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Work Plan for Land Configuration Design Basis Project

prepared by

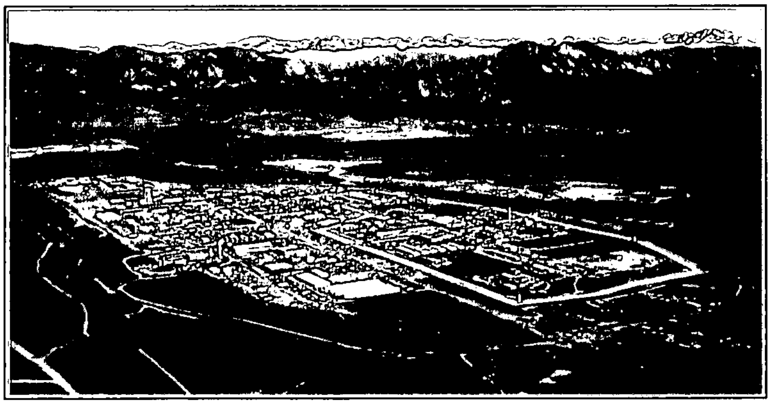
LCDB Project Team

for the

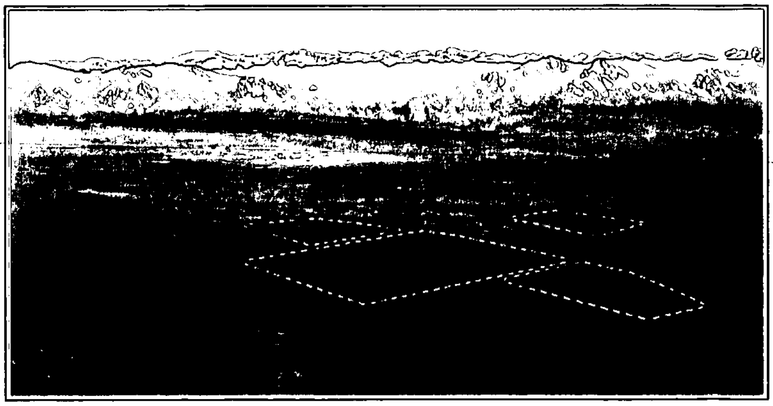
Rocky Flats Environmental Technology Site

Golden, Colorado

July 2001



Rocky Flats in 1998



Rocky Flats End State

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Kaiser-Hill Company, L.L.C.

Work Plan

for

Land Configuration Design Basis Project

Prepared For:

Rocky Flats Environmental Technology Site

United States Department of Energy
Golden, Colorado

July 2001

PARSONS

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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	decontamination 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	ground water
HDPE	high density polyethylene
IA	Industrial Area
Kaiser-Hill	Kaiser-Hill Company, LLC

LIST OF ACRONYMS AND ABBREVIATIONS

L	liter(s)
LCDB	Land Configuration Design Basis
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
PMJM	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

LIST OF ACRONYMS AND ABBREVIATIONS

USDA	U.S. Department of Agriculture
UHSU	upper hydrostratigraphic unit
USGS	U.S. Geological Survey
VOC	volatile organic compound
WWE	Wright Water Engineers
WWTP	wastewater treatment plant

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, it is recognized that legislation to designate RFETS a National Wildlife Refuge is also being considered. 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. If the proposed legislation is enacted, the 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 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. For instance, 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 can evaluate various components associated with each bounding scenario and assess the effectiveness of the initial conceptual design in achieving RFCA defined surface water quality standards.

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.

Section 8 of the work plan provides additional details regarding the various interfaces for the LCDB Project. Integration between the Site's closure programs (including the AME and SWWB Projects) will occur throughout the execution of the LCDB Project to develop the design basis for the final land configuration that is effective and acceptable to the RFCA parties.

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 decontamination 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.

Stewardship generally addresses the need for continued protection of human health and the environment once remediation activities are completed. 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 expected completion date for the design basis and CDR for issuance to the RFCA Parties [United States Environmental Protection Agency (EPA), and Colorado Department of Public Health and Environment (CDPHE)] for review and comment is January 2002. 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 (expected in March 2002).

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 insoluble 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. Although the LCDB Project will address the potential impacts to surface water via soil erosion and ground water transport mechanisms, the transport of insoluble actinides associated with surface soils by erosion is concluded to be the primary cause of the historical monitoring data that is elevated above the surface water action levels.

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 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 human health and the environment.

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 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 Prebles's meadow jumping mouse (PMJM), 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 PMJM, 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 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) 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 are ongoing and a final decision will be made later.

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 excluded from the LCDB Project boundaries because drainage into these basins is unlikely to be affected by activities conducted at RFETS.

Although the LCDB Project boundary includes 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,
- Decontamination and decommissioning (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.

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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 selected 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 Wetland Filtering and Treatment

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 denitrify surface waters, which may be appropriate to provide added or backup treatment for ground water discharges associated with the Solar Evaporation Pond plume. 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, hillslopes) 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).

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, hillslope 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, 2000).

4.9 Evapotranspiration Controls

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 controls 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. Water augmentation may be required to replace the amount of water that is lost through implementation of the ET controls. Decreases in runoff could also have a greater impact on wetlands and habitats.

4.10 Infiltration

This option would be used to promote infiltration in specific sectors that are susceptible to contaminant migration to reduce runoff and associated erosion of actinide-bearing soils. Increased infiltration may enhance preservation of wetlands by increasing flow to seepage areas. However, hillslopes 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 wetlands and habitats).
- 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 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 controls, 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 (±50 percent).
- A rough order of magnitude life cycle 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, have been constructed at RFETS over the years 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 reconfiguration strategy for the ponds will address the following factors and considerations:

- 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 strategy will be applied 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.

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. 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 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;
- Evapotranspiration controls;
- Closure of BZ access roads;
- Hillslope 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 PMJM.
- Specification for revegetation.
- 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 PMJM 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, monitoring, operations, maintenance, physical controls, institutional controls, management (including records and information systems), 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 stormwater 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 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.

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 CDR to DOE for Review	December 2001
• Issue CDR to Regulatory Agencies/Stakeholders / Public	January 2002
• Issue Final CDR	March 2002

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.

11.0 REFERENCES

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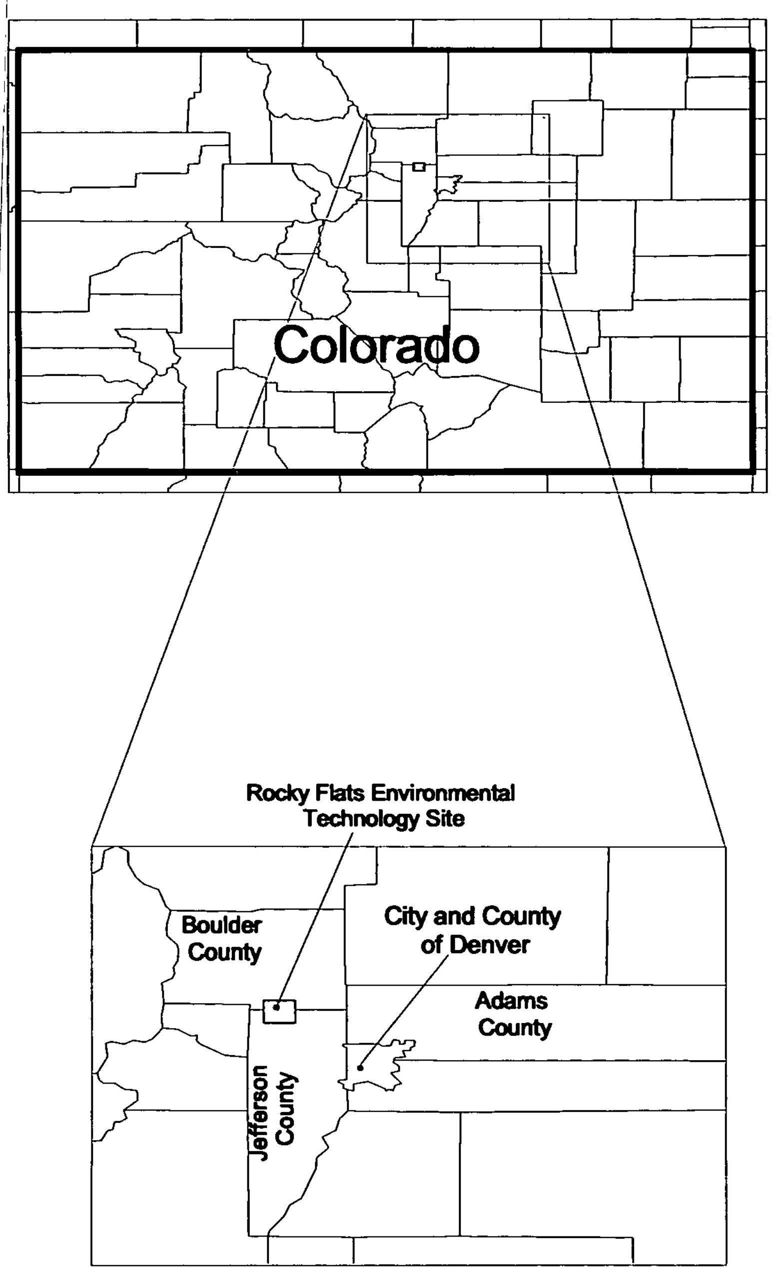

Figure 1

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

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May 16, 2001

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.
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.
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.
Evaluate the anticipated conditions at completion of active remediation	See Section 5.2	This task is in progress.
Develop bounding scenarios	See Section 5.3	This task is in progress.
Develop initial conceptual design	See Section 6.0	Task has not been initiated.
Develop pond reconfiguration strategy	See Section 6.1	This task is in progress.
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.

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

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 decisionmaking, including information acquisition, design development, and design evaluations, are appropriate for the intended purpose. EPA has issued guidelines to help decisionmakers develop site- and project-specific DQOs. The process is intended to:

- Clarify the project's objectives;
- Define the decisionmaking 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
  - 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

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
        - Topos, 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
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).

APPENDIX B
DESIGN BASIS FOR
THE FINAL LAND CONFIGURATION

DESIGN BASIS FOR THE FINAL LAND CONFIGURATION

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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 decontamination 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 evaluation and design of control measures for runoff from watersheds that flow offsite via tributaries and ditches that are not associated with a POC are not included within the scope of the LCDB Project.
- 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.

- 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.

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 contaminated buildings, structures, utilities, and associated soils in excess of the RFCA Tier I action levels that cannot be decontaminated will be removed or stabilized (see Section 2.2.3.2).
- Solis above Tier 1 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 grade regardless of contamination level (see Section 2.2.3.2). Telephone, alarm and electrical systems are not considered utilities for this purpose.
- Uncontaminated structures including foundations and slabs more than 3 feet below 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 existing surface topography, 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, three feet of clean fill dirt 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 Walnut Creek Diversion Ditch, South Interceptor Ditch, and East Trenches Diversion Ditch, 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, Upper Church Ditch, South Boulder Diversion Canal, Smart Ditch, and Mower Ditch, will not be altered and will continue to be used for water rights as 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.]

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).

1.1 Site Characteristics

1.1.1 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 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.

1.1.2 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

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. 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. 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

It is assumed that all buildings, slabs, tunnels, and other structures will be removed to a minimum depth of 3 feet below grade. Contaminated buildings, slabs, tunnels, other structures, and associated soil 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 existing surrounding topography. 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 as per the Concrete Recycling RFCA Standard Operating Protocol (RSOP). If recycled concrete is used, three feet of clean fill dirt will be placed over the concrete to facilitate final grading of the Site.

For the purpose of the LCDB Project, it is assumed all above ground structures, buildings, and slabs to a depth of 3 feet below grade (regardless of contamination) will be removed. 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 grade may remain in place. Underground structures that could provide a conduit for groundwater contaminant migration, such as tunnels and vaults, will be backfilled, grouted, or otherwise sealed or plugged in place.

Some underground structures may restrict or enhance groundwater flow. Should the removal of these structures cause existing groundwater remediation systems to be inadequate to protect surface water, it is assumed that additional control measures or remediation systems will be installed prior to completion of active remediation. The installation of these items is not included within the scope of the LCDB Project since the extent of such systems (if required) cannot be assessed at this time.

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 to the liquid waste treatment facility in Building 374. Process wastes may have included acids, bases, solvents, radionuclides, 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. 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. Solis above Tier 1 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 grade with clean dirt.

Intact sections of the old process waste lines will be left in-place and the pipe ends will be sealed with grout, cement, or foam. Intact sections of the new process waste lines will either be cleaned in-place by flushing with water or removed to meet closure requirements for hazardous waste units. 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. 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. Potential wastes that have been documented in storm drains are silver paints (DOE, 1992a). Storm drains will be characterized 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 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 Other Underground Utilities

There are numerous underground utilities located throughout the IA including building footing drains, water and gas supply pipelines; steam lines, and electrical, alarm, and telecommunication corridors. 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 grade at the building foundation. In the case of trailers, it is assumed that utilities will be removed to at least 3 feet below grade or to the nearest junction box. Remaining portions of the utility will be sealed to prevent water intrusion via the utility conduit or corridor. The telephone, alarm and electrical systems will not be considered utilities for this purpose.

Building footing drains will be characterized as part of the closure activities for the IA. If the footing drain is contaminated, it 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 Woman and Walnut Creeks. Minor drainage features include Mower Ditch, Badger Ditch, Kestrel Gulch, and three unnamed features.

Each principal and minor drainage feature 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 would be overtopped if runoff from major storm events 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 2,375 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).

2.3.1.1 McKay By-Pass 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 flows eastward paralleling the Upper Church Ditch for about 8,000 feet. The McKay By-Pass Canal is downslope of the Upper Church Ditch and will, therefore, 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 By-Pass 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 By-Pass 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 By-Pass Canal. In addition to the spillway, a 1-inch diameter PVC pipe is located approximately 4 inches from the base of the wall to maintain a minimum base flow into the downstream portion of the McKay By-Pass 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. As such, storm water runoff intercepted by the West Diversion Ditch and the McKay By-Pass 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. 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. 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 61 acres and flows into a 56-inch diameter CMP culvert. The basin upstream of SEL-03B is approximately 94 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.

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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 188 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 176 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.

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 via buried pipeline, northeast into the Broomfield Diversion Ditch, which flows to 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 2,880 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 flows beneath Woman Creek through a siphon pipe. The drainage basin associated with the SID is approximately 190 acres. 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 SID was originally designed to handle a 100-year precipitation event. However, erosion, sedimentation, and encroachment of vegetation have reduced the SID's flow velocity and capacity (EG&G, 1992). It is assumed that the SID, and its associated check dams, and Pond C-2 will remain intact and unaltered. 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.
- 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.

Other ponds located at RFETS include the Lindsay Ranch Pond, Ponds D-1 and D-2 in the Smart Ditch Drainage, and the Landfill Pond. The Lindsay Ranch Pond and Ponds D-1 and D-2 are not actively managed as part of the Site's water management system and are outside the LCDB Project boundary. As such, detailed information regarding these ponds is not provided.

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 of this pond is provided in Table B-06.

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.

The ponds were constructed at various dates from 1952 to 1979 to manage the surface water draining from the Site. Each pond is retained by a dam that is regulated by a spillway and, in most cases, an outlet works. The dams are earthfill 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. By-passes 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. The valves at Ponds A-3 and C-2 are at the downstream end, so that the outlet conduits are pressurized within the embankments.

The 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. Ponds A-2 and B-1 had both high- and low-level outlets; however, the low-level outlet is plugged or closed off at both ponds. At Pond B-1, the high-level outlet is plugged also, leaving the dam without a functioning outlet works. The outlet at Pond A-1 is also permanently plugged. At several dams, blind flanges have been installed on the outlet conduits, and pumping has since been used to remove water from the reservoirs.

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.

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 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.

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. 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. Additional details regarding the current operation for each series of ponds are provided below.

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. 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. 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 350 acres that also includes part of the northern 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. 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 can be sluiced into the ponds from the pipeline to prevent these pond sediments from drying out and becoming windborne. These sediments will be removed as required to meet Tier I Action Levels after closure activities for the IA have been completed. 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. 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.

- Effluent from the on-site wastewater treatment plant flows to Pond B-3, from which it is batch-discharged daily (during daylight hours) to Pond B-4. Characterization results indicate that a portion of Pond B-3 contains actinide-bearing sediments above Tier I action levels. These sediments will be removed from Pond B-3 at the same time as the sediments from Ponds B-1 and B-2 are removed. 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.
- Pond B-4 is used for storm water settling, as it is a shallow continuous flow-through pond with no downstream control valve. 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 water from Pond B-3 that is discharged on a daily basis. The water in Pond B-4 flows continuously into Pond B-5. Pond B-4 was built in 1952, and raised and rebuilt in 1972. 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. [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. The accumulated water is batch discharged into South Walnut Creek if the analytical results verify that the water is of acceptable quality. During discharge, samples are collected at RFCA POC monitoring station GS08. A gate valve and standpipe were installed in Pond B-5 in 1996 to allow direct discharge. 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. 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.

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 a man-made channel located to the north. The pond is batch-discharged, with a pump and a floating suction line, usually once a year, to Woman Creek and then to Woman Creek Reservoir. During discharge, samples are collected at RFCA POC monitoring station GS31.

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. With the cessation of imported water, a net loss to the watersheds of about 260 ac-ft/yr is likely to occur. 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.

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. The quantity and type of vegetation that can be sustained after closure can affect the erosion characteristics of the Site. For example, wetland vegetation on the upstream portion of detention facilities may slow the water entering the detention, which reduces the amount of scour from the basin bottom and reduce the amount of sediment that will have to settle out. The reduced velocities also promote increased deposition.

In addition, ditches and open channels lined with vegetation will have less erosion than dirt-lined channels.

2.3.9 Water Rights

Several water supply ditches that affect the hydrology in the vicinity of RFETS are shown on Figure B-02. The water rights 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 west of Highway 93 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. Currently, 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.
- 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.
- The **Upper Church Ditch** is seldom used, though still an active water conveyance structure which diverts water from Coal Creek west of Highway 93 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 runoff north of Upper Church Ditch will not crossover the elevated ditch banks.

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.

Runoff from this area typically flows north and crosses under State Route 128 to Rock Creek. 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 additional, 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 water rights for Mower Ditch are controlled by the City of Westminster. 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. 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 ditch 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 rights 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 basin due to a major flood in Coal Creek (EG&G, 1992). However, notable losses to the groundwater occur, as a result of these unlined ditches (WWE, 1995).

In addition to the water supply ditches that transverse RFETS, the water rights for the onsite portions of Walnut and Woman Creek drainage basins are not owned by the DOE. For Walnut Creek, the onsite water rights are controlled by the City of Broomfield. The onsite water rights for Woman Creek are under the control of City of Westminster. Long-term plans for these onsite water rights after the completion of active remediation have not yet been established with the individual stakeholders.

2.3.10 Channel Hydraulics and Sediment Transport

The channel hydraulics and the sediment transport capabilities of the Walnut and Woman Creek channels are as follows:

- For the Walnut Creek Watershed, the Manning's "n" values range from 0.03 to 0.08 in the channel bottoms, 0.03 to 0.07 along the channel banks, and 0.05 to 0.09 in the overbank areas.
- For Woman Creek, the Manning's "n" values range from 0.04 to 0.09 in the channel bottoms, 0.025 to 0.04 along the channel banks, and 0.05 in the overbank areas.
- For Mower Ditch, the Manning's "n" values are 0.06 in the channel bottoms, 0.04 along the channel banks, and 0.05 in the overbank areas.
- For the SID, the Manning's "n" values range from 0.02 to 0.08 in the channel bottoms, 0.04 along the channel banks, and 0.05 in the overbank areas.

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 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 <u>Disturbed Ground</u>

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 <u>Artificial Fill</u>

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 also considered to be 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.

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 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 ground water 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 in these sandstones (EG&G, 1991; 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, point bar, and floodplain deposits.

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.

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).

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 consists of coal beds and sandstones and is estimated to be about 285 feet thick (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 as a result 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 (Derby) Source Zone, and five regional sources were all evaluated in terms of recurrence probability and probable maximum magnitudes. It was concluded in 1994 that the Derby source zone dominated the seismic hazard to RFETS since the Colorado Geologic Survey classified it as "potentially active" in 1981. 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 (EG&G, 1994a).

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.

The greatest seismic hazard to RFETS is the Derby source zone, which has the shortest return period and the largest estimated magnitude for an earthquake. As such, a seismic event with a magnitude 7 on the Richter scale will be used for the design of LCDB Project where appropriate.

2.4.6 Hydrogeology

This section describes the hydrogeology of the RFETS area, including the unconfined and confined ground water 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 ground water recharge area. The shallow ground water 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 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 hydro-stratigraphic units, designated upper (UHSU) and lower (LHSU), have been identified at the Site. The unconfined ground water 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 ground water 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 highs. 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 probably exists between the uppermost Arapahoe Formation Sandstone and the overlying unconsolidated geologic materials, so that within limited areas where sandstone subcrops beneath the 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 are not generally believed to 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 $7x10^{-5}$ to $1x10^{-2}$ 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 $2x10^{-6}$ to $4x10^{-5}$ centimeters per second (0.63 to 12.6 meters per year) (DOE, 1992b).

The LHSU at RFETS include sandstone units of the Arapahoe Formation and the Laramie Formation that exist beneath RFETS. Interbedded claystones and silty claystones may confine ground water in these 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 as a result 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 $1x10^{-8}$ and $1x10^{-7}$ 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 $4x10^{-8}$ to $2x10^{-6}$ 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 no potential 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 $2.8x10^{-10}$ to $2.5x10^{-7}$ 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 site entrance at Indiana Street, 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 from the ridges and up gradient 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.

Exceptions to these generalized groundwater flow patterns occur in areas where sandy bedrock lithologies are proximal to the top of bedrock surface and in hydraulic connection with overlying or adjacent saturated units. Sandy bedrock lithologies have higher hydraulic conductivities associated with them in comparison to the more commonly encountered bedrock claystones. Thus, groundwater may percolate downward into the sandy bedrock lithologies and flow through them. The entire length of the northern bedrock ridge is composed of sandy bedrock lithologies; only the western end of the southern bedrock ridge is composed of sandy bedrock lithologies. Thus, there is a component of groundwater flow through the northern bedrock ridge, off the pediment, and down gradient along the bedrock-colluvium contact or out of seeps into the South Walnut Creek watershed. The sandy bedrock lithologies that compose the northern bedrock ridge display hydraulic conductivities in the range from approximately 10^{-3} to

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10^{-4} cm/sec, hydraulic conductivities for the basal few feet of alluvium in the incised bedrock channel are generally equal to, or greater than these values.

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 may 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.

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.

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 Surface Water Use Classifications

The State of Colorado Water Quality Control Commission (WQCC) is responsible to determine the present and future beneficial use of State surface waters. 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 in 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.
- **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 Class 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 Standley Lake, the Great Western Reservoir, and Walnut and Woman Creeks are discussed below.

2.5.1.1.1 Standley Lake Use Classifications

Standley Lake is currently being used for domestic potable water (after treatment) by the Cities of Westminster, Thornton, 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.

2.5.1.1.2 Great Western Reservoir Use Classifications

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 (also 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.

2.5.1.1.3 Walnut and Woman Creek Use Classifications

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 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	Surface Water Quality Standard
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. Because the surface water quality standards are already based on human health consumption of the water as a drinking water source, this assumption is reasonable.

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 ground water in stream alluvium. For the purpose of the LCDB Project, it is assumed that if the terminal ponds are removed, only the Walnut Creek (GS03) and Woman Creek (GS01) monitoring points at Indiana Street will be POCs.

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

Based on historical surface water monitoring results, the parameters that have been greater than their corresponding surface water quality standard include plutonium (Pu) and americium (Am). Table B-08 shows surface water exceedences of the 0.15 pCi/L 30-day moving average standard for Pu and Am from 1998 through 2000. Historically, exceedences have occurred at points of compliance (POCs) GS08 and points of evaluation (POEs) GS10, GS27, GS32, GS39, SW022, SW027, SW093, and SW120. The exceedences generally coincided with rainfall events. It was concluded that the most probable source of the reportable values was diffuse radionuclide contamination throughout the Walnut Creek watershed due to historical Site operations and incidents rather than a "hot spot" of elevated radioactivity (RMRS, 1998a).

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 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.

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 subsurface 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 an area to place 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.

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. Actinide concentrations are below Tier II action levels at most locations. Soil samples with results above Tier II 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).

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).

Since the radionuclide action levels for subsurface soils are the same as surface soils, the subsurface soil actions are considered to be 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. 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 Original Landfill

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. Surface radiological contamination has been detected in several areas. The current remedial action plan calls for hot spots identification and source removal prior to installation of the ET cover. The Backwash Pond located on the top of the landfill was used as an evaporation/settling pond for the back flushing sand filters from the B124 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 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)

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 are to be removed or remain in place. The SEPs will be closed in-place by backfilling the ponds 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 UMTRCA, is to be established as part of the ET cover project. The results of the ET cover design will be 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 free-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

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.

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. 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).

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, 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 collection 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).

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 will likely 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.

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 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. For the time period 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.

The intercepted groundwater flows by gravity to two reactive treatment cells containing mixture 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 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. For the time period 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.

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 collection trench severed the ITS pipes and redirects the intercepted groundwater previously captured by the ITS to the treatment chamber.

The water from the collection trench flows into a single 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. Wetlands (including rushes and cattails) are established at the discharge gallery. Foxtail grass and barnyard grass are also being established in the saturated soils. In general, wetland plants 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).

The system has been operational since September 1999. As of 5 March 2001, approximately 64,000 gallons of water were treated. For the time period from January 2000 to March 2001, the recorded flow rate ranged from 0 to 3.8 gpm with an overall average flow rate of approximately 0.11 gpm.

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 Meadow Jumping 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.

Surface water samples collected from Pond A-3 and GS-10 indicate that the concentrations for nitrate and uranium are well below their corresponding temporary modifications listed in the 1999 Decision Document of 100 mg/L for nitrate and 10 pCi/L for uranium (Kaiser-Hill, 2000d). The system is being closely monitored to determine if the Site can achieve compliance with the surface water quality standards when the temporary modification 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 time 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.

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.

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 to be 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 severed and the intercepted groundwater is now allowed to flow into the SID. As such, 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 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 1 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*) also 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 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 meadow jumping mouse (PMJM) (*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.

The T/E species of primary concern at RFETS is the PMJM. The PMJM's preferred habitat is found in the riparian corridors bordering streams, ponds, and wetlands at the Site. Detailed monitoring for PMJM has resulted in a large body of information regarding the mouse's habitat and the population at RFETS. The PMJM protection areas within the LCDB Project boundary are shown on Figure B-12.

Although PMJM population estimates are not definitive, much is known about their preferred habitat. The correlation between the presence of the PMJM and riparian habitats with specific vegetation structural characteristics is high. The changes in hydrology associated with closure of the IA would likely reduce riparian habitat acreage in the drainages at RFETS. As a result, the PMJM population at the Site would be expected to decline at some point after closure if supplemental water sources are not provided to support the current extent of riparian habitat.

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2.6.3 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 USAEC 1994 wetland report.

There are approximately 1,100 wetlands and deep water habitats that are considered "jurisdictional" at the Site as shown on Figure B-13. This number includes portions of the Site that are outside the bounds of the LCDB Project (e.g., Rock Creek), so the actual number of jurisdictional wetlands in the project area is less than 1,100. Roughly 106 acres of jurisdictional wetlands are within the LCDB Project boundary.

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 as a result of irregular and ephemeral stream flows in some areas, while other wetlands are more stable as a result of their association with regular inflows to the ponds. There are about 16 active seep areas in the upper Woman Creek drainage and about 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 as a result of closure of the IA. Review of historical aerial photographs (1951 and 1954) showed that stream wetlands were relatively limited compared to current conditions. 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. As hydrologic models are developed as part of the SWWB project, the extent of wetlands at closure could be more reliably predicted.

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.

Existing plant inventory and characterization investigations have documented a total of about 585 plant species on the entire property as of 1999 (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 in 1996 and continue through the present.

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 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 <u>Industrial Area</u>

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 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, and
4. Ground cover characteristics of dominant plant species.

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. It is expected that plant species rooting depths will 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 like red grama. 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 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.

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 to be the 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 level of soil unit mapping and characterization information is the primary reference for most 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 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 a total of 19 soil-mapping units. The LCDB component of the BZ contains a total of 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 to be adequate for all target plant species to be considered for developing the initial conceptual design. 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, it is assumed that open space is 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. There is potential for similar development south and west of the Site within the Jefferson Center, which is an approved 18,000-acre industrial, office, commercial, and residential community. 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 meadow jumping 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 meadow jumping 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. [P33]

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 Site mineral rights 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. A list of the mineral rights holders at RFETS is provided as Table B-14.

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. As the surface owner, the Site continues to adhere to Colorado law, which provides that a subsurface mineral owner may exercise its rights to extract subsurface minerals, while the surface owner retains 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 mineral rights within the LCDB Project area will not be exercised or rescinded by the State.

2.8.2.4 Easements

A list of private entitlers that possess easements at RFETS is provided as Table B-15. A list of federal license/easement agreements for land at RFETS is provided as Table B-16. 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

For the purpose of the LCDB Project, it is assumed that RFETS and the LCDB project area will be designated as open space. 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

For the purpose of developing the design basis and initial conceptual design for the final land configuration, it is assumed that the designated final land use for RFETS will be open space. However, it is recognized that legislation to designate RFETS a National Wildlife Refuge is also being considered. The potential impacts associated with changing the final land use from open space to National Wildlife Refuge are discussed in this section.

Although the potential impacts are discussed in this section, scenario development and evaluation will be solely based on consideration of open space. Should the proposed RFETS National Wildlife Refuge legislation be enacted, the design basis will be appropriately modified as required.

The identification of potential impacts are based on consideration that the RFETS legislation will be similar to the Rocky Mountain Arsenal National Wildlife Refuge Act of 1992 (Public Law 102-402). 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 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 response actions.
- 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.
- 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. 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.
- The refuge would not be subject to annexation by any unit of general local government, nor would public road construction be allowed through a refuge.
- 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 groundwater 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 periodic cleaning, replacement 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). Also, 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. 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-17. 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 **ground water** remediation systems and the control of ground water 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.

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.

TABLES

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 time 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.

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 time 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 time 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.

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 time 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 time 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.

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	NP - 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	NP - 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	---	---	---	NP	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 - 27	---

Table B-08
Summary of Surface Water Exceedences

Surface Water Sample Location	Pu Activity (pCi/L)	Period of Sample Collection	Am Activity (pCi/L)	Period of Sample Collection
GS08 (POC)	0.864	August 11- 17, 2000	0.275	May 2-10, 2000
	0.603	June 23-30, 1999	0.154	June 23-30, 1999
GS10 (POE)	2.270	May 15-25, 2000	8.385	May 15-25, 2000
	0.543	May 10-24, 1999	0.768	May 10-24, 1999
	0.761	May 12-23, 1998	0.728	July 23-25, 1998
GS27 (POE)	6.900	August 17, 2000	1.020	August 27, 2000
	26.800	May 20, 1999	7.28	May 20, 1999
	64.300	May 22, 1998	14.800	May 22, 1998
GS32 (POE)	7.140	June 6, 2000	4.060	July 13, 2000
	11.5	July 24, 1999	3.96	July 24, 1999
	6.970	May 22, 1998	3.260	May 22, 1998
GS39 (POE)	0.170	August 27, 2000		
	0.824	March 18-19, 1998	0.160	March 18-19, 1998
SW022 (POE)	0.546	June 17-July 17, 2000		
	1.430	May 20, 1999	0.354	May 20, 1999
	9.490	May 22, 1998	1.760	May 22, 1998
SW027 (POE)	1.030	May 11-July 17, 2000	0.177	May 11-July 17, 2000
	0.190	April 30- May 1, 1999		
	0.802	April 30- May 8, 1998		
SW093 (POE)	0.174	Aug 18-28, 2000		
	0.312	July 15-26, 1999	0.188	July 26-Aug 1, 1999
SW120 (POE)	0.724	July 17-September 28, 2000	0.269	July 17-September 28, 2000

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.

Table B-10
Summary of Evapotranspiration (ET) 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.

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

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	
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)

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 Mineral Rights Holders

Acres	Minerals	Owner
960	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals U.S. Government Union Pacific Railroad
1,120	Coal, Oil, Gas,	Private Individuals Union Pacific Railroad
400	Coal, Oil, Gas, Ore.	Private Individuals U.S. Government
31.38	All minerals revested to landowner with subordinated surface rights	Private Individual
446.36	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	U. S. Government UP Railroad Colo. Investment services Inc.
27.61	All mineral rights	Public Service Co. of Colorado U.S. Government UP Railroad
352.46	All mineral rights	Private Individuals UP Railroad U.S. Government
619.09	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals U.P. Railroad
160	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals Rocky Mtn. Fuel Co. Private Individuals
160	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals U.S. Government Union Pacific Railroad
310.65	All mineral rights	Private Individual U.P Land Resources Corp.
480	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals

Table B-14
List of Mineral Rights Holders

Acres	Minerals	Owner
160	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals U.S. Government Glen Young and Co.
660	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Union Pacific Railroad Private Individual UP Land Resources Corp.
14.85	All coal, oil, gas	U.S. Government Rocky Mountain Energy Co.
317.84	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals U.S. Government
160	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individual U.S. Government
150.76	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Private Individuals U.S. Government
9.35	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Rocky Mt. Energy U.S. Government U.P Railroad
461.66	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	State of Colorado
2	All mineral rights shared with Owners in varying amounts. Union Pacific Railroad has Coal	Aldolph Coors U.S. Government

Table B-15
List of Private Easement Holders

Easement Holder	Utility	Activities
Public Service Company	Electric lines	Periodic line inspections, either by helicopter or by pickup truck
United Power	Electric lines	Periodic inspections w/vehicle, maintenance
Rocky Mountain Energy	Low-pressure gas line	Periodic inspections w/vehicle, maintenance
Coors Gas Line	High-pressure gas line	Periodic inspections w/vehicle, maintenance
Sprint/US West	Fiber optic lines	Periodic inspections w/vehicle, maintenance
Mountain States Telephone and Telegraph	Telephone lines	Periodic inspections w/vehicle, maintenance
US West Communication	Telephone lines	Periodic inspections w/vehicle, maintenance
Southern Pacific Railroad	Railroad spur line	Periodic train traffic to Western Aggregates gravel operations, Lafarge
State of Colorado Emergency Preparedness	Telecommunications and meteorological equipment	Periodic maintenance
Denver Water Board	Water pipeline	No routine activity
City of Broomfield (McKay Ditch, Upper Church Ditch)	Water conveyance ditches for water rights	Biweekly or more frequent inspection visits during exercise of water rights, maintenance
Church Ranch, Inc. (Charles McKay)	Smart Ditch and Church Ditch water conveyances for water rights	Water rights are run through ditches and ponds across DOE surface, in accordance with longstanding easement

Table B-16
List of Federal License/Easement Agreements with Offsite Outside Parties

Acres	Purpose	Minerals	Owner
25.78			
19.84 acres merged into Tract 35	Access Road	All Oil & Gas to owners	Private Individual
5.51	Water line & RR spur	All Coal rights to U.P.RR. All Oil & Gas rights subordinated to surface rights	Private Individuals Union Pacific Railroad
No area recorded	RR Crossing HWY 93	None	State of Colorado
No area recorded	R.R. under power line	None	Arvada Elec. Co.
No area recorded	R.R. Crossing HWY 72	None	State of Colorado
No area recorded	R.R. under power line	None	Union R.E.A., Inc
6.11	Water line & RR spur	All minerals	Private Individuals
No area recorded	R.R. Crossing & water line Res. Inlet	None	Private Individuals
17.26	Water line & RR spur	All minerals	State of Colorado
No area recorded	R.R. Spur Crossing under power line	None	Arvada Elec. Co.
No area recorded	R.R. Crossing Boulder Canal	None	City & County of Denver
No area recorded	R.R. Spur Crossing under telephone line	None	Public Service Co. of Colorado
No area recorded	R.R. spur crossing under Trans. Line	None	Public Service Co. of Colorado
No area recorded	R.R. & Water line Crossing Woman Creek.	None	Farmers Res. & Irrigation Co.
1.08	Water line & RR spur	All minerals	State Of Colorado
5.99	Water Line	None	Private Individuals
No area recorded	Water Line R/W to cross R.R.	None	Denver & Rio Grande Western R.R. Co.

Table B-16
List of Federal License/Easement Agreements with Offsite Outside Parties

Acres	Purpose	Minerals	Owner
4.82	Water Line	None	Private Individuals
5.02	Const. & Maint. of Raw Water Line	None	City & County of Denver
No area recorded	Const. & Maint. of Raw Water Line	None	City & County of Denver
No area recorded	Const. & Maint. of Raw Water Line	None	City & County of Denver

Table B-17
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 ground water 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 ground water transport.	RFCA, Attachment 5, Section 4.1.

Table B-17
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 meadow jumping mouse (PMJM) 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 PMJM 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 meadow jumping mouse (PMJM) 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

Table B-17
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 PMJM 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

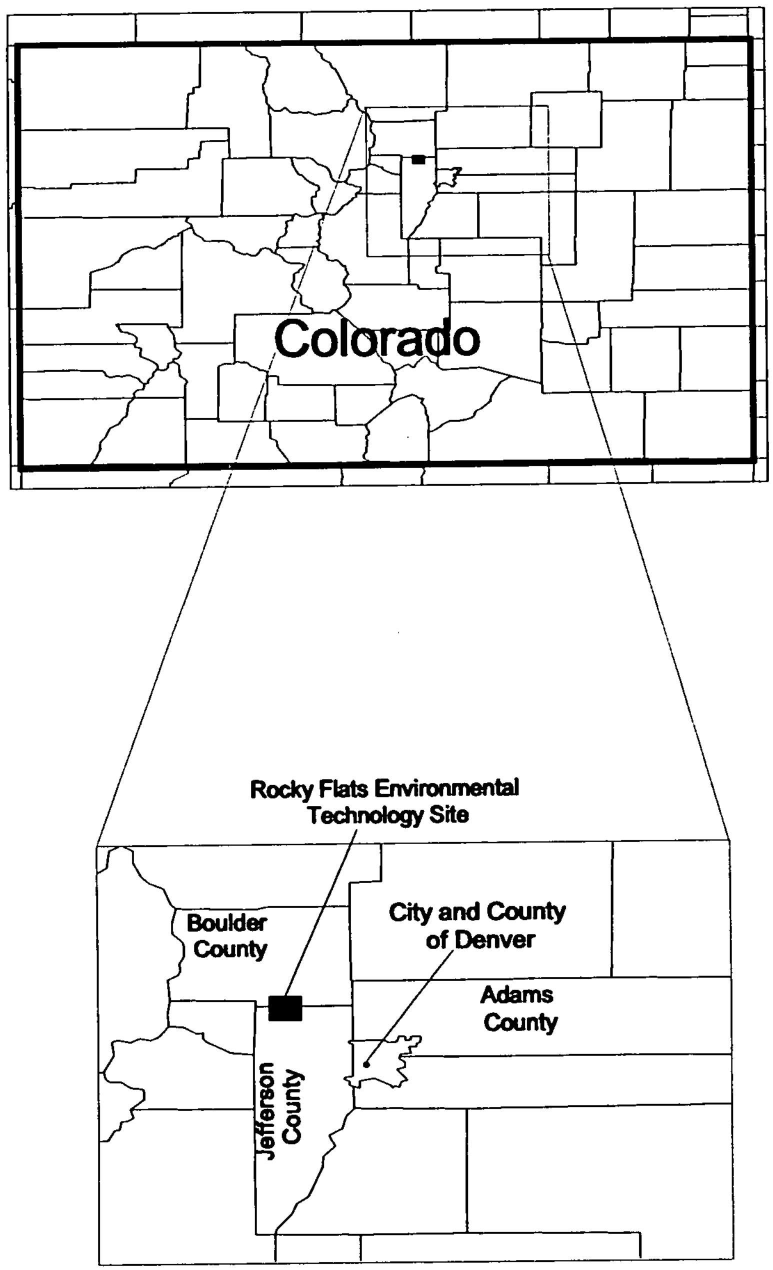

Figure B-01

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

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

May 16, 2001

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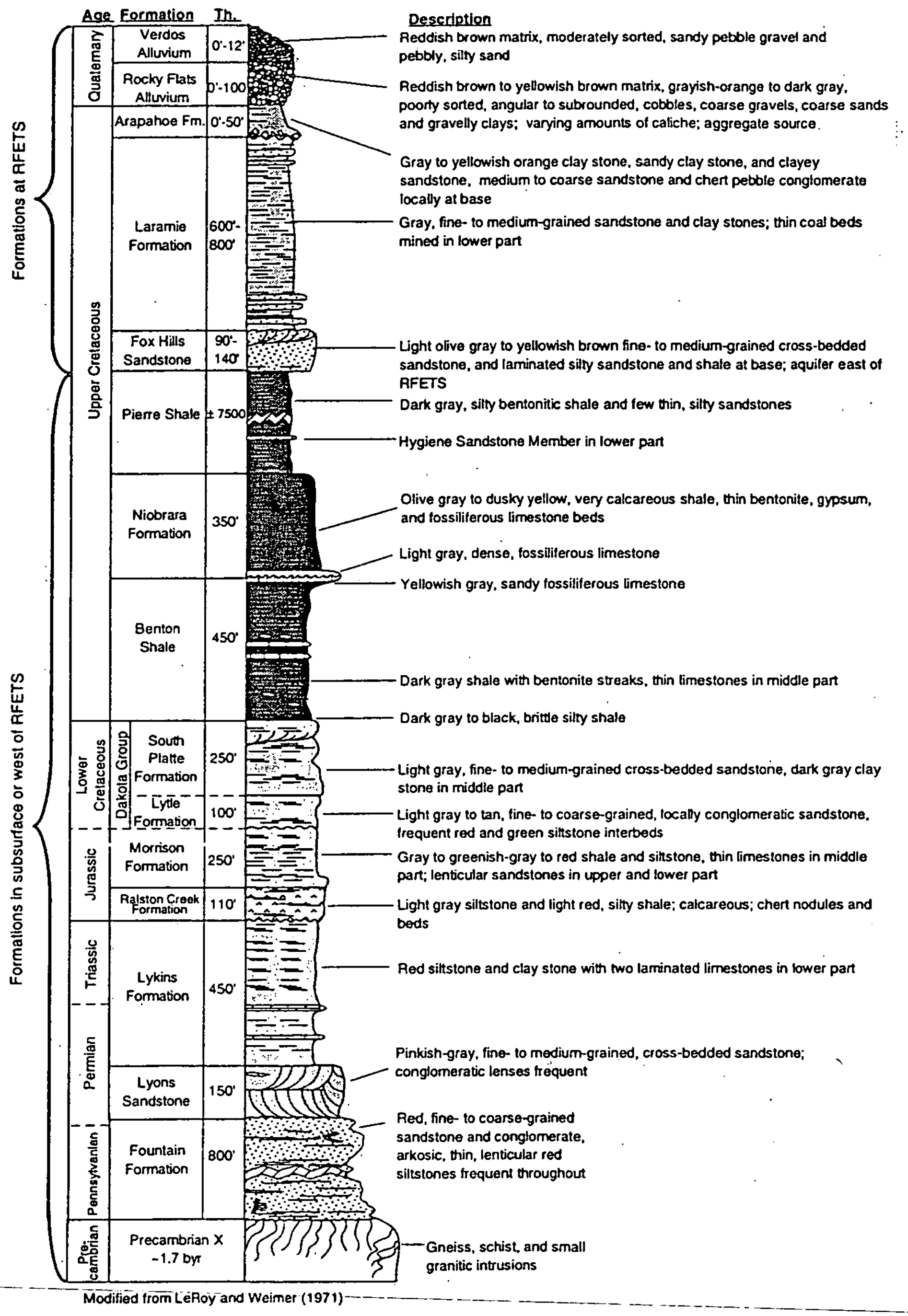

G95\ES\2801\Geol. Char. Rpt.mdw

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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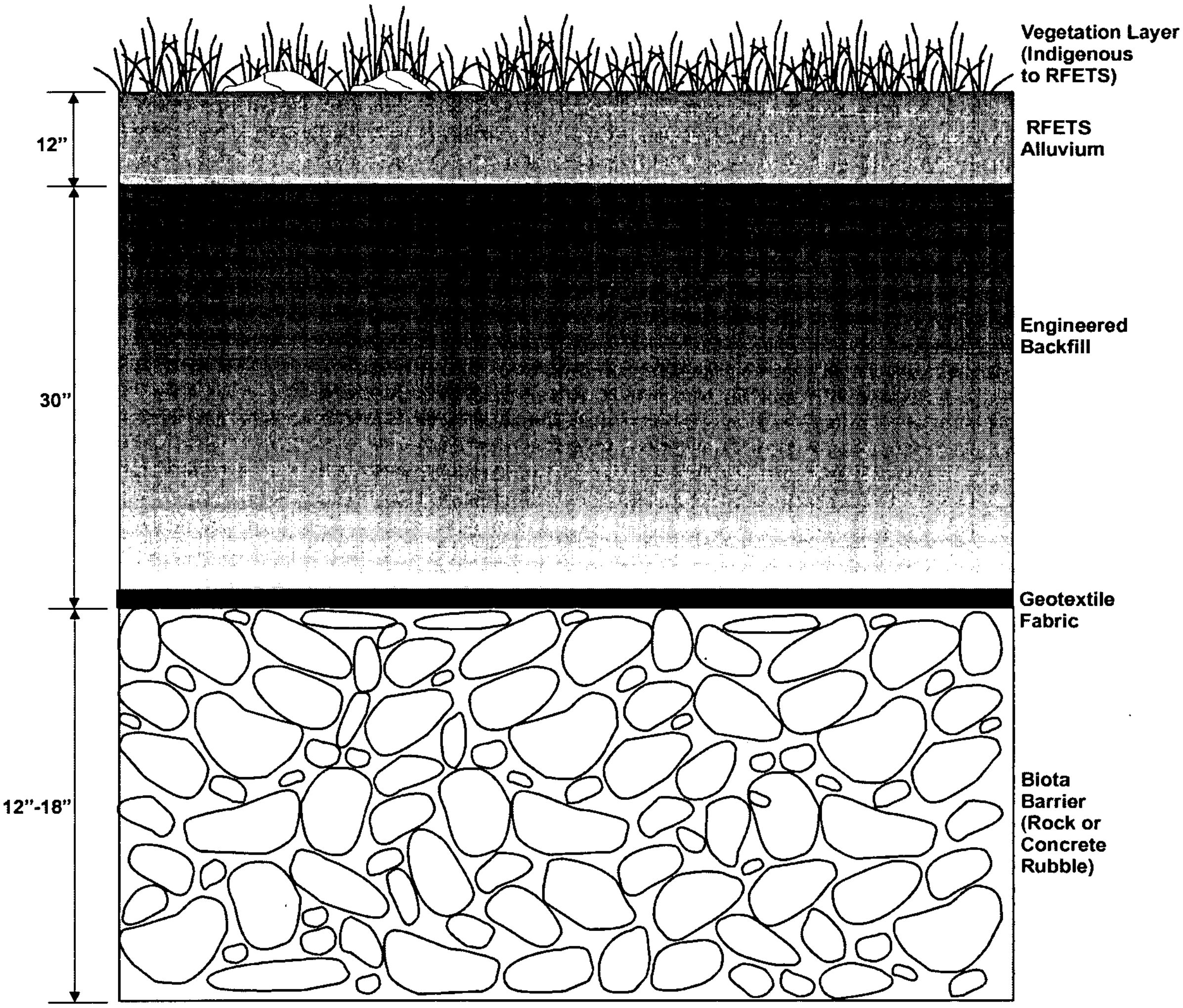

FIGURE B-10
Components of a Typical ET Cover

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

1.0 IDENTIFICATION OF DATA GAPS

Data gaps include missing information, uncertainties, tentative plans, unsubstantiated constraints and assumptions that could 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. An unique number and subject area was assigned to each data gap for tracking purposes. The subject areas are as follows:

- GEN – **General** objectives related to the overall functions and criteria of the LCDB Project.
- GW – Objectives related to the function of **ground water** remediation systems and the control of ground water 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 **surface 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.

2.0 DATA GAP RESOLUTION AND DATA ACQUISTION

It is expected that most of the data gaps identified in Table C-01 will be filled by information from electronic and GIS databases, available Site information, discussions with Site personnel, the results from other ongoing RFETS projects, or as additional decisions regarding the final land configuration are made. However, resolution of some data gaps may require completion of a special sub-study. The scope of these sub-studies will be developed as the project proceeds.

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 the data gap is not expected to be resolved, "Use Assumption" is listed in the proposed resolution date column and the corresponding assumption will be 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 will be 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. Although resolved data gaps will be deleted from Table C-01, the data gap IDs will not be changed.

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.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X004	GEN	Prediction of long-term climate changes for temperature, precipitation, and storm event duration and severity.	Conduct literature search to determine availability of predictions for future Front Range climate changes.	Moderate	September 2001	No significant climate changes will occur over the next 1,000 years.
GAP-X002	GEN	Need to include air dispersion controls in developing the final land configuration.	AME pathway report to address.	Moderate	October 2001	Air pathway is not significant. Historical air monitoring has not indicated that the air pathway needs to be addressed.
GAP-X012	GEN	Location of any future easements, especially for new power line.	Easement restrictions and negotiations.	Low	December 2001	Current easements will need to be maintained after completion of active remediation. Any future easements will not interfere with implementing the final land configuration.
GAP-X013	GEN	Feasibility of installing ET cover over the original landfill.	ET Cover Project to address in feasibility study.	Moderate	December 2001	An ET cover will be installed over the Original Landfill to minimize infiltration.
GAP-X001	GEN	Structures and other components that will remain in the IA area after completion of active remediation.	Adopt plans / strategy for IA closure developed by D&D / ER.	Moderate	2006 Use Assumption	All subsurface concrete structures will be removed to a depth of 3' below grade. Any structures below 3' that are contaminated above Tier I levels will be removed or stabilized. Other assumptions are provided in Section 2.1.2 of Appendix B. The wastewater treatment plant will be closed.
GAP-X006	GEN GW	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 remediation systems will be address in future decision documents.	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.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X005	GEN SOIL	Residual actinide locations and concentrations in the IA.	Compile post-D&D characterization data.	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 concentrations will be at background levels where imported fill and topsoil is used.
GAP-X003	GEN	Establishment of final remediation goals in the CAD/ROD.	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. RFCA Action Levels are protective of potential human and ecological receptors.
GAP-X113	GEN	Identify the location of long term monitoring systems for air.	None	Low	2006 Use Assumption	The location of long term air monitoring stations are inconsequential to the LCDB Project.
GAP-X016	GW WET	Impacts on groundwater remediation systems, Vadose Zone, groundwater contaminant transport, and wetlands due to cessation of imported water, Site closure, or other land reconfiguration.	SWWB Project Team is modeling various scenarios to address this data gap. Evaluate historical aerial photos to determine conditions prior to construction of RFETS.	Moderate to High	December 2001	The groundwater flows and systems will not be changed, however, groundwater seeps and springs emanating from groundwater sources below the IA will dry up after site closure. Groundwater seeps and springs will not significantly contribute to surface water flow after closure. Site wetlands will revert to pre-Site conditions as determined from aerial photo review.
GAP-X125	GW SW	Location UG structures in the IA area remaining after completion of active remediation that may influence movement of existing plumes.	Adopt plans / strategy for IA closure developed by D&D / ER. Use SWWB model results to assess potential impacts.	Moderate	December 2001	Any remaining UG structures will not cause plumes to impact surface water. Additional remedial actions would be taken prior to completion of active remediation if required.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X015	GW	Location of monitoring wells required for long-term monitoring of the Site.	Well abandonment planning to start in FY 2002.	Low	2003 Use Assumption	Existing monitoring wells will be relocated or replaced as required to implement the final land configuration. Access to monitoring wells will be by low-impact ATVs; road for collecting samples will not be required.
GAP-X023	SEIS	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-X032	SOIL	Geotechnical and soil properties for imported fill materials (required for WEPP input files). Source of imported fill materials.	Obtain test information from offsite borrow areas.	Moderate	Use Assumption	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.
GAP-X049	SOIL VEG	Geotechnical and soil properties for imported topsoil materials (required for WEPP input files). Ability of topsoil to support vegetation. Source of topsoil materials.	Obtain test information from offsite borrow areas.	Moderate	Use Assumption	If testing data for imported topsoil is not available, assume that existing data for onsite soils is representative of imported topsoil. Specification for imported topsoil will identify any required geotechnical and soil properties. Topsoil texture, fertility, and weed-free status will be assumed to be acceptable.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X019	SOIL	Rate for Rapid Mass Movements (i.e. landslides, debris flows)	Review geotechnical investigation for modular tanks, reference documents, and aerial photographs.	Moderate	August 2001	Appropriate value from literature review will be used.
GAP-X021	SOIL	Rate of channel incision and headward erosion.	Conduct literature review.	Low	August 2001	Appropriate value from literature review will be used.
GAP-X027	SOIL	Relationship between surface water actinide concentrations and sediment actinide concentrations	AME Project Team to evaluate during scenario evaluation.	High	August 2001	Use predicted sediment loading to drainages as basis for scenario evaluation if predicted actinide concentrations are not available.
GAP-X026	SOIL	Geotechnical and soil properties for concrete rubble, asphalt rubble, and other construction material that will be used for fill in IA.	Develop during D&D closure of IA.	Low	2006 Use Assumption	Use of concrete rubble will not adversely impact the final land configuration.
GAP-X065	SW	Significance of storm water from Woman Creek to Mower Ditch during storm events.	Discuss with SW group or conduct field observation.	Moderate	Use Assumption	Diversion of storm water from Woman Creek to Mower Ditch is insignificant during storm events. All runoff draining into Mower Ditch will not cross over into the Woman Creek channel. This assumption is consistent with the AME study.
GAP-X070	SW	Amount of runoff north of Upper Church Ditch.	Discuss with SW group or conduct field observation.	Moderate	Use Assumption	The runoff north of Upper Church Ditch will not crossover the elevated ditch banks.
GAP-X067	SW	Contribution of runoff in the watersheds west of the South Boulder Diversion Ditch.	Discuss with SW group or conduct field observation.	Moderate	Use Assumption	Runoff in the watersheds west of the South Boulder Diversion Ditch is either insignificant or intercepted. This assumption is consistent with the AME study.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X063	SW	Continued operation and operation mode of McKay Ditch / pipeline and West Diversion Ditch.	Discuss with City of Broomfield.	Moderate	Use Assumption	Current mode of operation as described in Section 2.3.1.1 of Appendix will continue. All runoff generated within the upper reaches of Walnut Creek will be intercepted and diverted, and are therefore excluded from consideration.
GAP-X066	SW	Status of Kinnear Ditch after remediation endpoint.	Discuss with City of Westminster.	Moderate	Use Assumption	In the future, Last Chance Ditch 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.
GAP-X055	SW	Location of storm water structures, culverts, and ditches that will remain in the IA after completion of active remediation.	Address decision criteria in Sector Strategy and identify locations in initial conceptual design. Significant changes / impacts to WEPP results will be assessed during the initial conceptual design.	Moderate	October 2001	All structural storm water controls within the IA will be removed, plugged, or otherwise made non-functional, except the structures associated with the remaining roads. These controls include: street curbs, gutters, storm sewers, inlets, catch basins, manholes, outlets, diversion / containment dikes, berms, and subsurface drains. For roads that will remain after closure all associated stormwater controls will remain intact and unaltered. The Central Avenue Drainage Ditch will be filled and graded so that runoff from the IA will flow directly into the South Walnut Creek channel. The SID, and check dams will remain intact and unaltered.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X057	SW	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 in the BZ.	Address decision criteria in Sector and Pond Strategies and identify locations in initial conceptual design. Significant changes / impacts to WEPP results will be assessed during the initial conceptual design.	Moderate	October 2001	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 will in the buffer zone remain intact and unaltered unless their removal is included as a specific element during scenario development. The A-, B-, and C-Series ponds will remain in current configuration unless modifications are justified by pond reconfiguration strategy.
GAP-X114	SW	Identify the location of long term monitoring systems for surface water.	None	Low	2006 Use Assumption	POC locations will be used for long term monitoring systems.
GAP-X115	SW	Location of POCs if terminal ponds are removed.	Location to be negotiated between DOE and Regulatory Agencies if terminal ponds are to be removed. Need for terminal to be addressed in CDR.	Moderate	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-X069	SW	Amount of runoff, base flow and sediment concentrations from McKay Ditch.	Use Station SW998 data to approximate average values for base flow and sediment concentrations.	Moderate	Use Assumption	The quantity of off-site runoff that the McKay Ditch intercepts is insignificant and will not be included in this study.
GAP-X073	T/E	Extent of riparian/wetland habitat that is used by Preble's meadow jumping mouse (PMJM) due to hydrology changes at remediation endpoint.	Obtain and assess SWWB calibration and scenarios 0 and 1 results.	High	December 2001	Extent of riparian habitat after remediation will be similar to what can be seen in the 1951 and 1954 aerial photographs (i.e., significantly less acreage than currently exists). PMJM population would decline.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X072	T/E	Identification additional federal and state T/E species that would impact the final land configuration.	None. Uncertainty will remain until 2006.	Moderate	2006 Use Assumption	No changes to the current federal or state T/E lists would occur.
GAP-X074	T/E	Results of a future "Programmatic Biological Assessment" (prepared per the Endangered Species Act) to address land configuration changes and activities which may affect the Preble's Meadow Jumping Mouse.	None	Moderate	Use Assumption	No impact from future PBA.
GAP-X078	USE	Future mining activities.	None	Low	Use Assumption	Mineral rights within the LCDB Project area will not be exercised or rescinded by the State.
GAP-X081	VEG	Average canopy diameter for shrubs, trees, and grasses.	Correlate Aerial Photos.	High	Use Assumption	Average values generated by AME group will be used.
GAP-X082	VEG	Average height for trees and shrubs.	Field Work	High	Use Assumption	Average values generated by AME group will be used.
GAP-X083	VEG	Average number of shrubs, trees and grasses along a 100 m belt transect.	Correlate aerial photos.	High	Use Assumption	Average values generated by AME group will be used.
GAP-X084	VEG	Coefficient for leaf area index.	Color IR Data	High	Use Assumption	Average values generated by AME group will be used.
GAP-X107	VEG	Future vegetation type and distribution	Estimated from assumptions regarding future land uses and identification of areas to be disturbed by remediation activities.	High	Use Assumption	Future vegetation type and distribution will be similar to the present species.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X051	VEG	Plant growth for all target plant species to be planted in the BZ areas.	Literature search to determine pertinent local data.	Moderate	August 2001 Use Assumption	Soil fertility characteristics will be adequate to support plant growth (as evident from existing range grass conditions) for all target plant species to be considered for development during the conceptual planning activities for all BZ areas.
GAP-X033	VEG	Properties of final vegetative cover for IA. (required for WEPP input files).	Long term vegetation mixes are under consideration and development.	Moderate	Use Assumption	Vegetative cover will be same as adjacent existing vegetation with the same soil type.
GAP-X108	WET	Determination of sustainability of wetlands (other than seep areas on slopes) in North and South Walnut Creeks if the dams are removed. A defensible method for converting the output parameters from the SWWB balance into acreage by type of Wetlands, riparian, and Preble's meadow jumping mouse habitat.	Estimate based in part on SWWB. However, SWWB balance will NOT provide this correlation by itself.	High	July 2001	Remediation endpoint hydrology (without supplements) will only support wetland conditions similar to those in 1951 and 1954 aerial photographs. Wetland acreage will be reduced.
GAP-X110	WET	Groundwater elevations at completion of active remediation. This includes locations, quantity, and seasonal distribution of groundwater discharges.	Obtain SWWB calibration and scenarios 0 and 1 results.	High	December 2001	Groundwater elevations will be lower than present. Hydrology at completion of active remediation (without supplemental water) will only support wetland conditions similar to those in 1951 and 1954 aerial photographs. Wetland acreage will be reduced. Groundwater seeps that contribute to soil saturation would support wetland vegetation.
GAP-X111	WET	Extent of jurisdictional wetlands in IA.	An evaluation of the jurisdictional status of IA wetlands will determine extent.	Low	Use Assumption	Extent of jurisdictional wetlands will be the same as it is at the present time.

Table C-01
Data Gaps and Assumptions for the LCDB Project

ID	Subject Area	Data Gap Description	Proposed Resolution/ Data Acquisition	Priority for Resolution	Proposed Date for Resolution	Assumption for LCDB Project
GAP-X112	WILD	Unknown composition of wildlife populations (e.g., potential change in black-tailed prairie dog populations as they recover from a sylvatic plague outbreak, use of newly available area [i.e., Industrial Area] not known).	None. Uncertainty will remain until 2006.	Low	2006 Use Assumption	Wildlife populations at RFETS will not change significantly by 2006.

APPENDIX D
ANNOTATED OUTLINE FOR THE CONCEPTUAL DESIGN REPORT

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 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,
- 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.

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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

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 (PMJM) protection areas, wildlife, and vegetation. There is overlap among these resource categories that could be affected by each bounding scenario. For example, the PMJM 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, PMJM 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 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.

3.1.1 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.

3.1.2 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 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.

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3.1.3 Selected outputs from the SWWB model will be used 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 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.

3.1.4 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.

3.1.5 Direct physical effects, such as regrading or removing ponds and the wetlands associated with them, would be assessed and included in the evaluation.

3.2 Riparian Habitats

Riparian habitats are critical to support the PMJM 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.

3.2.1 Historic and recent aerial photographs will be evaluated to identify changes to riparian habitats (including PMJM 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

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information showing where riparian habitats, particularly stands of cottonwoods, found suitable conditions for establishment and success.

3.2.2 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).

3.2.3 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.

3.2.4 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 PMJM 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 PMJM protection areas. PMJM 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 PMJM. GIS mapping will be used to compile the intersection of predicted area changes and calculate the areal extent of changes that the PMJM 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.

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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.

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.

APPENDIX F
EROSION AND HYDROLOGIC EVALUATION FOR LAND CONFIGURATION DESIGN BASIS PROJECT

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 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 select 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.

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 Water Erosion Prediction Project (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. For example, the possible effects of irrigation canals and ditches will be ignored. It is assumed that overland runoff will flow over the canals, and the canal flow entering the RFETS will not over top its banks.

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.

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.

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 select 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 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.

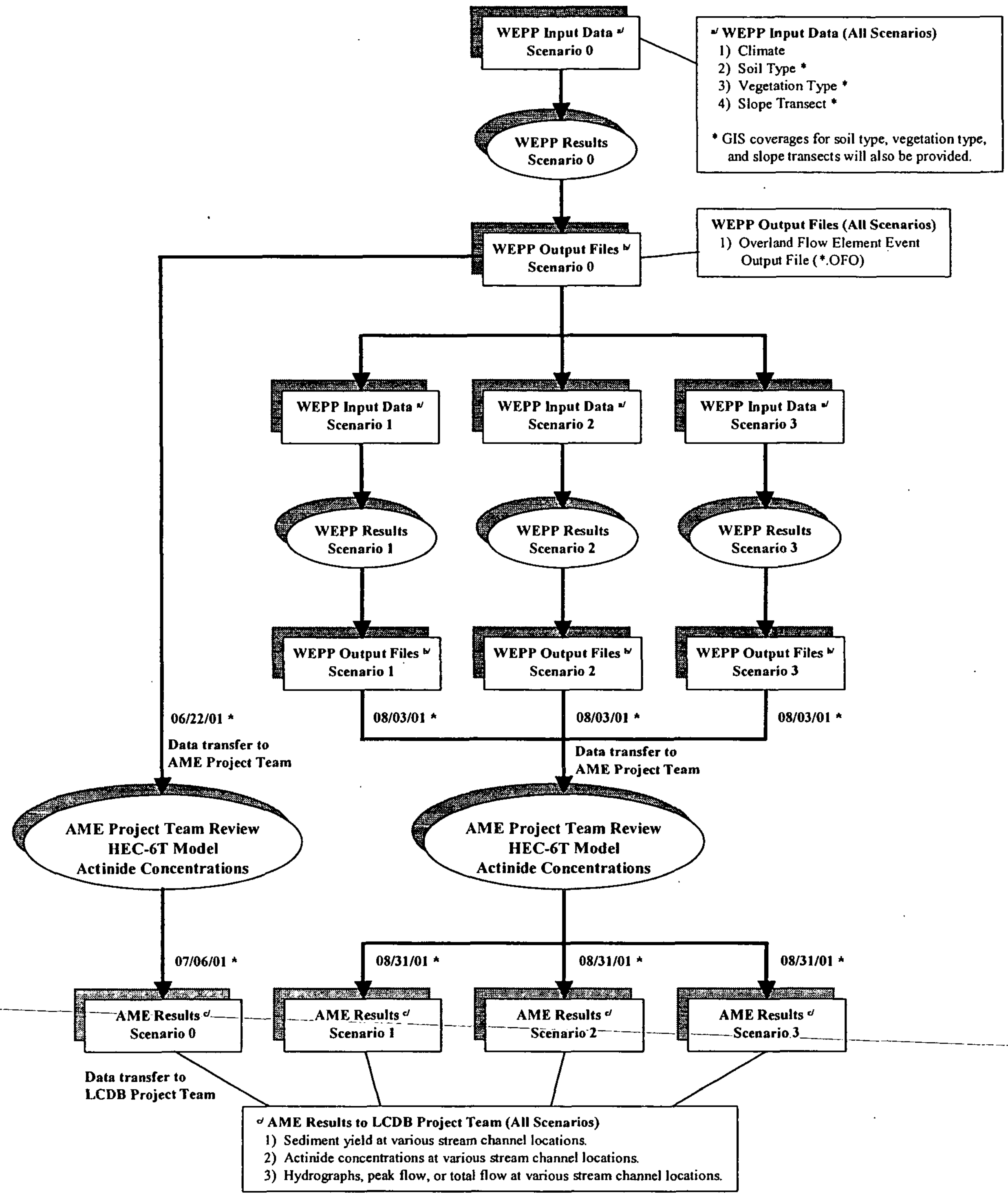
5.0 INITIAL CONCEPTUAL DESIGN

An initial conceptual design will be developed to incorporate and expand the scenario components selected 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.

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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APPENDIX G
GEOMORPHIC EVALUATION FOR
LAND CONFIGURATION DESIGN BASIS PROJECT

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 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 was selected to be 1,000 years because predictions for longer time 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.

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.
- **Tectonics** - It is assumed that seismic events, which could alter erosion rates, will not occur over the 1,000-year evaluation period.
- **Anthropogenic Influences** - It is assumed that significant landform changes will not result from any roads and/or other anthropogenic activities at the Site. 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.

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 currently not available. As such, an appropriate value will be determined from published literature.
- **Channel Incision** - Site-specific data for channel incision is currently 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 previously described 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 scenario to withstand / accommodate long-term geomorphic changes.

6.0 INITIAL CONCEPTUAL DESIGN

A topographic map to depict the predicted future landform conditions over the 1,000-year evaluation time period will be generated for the initial conceptual design using GIS. 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.

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.
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.
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.
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.
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. Minimal disruption to established habitat. 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.

Table 2
Summary of Potential Land Configuration Options

Land Configuration Option	Relative Cost		Advantages	Disadvantages	Additional Considerations
	Capital	Operational			
4. **Wetland Filtering / Treatment** Runoff from specified drainage is routed through constructed wetland(s) to remove suspended solids by reducing runoff velocity and filtering. Wetland(s) could also be used to treat nitrate/nitrite.	Low	Low	Provides uptake and reduction of nitrate 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 PMJM 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.
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.	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.	Long-term 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) Controls** ET controls could be used for surface soils that are susceptible to contaminant migration to minimize runoff. ET controls 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 PMJM. ET controls could require import of offsite borrow soils.	None identified.

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Table 2
Summary of Potential Land Configuration Options

Land Configuration Option	Relative Cost		Advantages	Disadvantages	Additional Considerations
	Capital	Operational			
10. Infiltration Infiltration could be used for surface soils that are susceptible to contaminant migration to minimize runoff. Infiltration could be used to promote wetlands and habitats through increased seepage. Infiltration could also be used in conjunction with ground water treatment systems to flush contaminants.	Low	Low	Runoff and erosion would be reduced. Can be used to maintain wetlands and habitats.	Hillslopes may become unstable if infiltration is increased. Ground water flows may be altered which could adversely impact effectiveness of ground water treatment systems.	None identified.
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.

Table B-06
Summary Information for Pond Reconfiguration

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) a/	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 permanently 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 conduit consists of corrugated metal pipe, grouted closed. Embankment lacks d/s toe drain.
	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 Low level 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 high- and low-level inlets. High-level outlet conduit consists of corrugated metal pipe. Low-level outlet 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	--	5,770	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 conduit consists of ductile iron 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	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 conduit consists of reinforced concrete pipe.
	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	--	Outlet works permanently 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 high- and low-level inlets. High-level outlet conduit consists of corrugated metal pipe, grouted closed. Low-level conduit is ductile iron pipe, grouted closed.
	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	Constructed....Prior to 1952 Raised & modified....1972	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. Outlet conduit consists of corrugated metal pipe w/HDPE liner 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	--	Not available	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 high- and low-level inlets. The higher inlet is located in the spillway approach channel. The spillway can pass about 60% of the PMP flood. Outlet conduit consists of corrugated metal 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	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. 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				

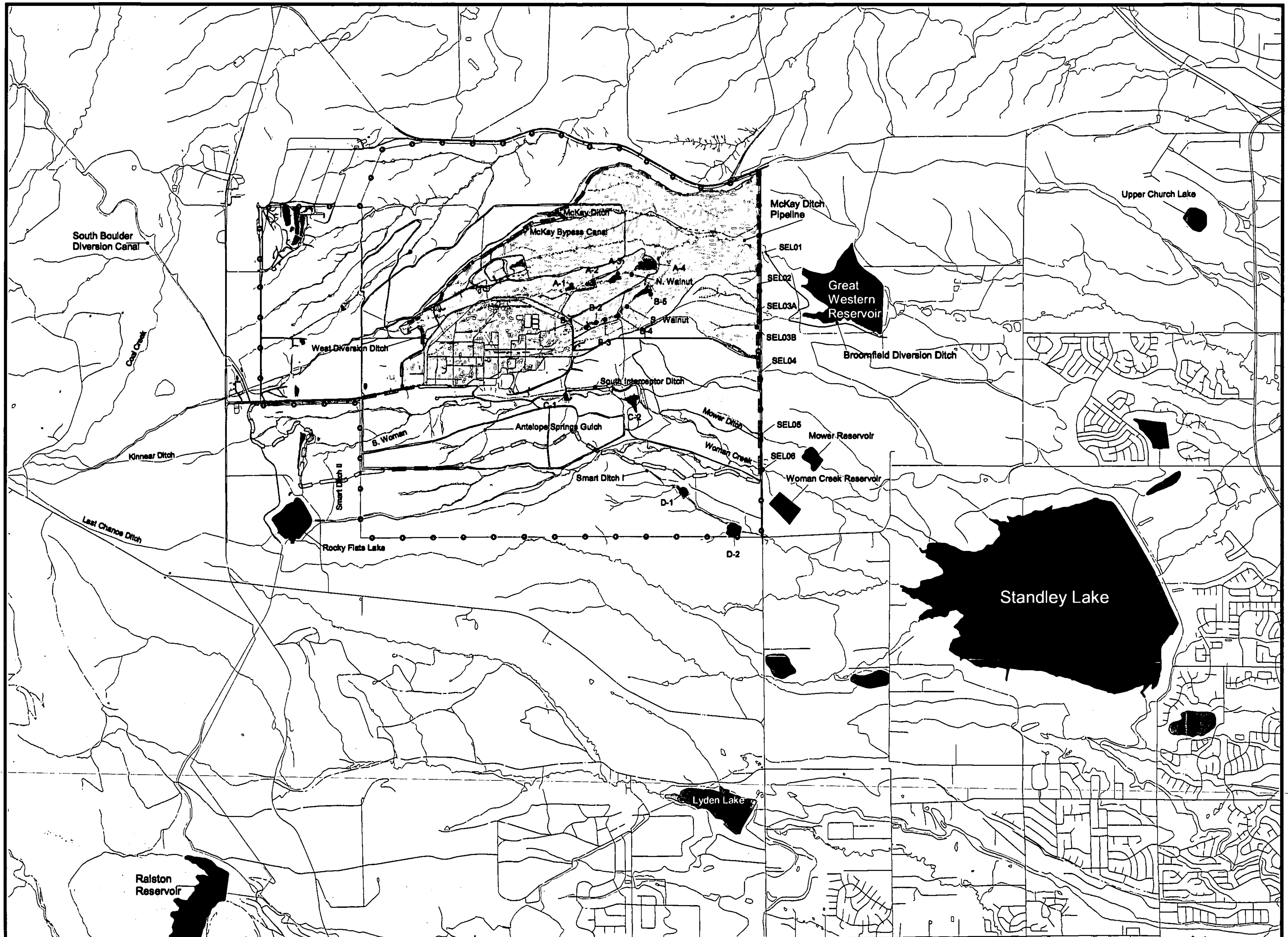
Table B-06
Summary Information for Pond Reconfiguration

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) a/	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	--	5,782 (main outlet) 5,765 (drain bed pipe)	Constructed ....1979 Outlet, u/s face & rt abutment modified ....1984 Crest monuments installed....1993 Outlet modified 1996	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 reinforced concrete pipe. 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	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	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 reinforced concrete pipe.
	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	--	Outlet is non-functional	Constructed ....1974 Crest monuments installed..........	Outlet works is inoperable due to bent valve stem. Wave erosion is present along waterline at upstream face.	Spillway flows through a concrete box culvert.
	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.

Figure B-02

LCDB Project Boundary and Drainage Features



Legend

- Solar Ponds
- Lakes\Ponds
- Streams, ditches, or other drainage features
- Contour Lines

Areas of Sub-basins

SEL01	1544	acres
SEL02	21	
SEL03A	61	
SEL03B	94	
SEL04	188	
SEL05	176	
SEL06	1334	

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
Drainage Basin data - Approved by Win Chromes (RMRS, 303-966-4535)
Woman Creek Reservoir, Broomfield Diversion Ditch, and McKay Ditch Pipeline added. Not to Scale.

N

Scale

2000 0 2000 4000 Feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

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Rocky Flats Environmental Technology Site
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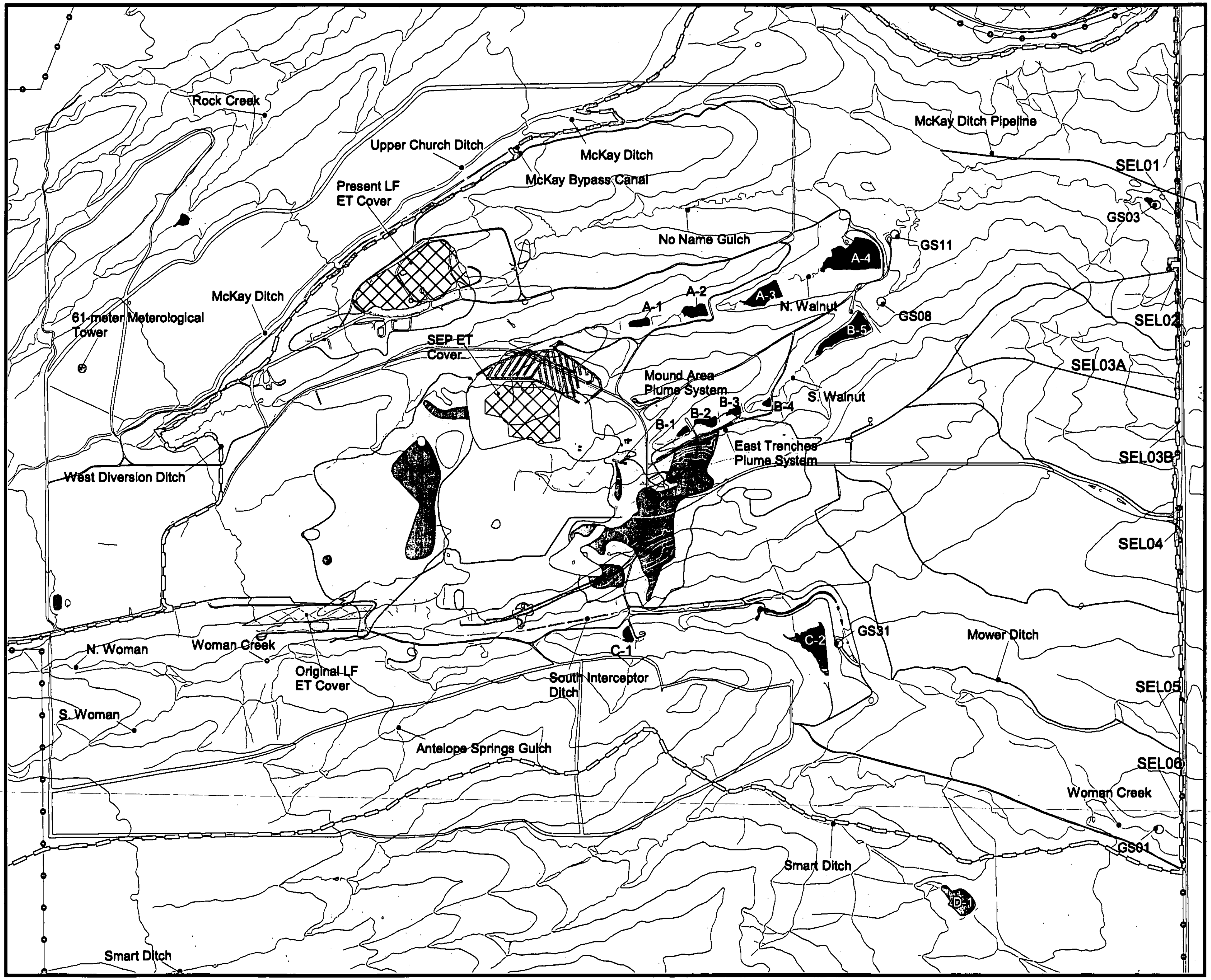
Figure B-03

Anticipated Conditions and Physical Constraints After Active Remediation



Legend

- Lakes/Ponds
- Plume System
- Streams, ditches, or other drainage features
- Drainage Basin Boundary
- Nitrate concentration equal to or greater than 10 mg/L (as N)
- Nitrate concentration equal to or greater than 1000 mg/L (as N)
- Composite VOC Groundwater Plume (concentration equal to or greater than MCL)
- Composite VOC Groundwater Plume (concentration equal to or greater than 100 times MCL)
- ET Cover
- Surface water monitoring Point of Compliance
- 10' Contour
- 50' Contour

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
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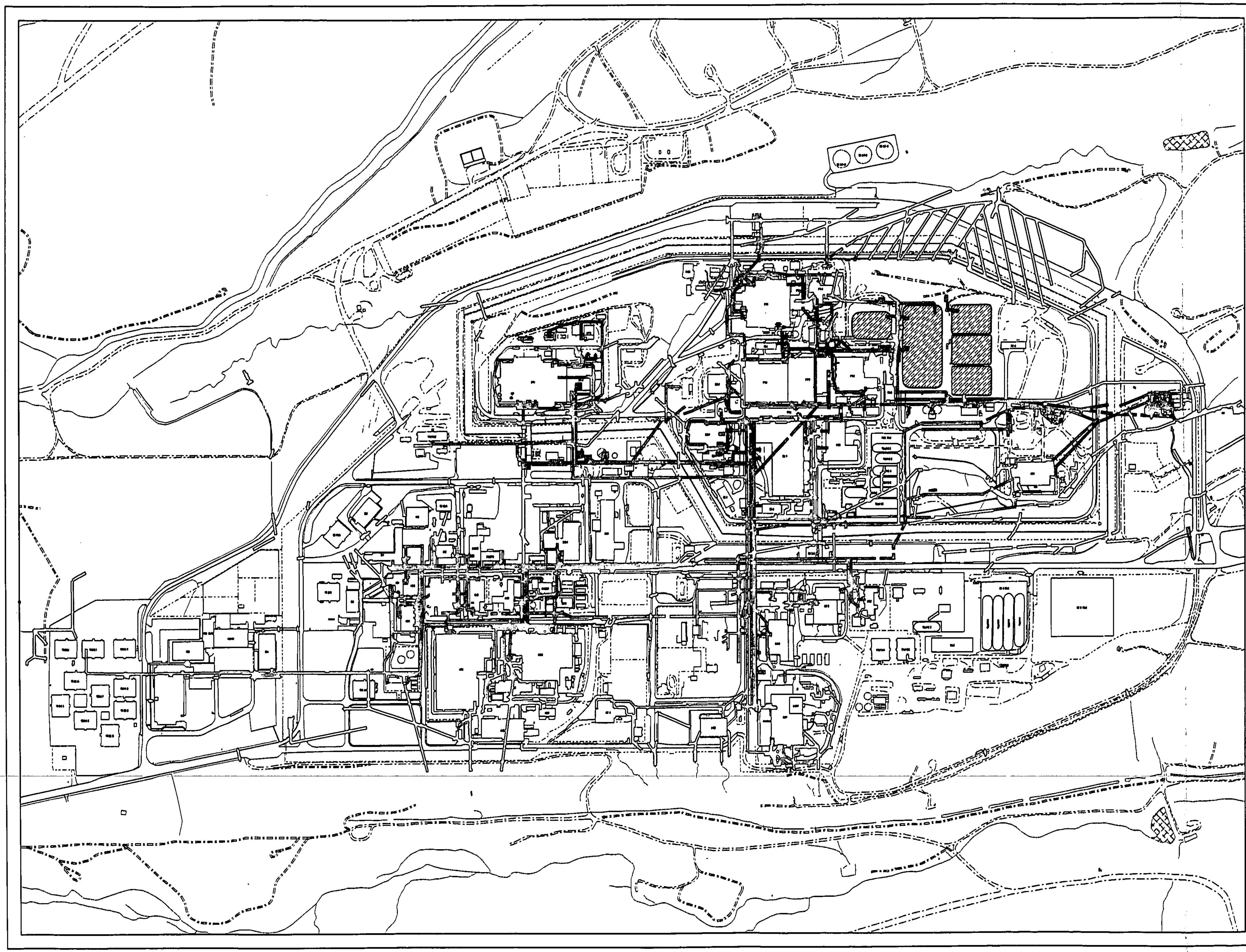

Figure B-04

Location of Process Waste Lines, Sanitary Sewers and Storm Drains

Legend

- Solar Ponds
- Lakes/Ponds
- New Process Waste Line
- Storm Drains
- Sanitary Sewer System

Data Source:
The utilites (above and underground) information was supplied by EG&G Facilities Department in DXF format, Aug 1993. The GIS department created ARC coverages (data layers rom the DXF files and converted the data from Rocky Flats Coordinate system to State Plane Coordinate system. Utility data as presented in Industrial Area Characterization and Remediation Strategy. RMRS and Kaiser-Hill, Sept. 1999, 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

N

Scale

2000 0 2000 Feet

State Plane Coordinate Projection
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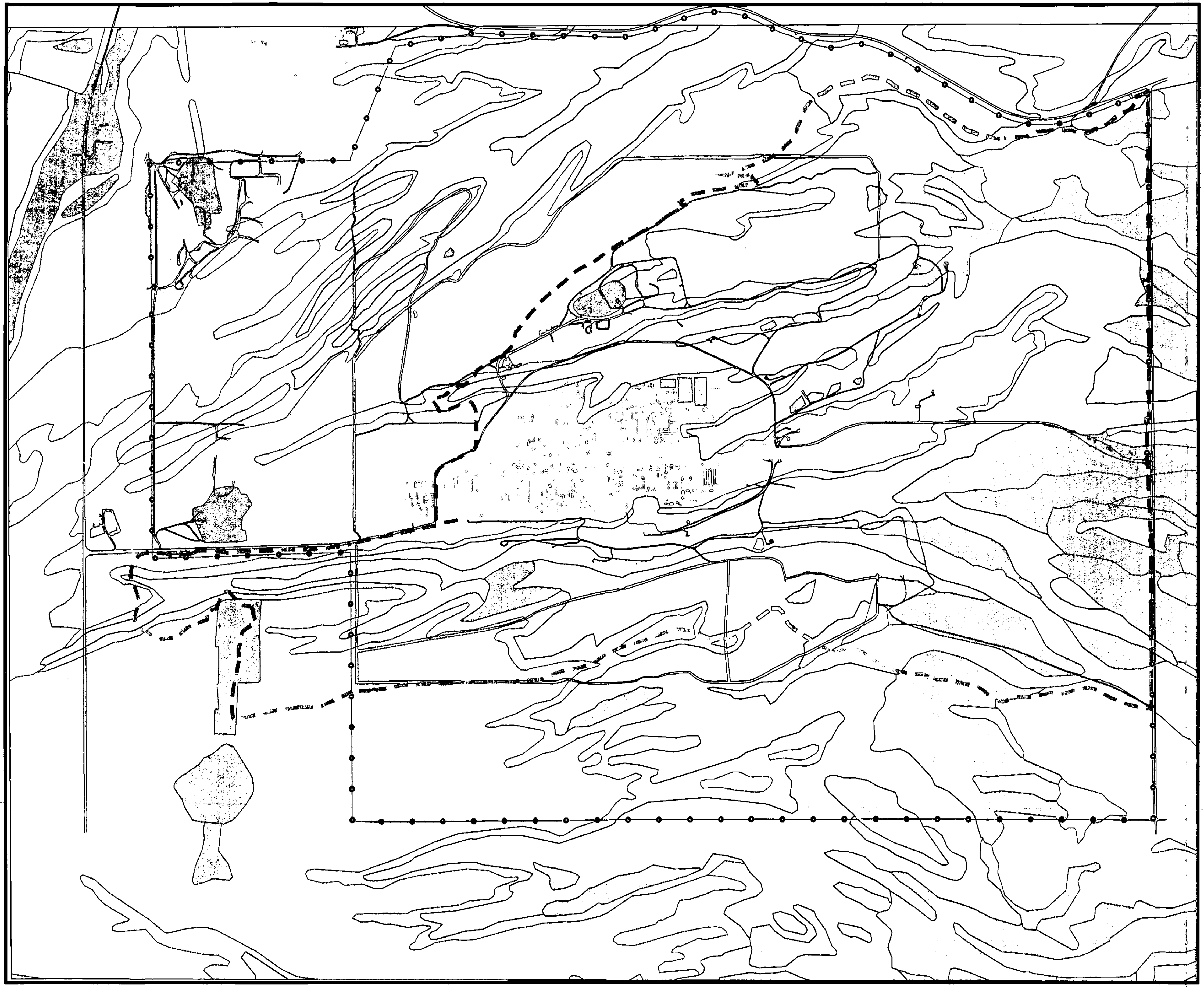

Figure B-05
Soil Infiltration Map
Legend

- 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

N

Scale
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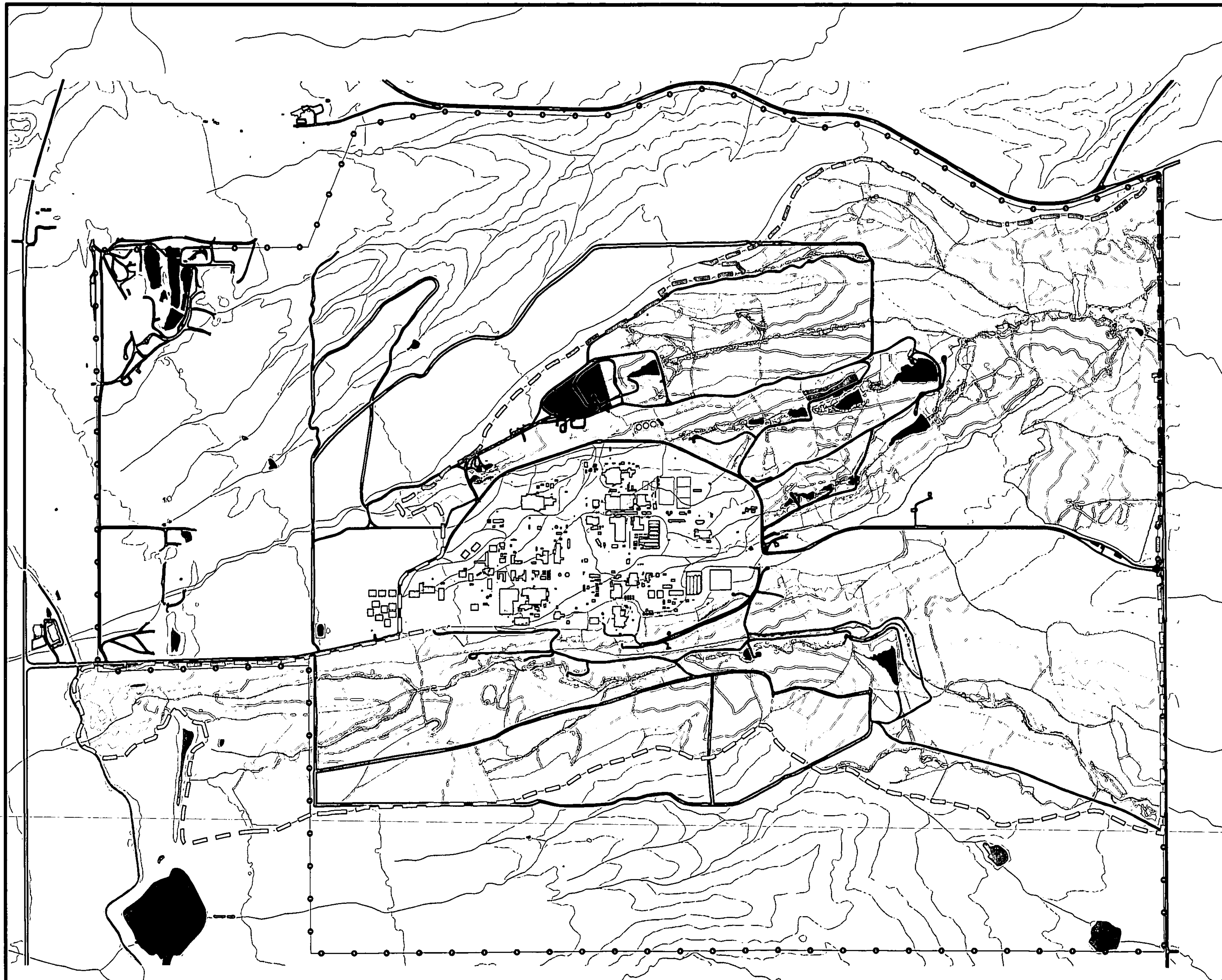
Figure B-06

Predicted 100-Year Average Erosion Map



Legend

- >0.400 Kg/m2 (0.737 Lbs/yd2) Deposition
- 0.200 Kg/m2 (0.369 Lbs/yd2) Detatchment
- 0.020 Kg/m2 (0.037 Lbs/yd2) Deposition
- No Deposition or Detachment
- 0.010 Kg/m2 (0.018 Lbs/yd2) Detatchment
- 0.025 Kg/m2 (0.046 Lbs/yd2) Detatchment
- 0.050 Kg/m2 (0.092 Lbs/yd2) Detatchment
- 0.100 Kg/m2 (0.184 Lbs/yd2) Detatchment
- 0.150 Kg/m2 (0.276 Lbs/yd2) Detatchment
- 0.200 Kg/m2 (0.369 Lbs/yd2) Deposition
- 0.250 Kg/m2 (0.461 Lbs/yd2) Detatchment
- 0.300 Kg/m2 (0.553 Lbs/yd2) Detatchment
- 0.350 Kg/m2 (0.645 Lbs/yd2) Detatchment
- Industrial Area
- South Interceptor Ditch (SID)
- Walnut Creek
- Woman Creek
- Buildings
- Lakes/Ponds
- Streams, ditches, or other drainage features
- 50' Contour

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

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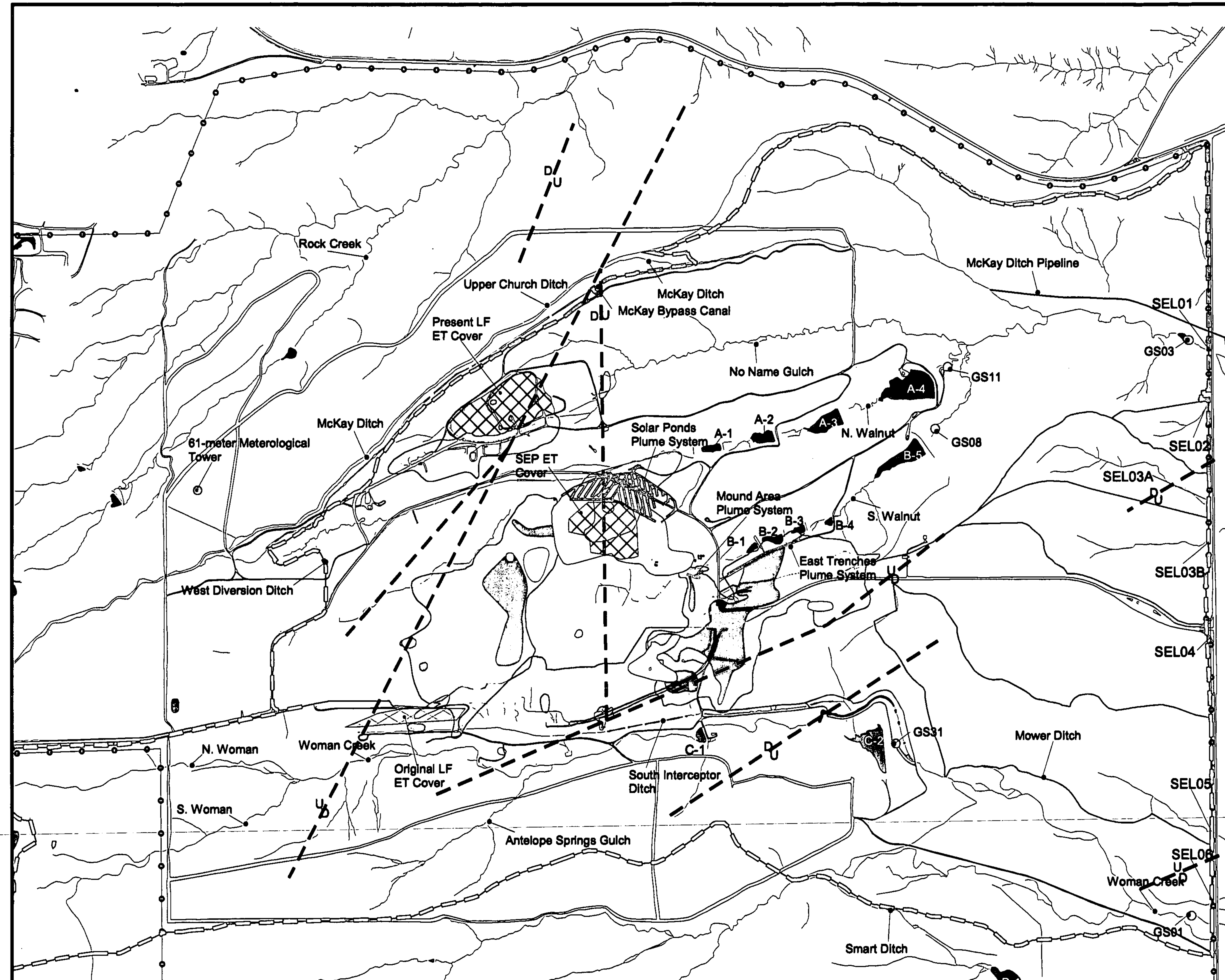

Figure B-08

Inferred Fault Locations

Legend

- Inferred Fault
- U/D Fault Direction
- Lakes/Ponds
- Plume System
- Streams, ditches, or other drainage features
- Drainage Basin Boundary
- Nitrate concentration equal to or greater than 10 mg/L (as N)
- Nitrate concentration equal to or greater than 1000 mg/L (as N)
- Composite VOC Groundwater Plume (concentration equal to or greater than MCL)
- Composite VOC Groundwater Plume (concentration equal to or greater than 100 times MCL)
- ET Cover
- Surface water monitoring Point of Compliance

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

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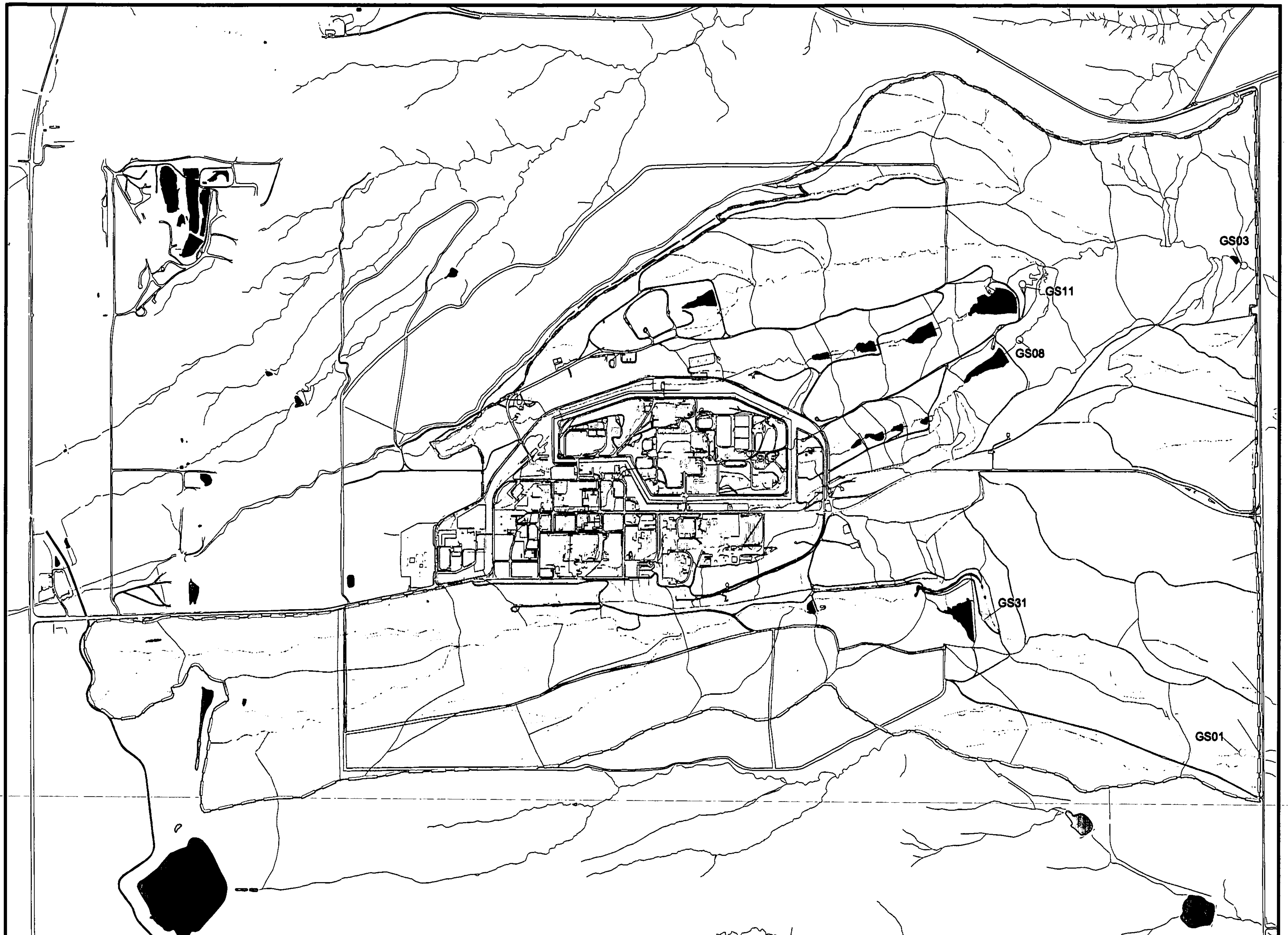
Figure B-9

Location of Surface Water Use Classifications



Legend

- Segment 4a
- Segment 4b
- Segment 5
- Solar ponds
- Lakes/Ponds
- Streams, ditches, or other drainage features
- Drainage Basins

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

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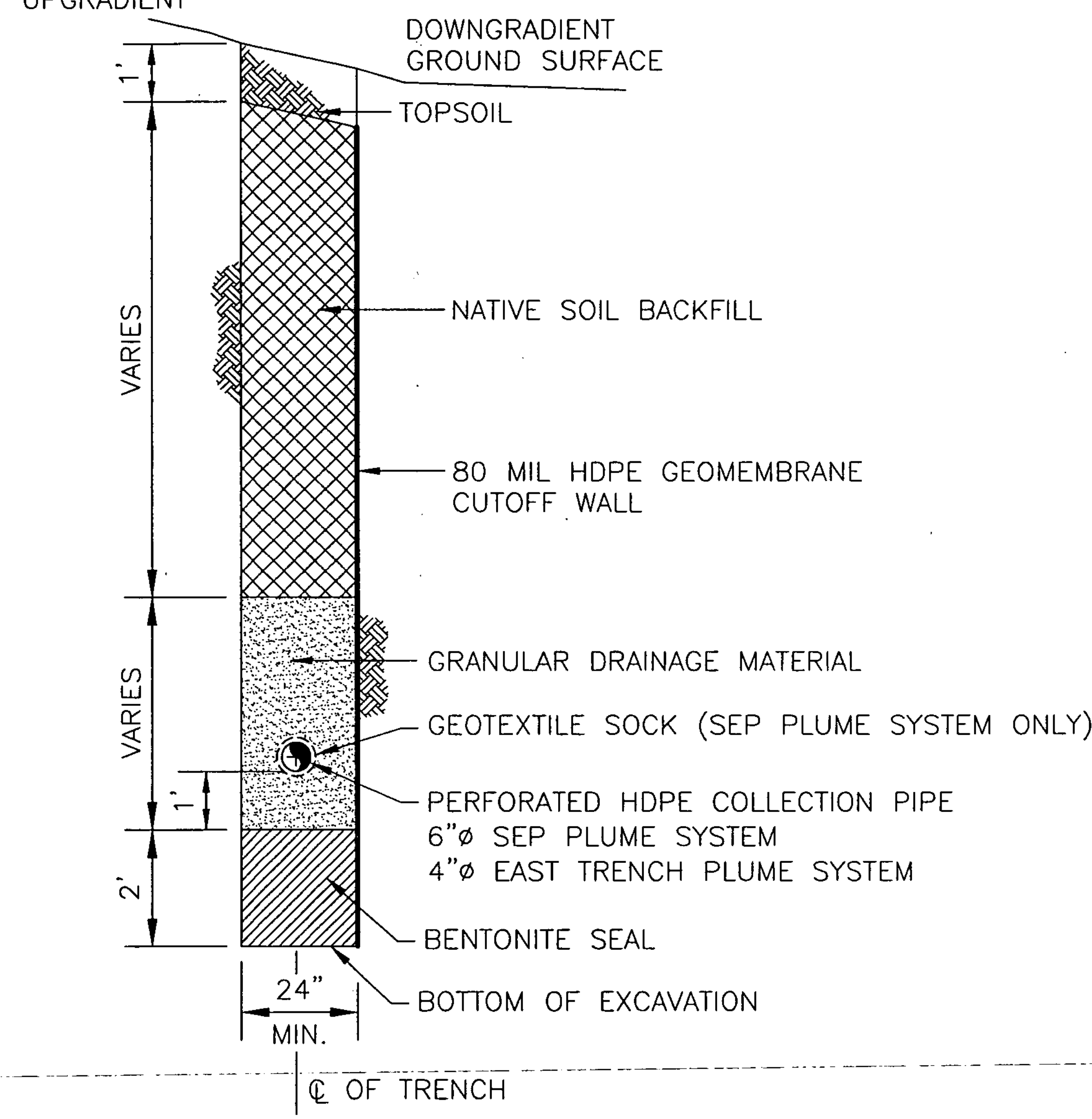
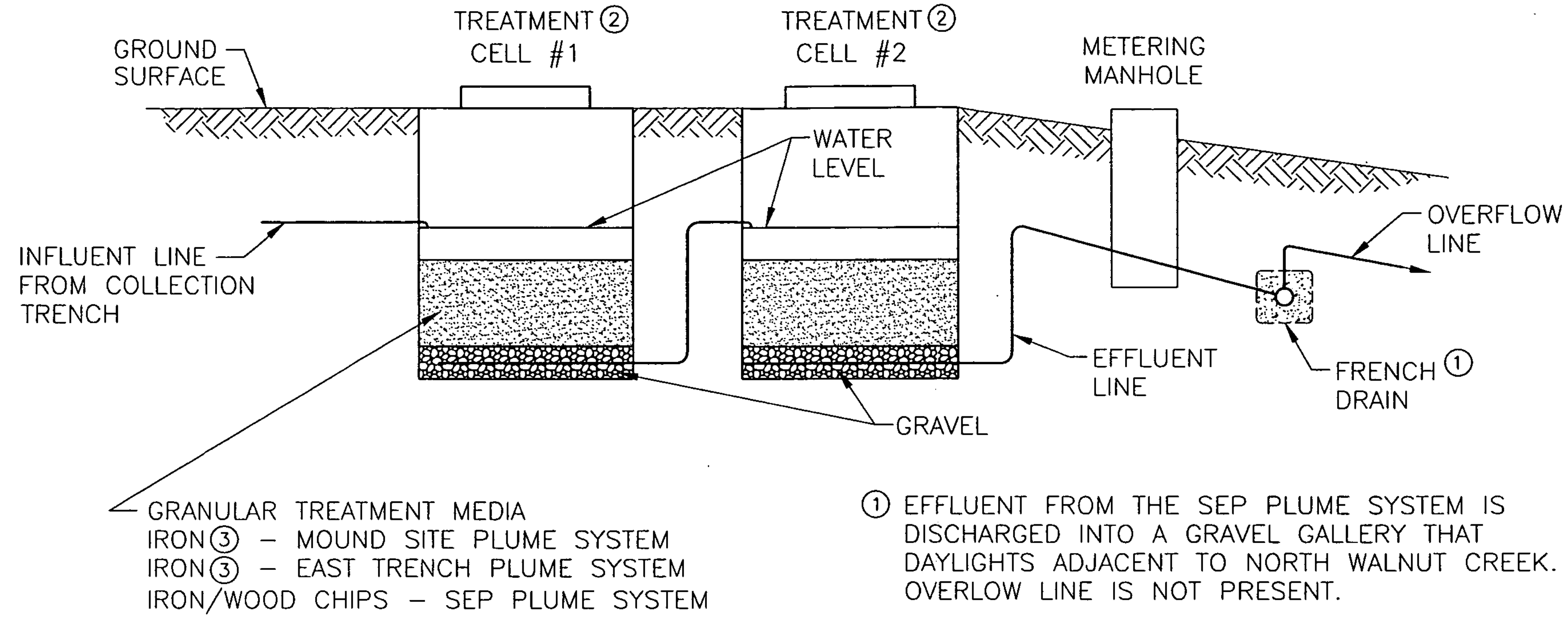


TYPICAL GROUNDWATER COLLECTION TRENCH CROSS SECTION

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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164

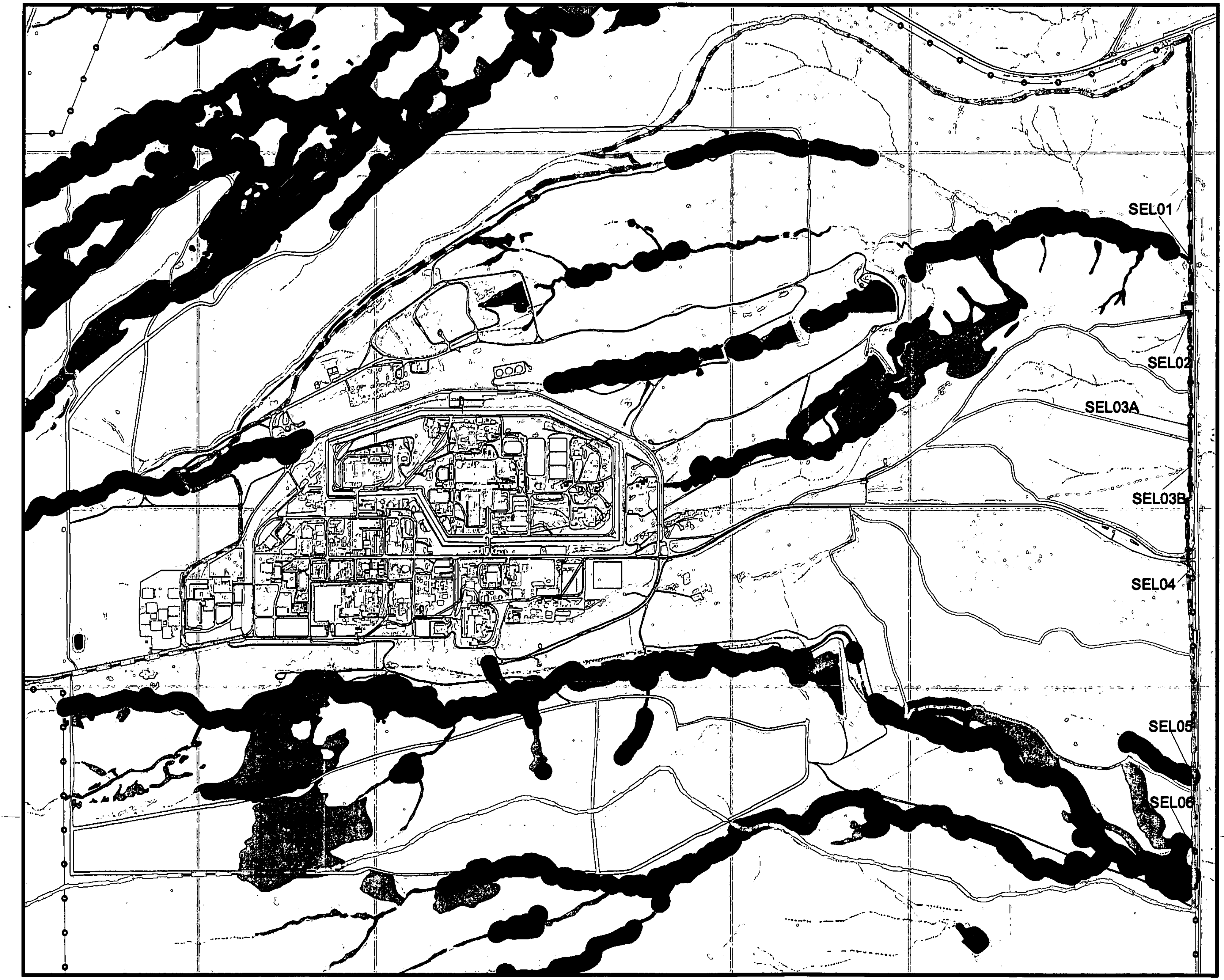

Figure B-12

Current Preble's Jumping Mouse Habitat

Legend

	Acres within LCDB Project Boundary
Contiguous wetland	186
Protection area	367
Solar Ponds	
Lakes/Ponds	
Streams, ditches, or other drainage features	
Drainage Basins	

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
Habitat Maps from 1999 Annual Wildlife Report (Kaiser-Hill, August 2000h)

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Scale

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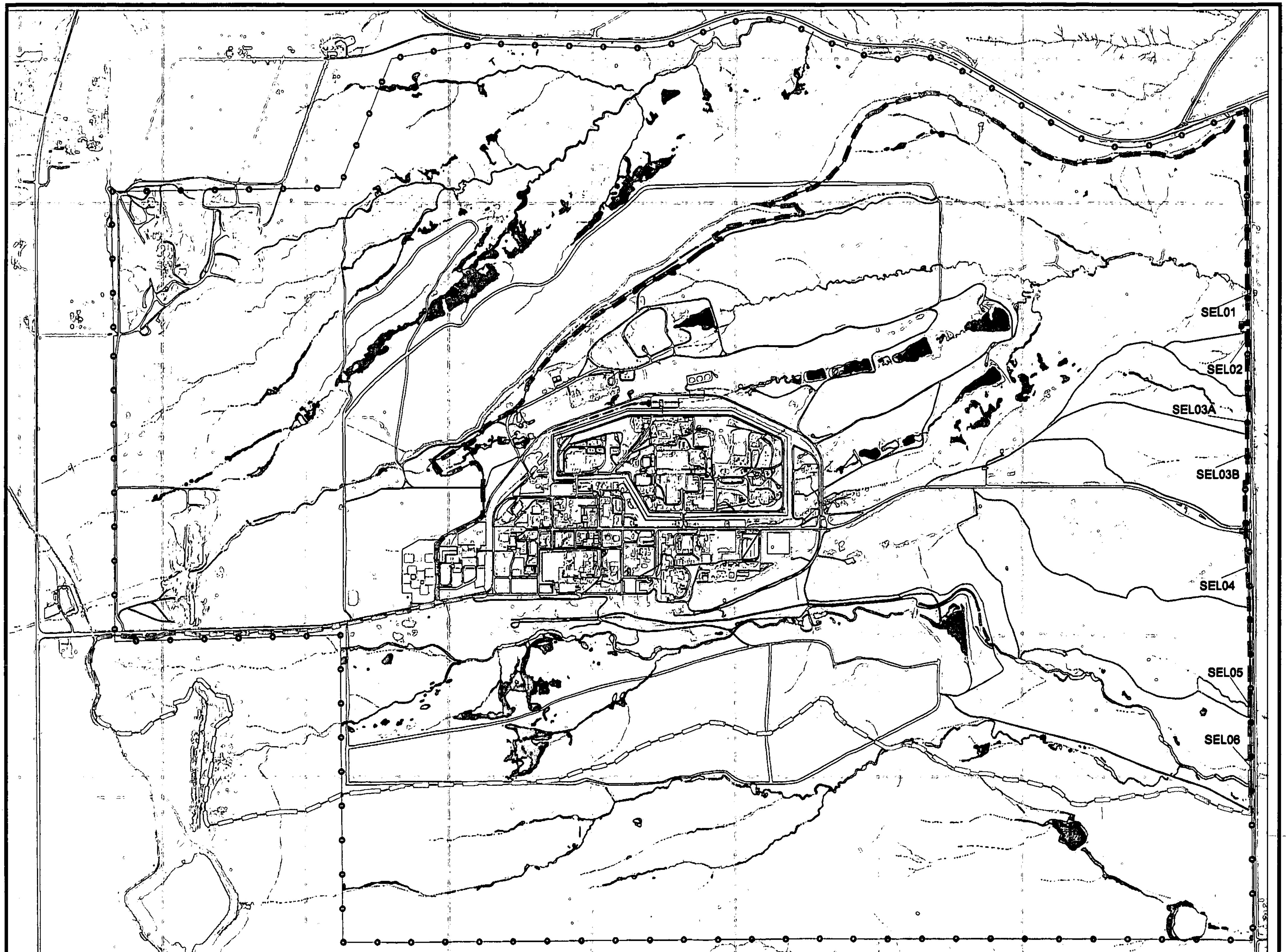

Figure B-13

Current Wetland Location Map

Legend

Wetland Types	Wetland Acreages
L1UBH	19.6
PABH	1.5
PEMA	39.4
PEMB	38.3
PEMC	42.4
PEMF	4.5
PFOA	0.1
PFOC	1.9
PSSA	7.7
PSSC	22.9
PUBF	7.2
PUBH	2.3
PUSC	0.3
R4SBC	0.5
R4SBG	0.5
R4SBJ	3.0

Streams, ditches, or other drainage features
Palustrine
Riverine
Drainage Basins

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, 1/96
Wetland data sruveyed, compiled, and assembled by the US Army Corps of Engineeres, 1994.
Source Kaiser-Hill

N

Scale

2000 0 2000 Feet

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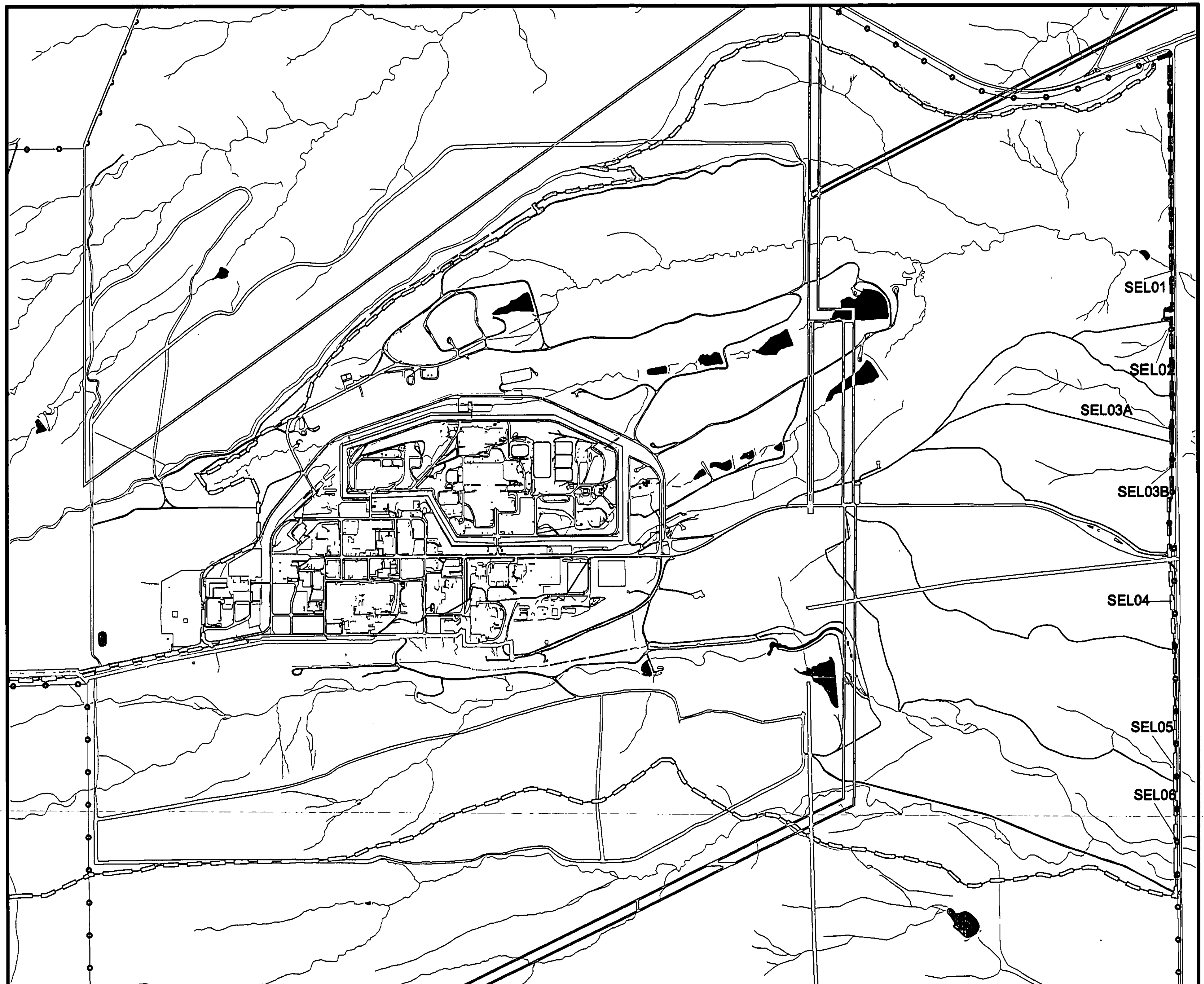

Figure B-14
Utility and Easement Location Map
Legend

- Gas Utility
- Electirc Utility
- Unknown Easement
- Solar Ponds
- Lake/Ponds
- Streams, ditches, or other drainage features
- Drainage Basins

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 Kaiser-Hill

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Scale
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