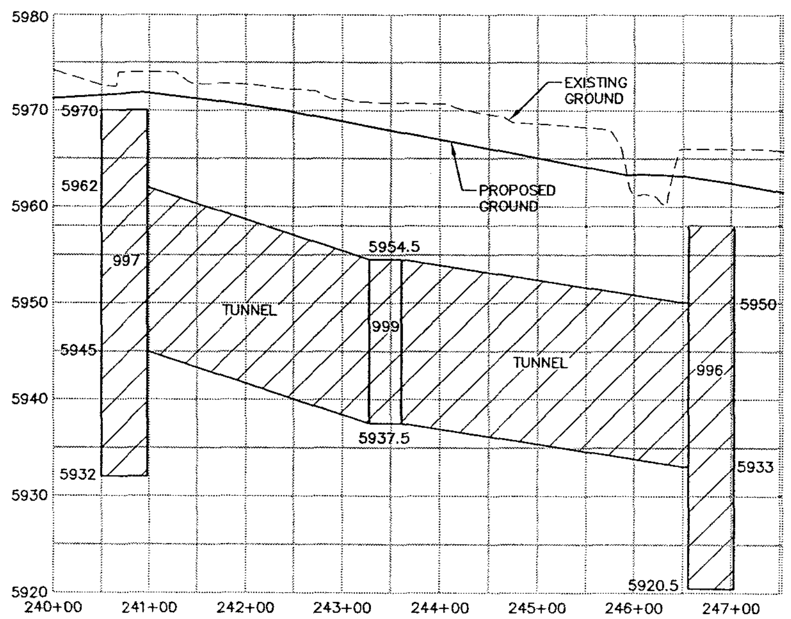
BUILDING 991, G-G' WEST - EAST

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



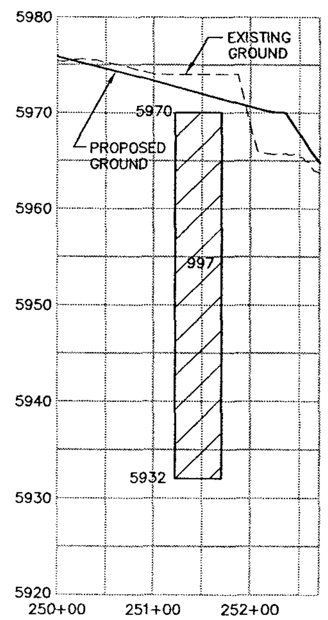
BUILDING 991/998, H-H' NORTH - SOUTH

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



996/997/999 TUNNEL E-E' WEST - EAST

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



BUILDING 997, F-F' NORTH - SOUTH

HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'

NOTES:

1. BUILDING CROSS-SECTIONS REPRESENT A SIMPLIFIED CONSERVATIVE ENVELOPE OF MAJOR SUBSURFACE BUILDING FOOTER/FOUNDATIONS AND DO NOT DEPICT ACTUAL LOCATIONS OF INDIVIDUAL STRUCTURAL COMPONENTS.

2. THE BASE OF THE CROSS HATCHED AREA REPRESENTS THE BOTTOM OF THE LOWEST ELEVATION OF THE BUILDING FOOTER/FOUNDATION. THE TOP OF THE CROSS HATCHED AREA REPRESENTS THE ELEVATION OF THE TOP OF THE LOWEST REMAINING BUILDING SLAB (TOP OF TUNNEL FOR TUNNELS) PLUS THREE FEET.

3. THE INDICATED BUILDING ROOF ELEVATION IS THE HIGHEST FINISHED BUILDING MAIN ROOF HEIGHT FOR THE STRUCTURE.

4. FOUNDATION/FOOTER INFORMATION IS APPROXIMATE FROM HYDROGEOLOGIC CHARACTERIZATION REPORT FOR RFETS, APRIL 1995 AND BUILDING DRAWINGS.

5. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.

DRAWINGS ARE NOT FOR CONSTRUCTION

0 (ISSUE)	ORIGINAL ISSUE/CONCEPTUAL DESIGN (DESCRIPTION)	
KEYWORDS	TOLERANCES: FRACT. ± ANGLE ± DEC. UNLESS NOTED OTHERWISE; REMOVE BURRS AND SHARP EDGES	DESIGN COMPANY: PARSONS I&T
1.LAND		DESIGNED BY: J. KAPINOS JMK
2.CONFIG.		DRAWN BY: J. HARSCH JLH
3.DRAINAGE		CHECKED BY: R.STEGEN RLS 01/23/02
4.CONTOUR		INDEPENDENT VERIFIER
5.CONCEPT		APPROVED BY
BLDG./FACILITY: SITE	NEXT ASSEMBLY: N/A	CLASSIFIER
ROOM/AREA: N/A	SCALE: AS SHOWN	ADDITIONAL APPROVALS
GRID COORD./COL NO.: N/A		

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

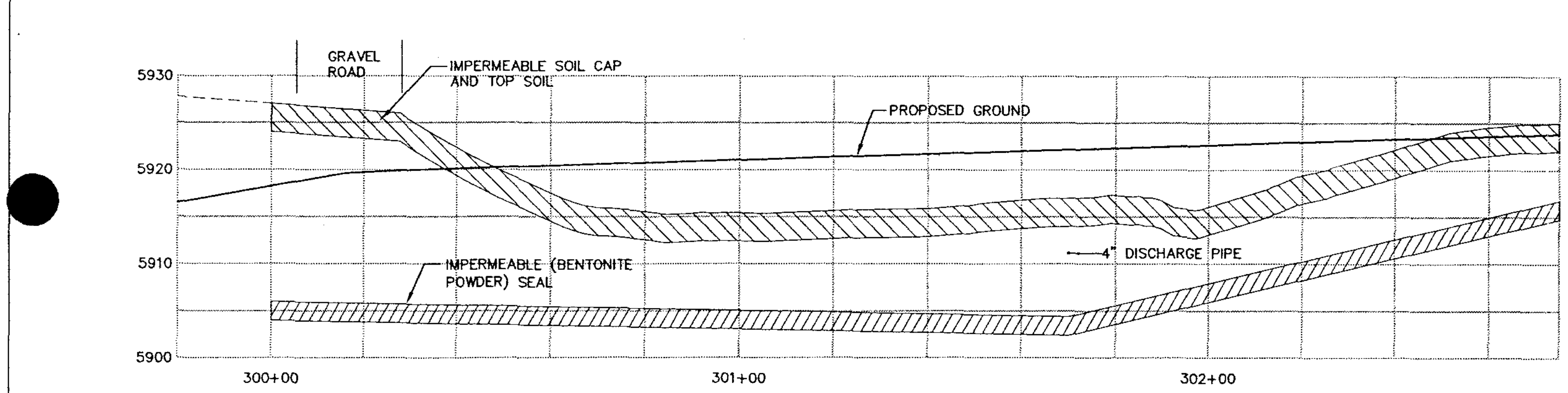
Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-08 PLAN AND PROFILE
BUILDING 991 SECTIONS

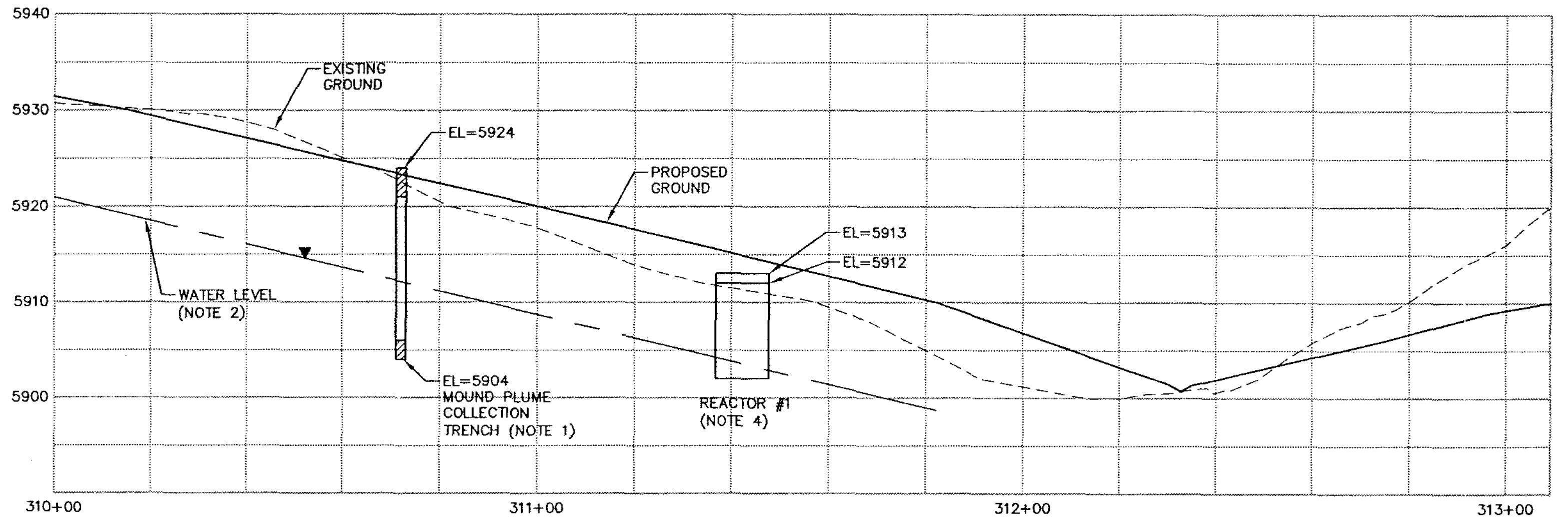
SIZE	DRAWING NUMBER	ISSUE
D	51754-C008	0

510



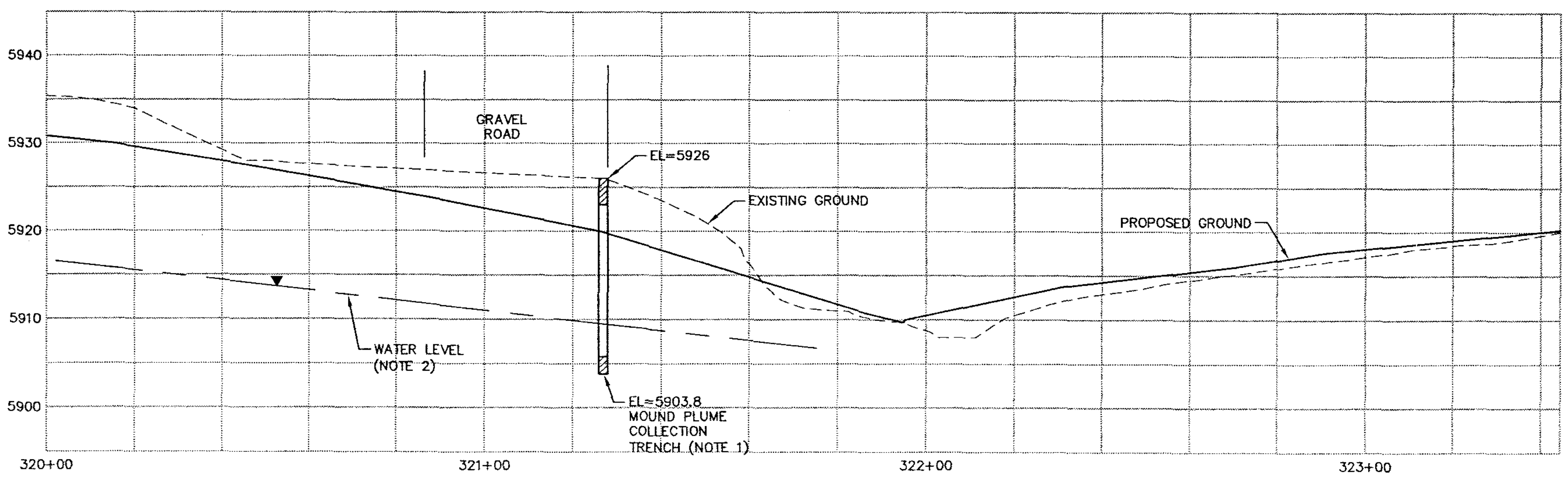
SECTION I - I'

SCALE: HORIZ. 1" = 10' VERT. 1" = 5'



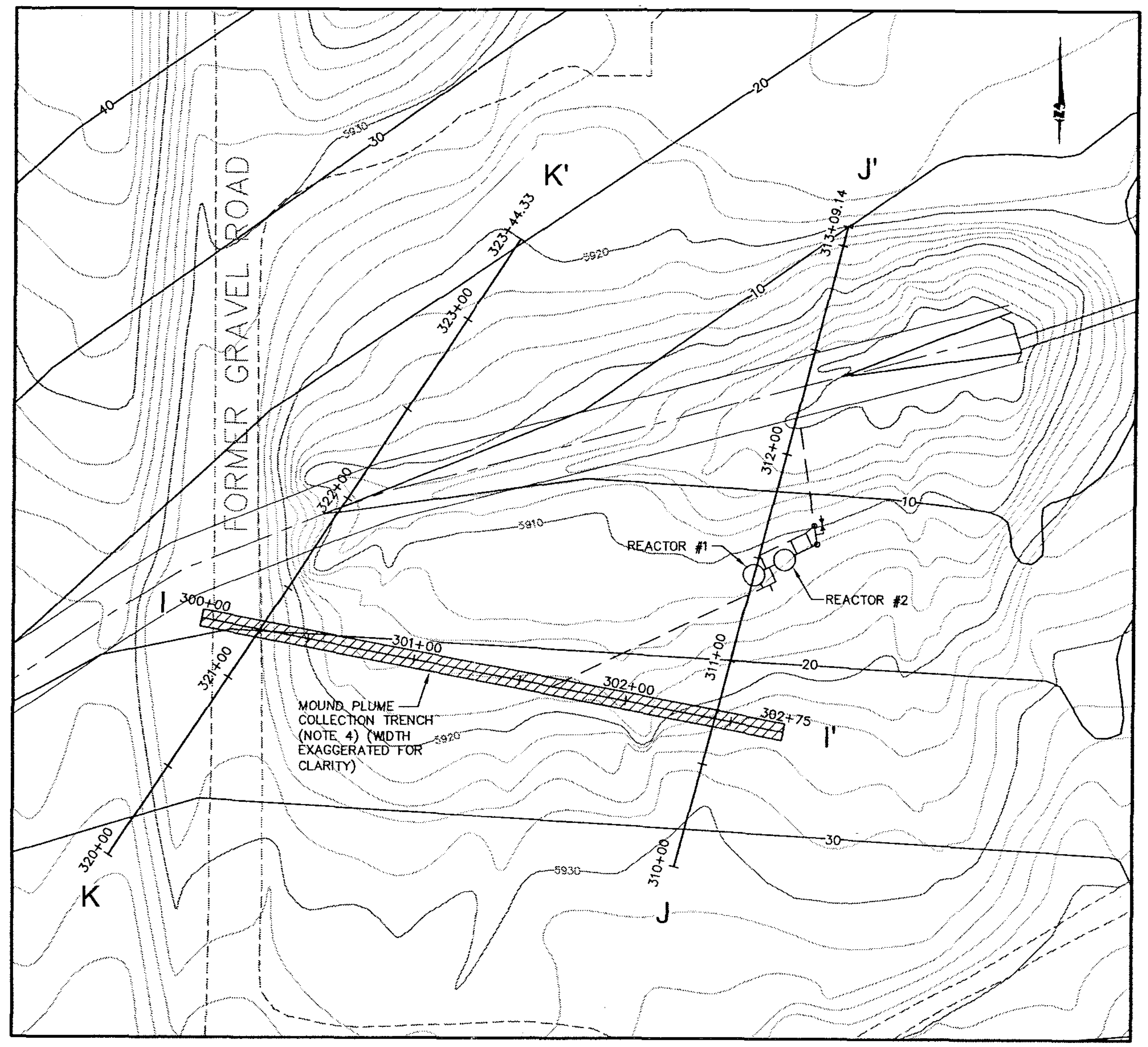
SECTION J - J'

SCALE: HORIZ. 1" = 10' VERT. 1" = 5'



SECTION K - K'

SCALE: HORIZ. 1" = 10' VERT. 1" = 5'



PLAN VIEW

SCALE: 1" = 40'

NOTES:

1.) LOCATIONS, DIMENSIONS, AND ELEVATIONS OF MOUND PLUME SYSTEM COMPONENTS TAKEN FROM DESIGN DRAWING 51521-X001 (USACE, 1997).

2.) GROUNDWATER ELEVATIONS REFLECT DATA FROM 30 APR 97 AS IDENTIFIED ON DESIGN DRAWING 51521-0105.

3.) IMPACT ON MOUND PLUME TRENCH TO BE FURTHER EVALUATED FOLLOWING COMPLETION OF SITE WIDE WATER BALANCE.

4.) EXTEND EXISTING REACTOR ACCESS RISERS (REACTOR #1 AND 2) TO 1 FOOT ABOVE PROPOSED GRADE.

5. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.

6. SEP ET COVER DETAILS FROM CONCEPTUAL DESIGN.

DRAWINGS ARE NOT FOR CONSTRUCTION

ISSUE	DESCRIPTION	
0	ORIGINAL ISSUE/CONCEPTUAL DESIGN	

KEYWORDS	TOLERANCES	
1.LAND	FRACT. ±	DESIGN COMPANY: PARSONS I&T
2.CONFIG.	ANGLE ±	DESIGNED BY: J. KAPINOS — JMK
3.DRAINAGE	DEC.	DRAWN BY: J. HARSCH — JLH
4.CONTOUR	UNLESS NOTED OTHERWISE	CHECKED BY: R. STEGEN — RLS — 01/23/02
5.CONCEPT	REMOVE BURRS AND SHARP EDGES	INDEPENDENT VERIFIER
BLDG./FACILITY: SITE	NEXT ASSEMBLY: N/A	APPROVED BY
ROOM/AREA: N/A	SCALE: AS SHOWN	CLASSIFIER
GRID COORD./COL NO.: N/A		ADDITIONAL APPROVALS

KH900286-003
PROJECT/WCF NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS OFFICE GOLDEN, COLORADO

Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

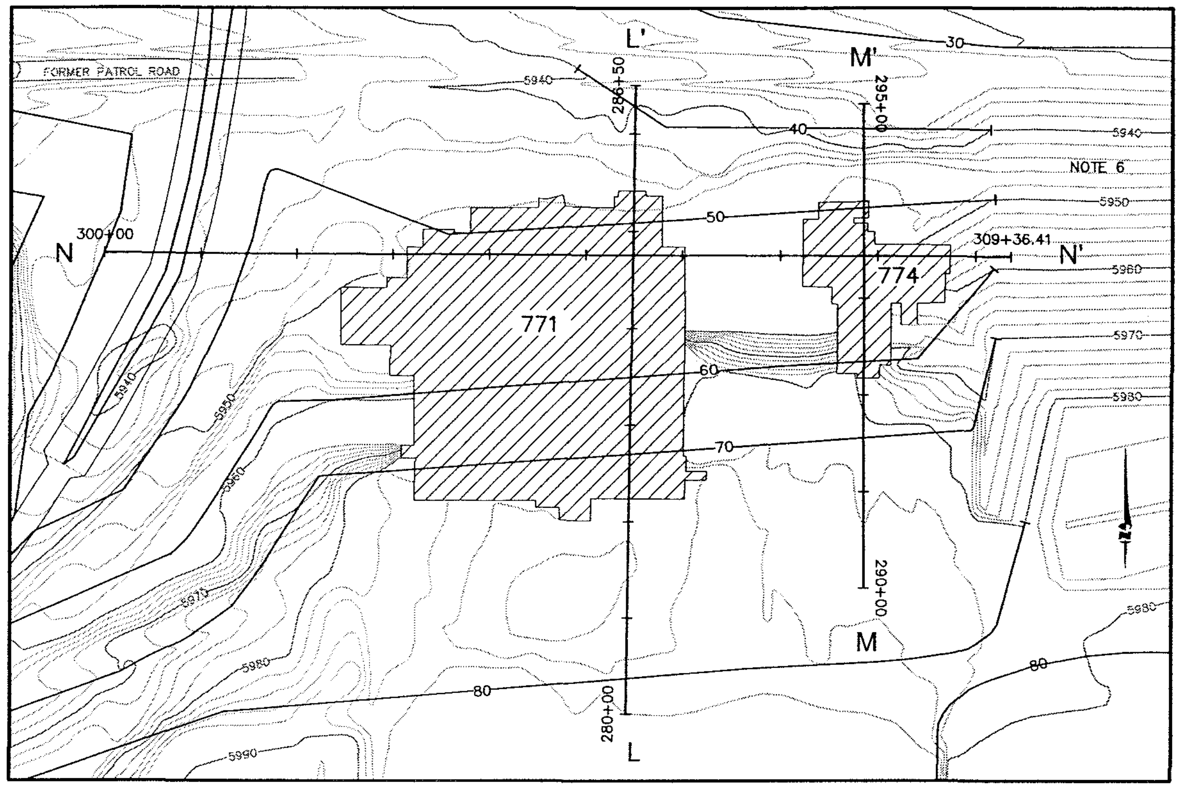
LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-09 PLAN AND PROFILE
MOUND PLUME SYSTEM SECTIONS

SIZE	DRAWING NUMBER	ISSUE
D	51754-C009	0

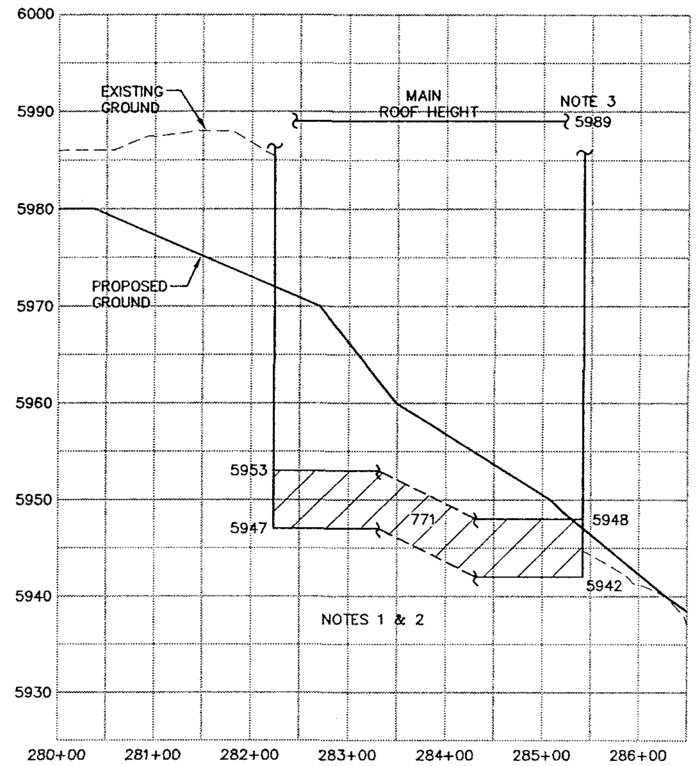
ITEM NO.	QUAN.	DESCRIPTION	MATERIAL

ITEM NO.	QUAN.	DESCRIPTION	MATERIAL



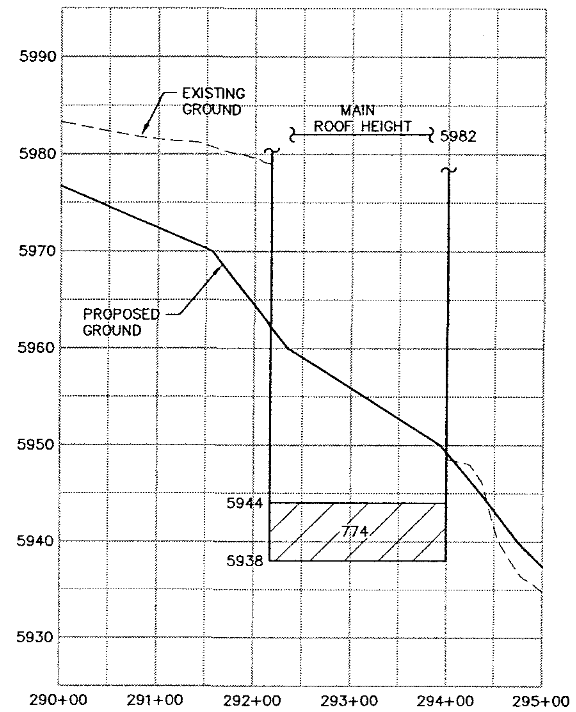
BUILDING 371 PLAN VIEW

0 25 50 100 200
SCALE: 1" = 100'



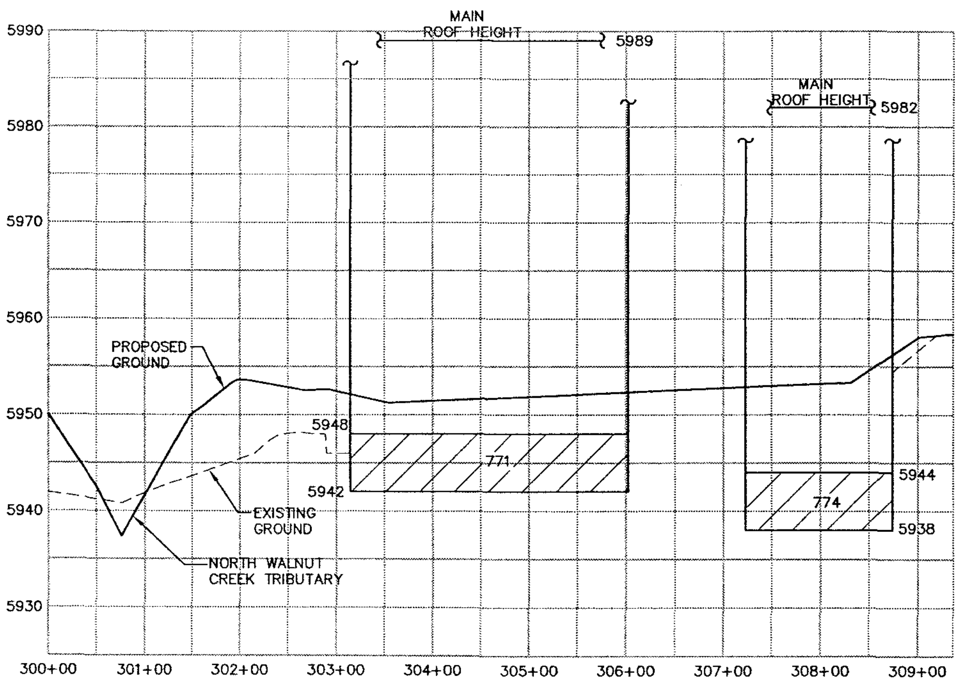
BUILDING 771, L-L' SOUTH - NORTH

SCALE: HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



BUILDING 774, M-M' SOUTH - NORTH

SCALE: HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'



BUILDING 771/774, N-N' WEST - EAST

SCALE: HORIZONTAL 1" = 100'
VERTICAL: 1" = 10'

NOTES:

1. BUILDING CROSS-SECTIONS REPRESENT A SIMPLIFIED CONSERVATIVE ENVELOPE OF MAJOR SUBSURFACE BUILDING FOOTER/FOUNDATIONS AND DO NOT DEPICT ACTUAL LOCATIONS OF INDIVIDUAL STRUCTURAL COMPONENTS.

2. THE BASE OF THE CROSS HATCHED AREA REPRESENTS THE BOTTOM OF THE LOWEST ELEVATION OF THE BUILDING FOOTER/FOUNDATION. THE TOP OF THE CROSS HATCHED AREA REPRESENTS THE ELEVATION OF THE TOP OF THE LOWEST REMAINING BUILDING SLAB (TOP OF TUNNEL FOR TUNNELS) PLUS THREE FEET.

3. THE INDICATED BUILDING ROOF ELEVATION IS THE HIGHEST FINISHED BUILDING MAIN ROOF HEIGHT FOR THE STRUCTURE.

4. FOUNDATION/FOOTER INFORMATION IS APPROXIMATE FROM HYDROGEOLOGIC CHARACTERIZATION REPORT FOR RFETS, APRIL 1995.

5. SEE LCDB REPORT (FEB 2002) FOR DESCRIPTION AND LIMITATIONS OF GRADING AND DRAINAGE CONCEPT.

6. SEP ET COVER DETAILS FROM CONCEPTUAL DESIGN.

DRAWINGS ARE NOT FOR CONSTRUCTION

ISSUE	DESCRIPTION	
0	ORIGINAL ISSUE/CONCEPTUAL DESIGN	
KEYWORDS: 1.LAND 2.CONFIG. 3.DRAINAGE 4.CONTOUR 5.CONCEPT	TOLERANCES: FRACT. ± ANGLE ± DEC. UNLESS NOTED OTHERWISE; REMOVE BURRS AND SHARP EDGES	DESIGN COMPANY: PARSONS I&T
		DESIGNED BY: J. KAPINOS JMK
		DRAWN BY: J. HARSCH JLH
		CHECKED BY: R. STEGEN RLS 01/23/02
		INDEPENDENT VERIFIER
BLDG./FACILITY: SITE		APPROVED BY
ROOM/AREA: N/A	NEXT ASSEMBLY: N/A	CLASSIFIER
GRID COORD./COL NO.: N/A	SCALE: AS SHOWN	ADDITIONAL APPROVALS

KH900286-003
PROJECT/WCF NO.

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ROCKY FLATS OFFICE GOLDEN, COLORADO

Rocky Flats Environmental Technology Site
GOLDEN, COLORADO

LAND CONFIGURATION DESIGN BASIS
GRADING AND DRAINAGE CONCEPT

FIGURE E-10 PLAN AND PROFILE
BUILDING 771/774 SECTIONS

SIZE	DRAWING NUMBER	ISSUE
D	51754-C010	0

512