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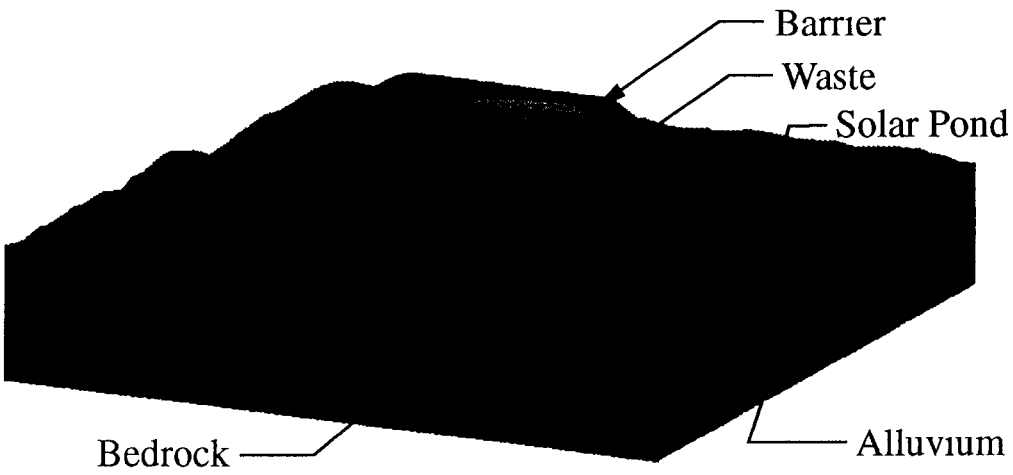
OU4 Solar Evaporation Ponds
Interim Measure/Interim Remedial Action
Environmental Assessment
Decision Document

U S Department of Energy
Rocky Flats Environmental Technology Site
Golden, Colorado

February 1995

Revision Proposed

Parts IV and V



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DOCUMENT ORGANIZATION

Operable Unit 4 Solar Evaporation Pond Interim Measure/Interim Remedial Action - Environmental Assessment Decision Document

Part I	-	Executive Summary and Introduction
Part II	-	Operable Unit 4 Phase I RCRA Facility Investigation/Remedial Investigation Report
		Volume 1 - Sections 1 through 8 (Figures for Section 3 are in Volume 2)
		Volume 2 - Section 3 Figures
		Volume 3 - Appendices A through G
		Volume 4 - Appendices H through L
		Volume 5 - Appendices M through O
		Volume 6 - Appendices P through Q
		Volume 7 - Appendices R through V
		Volume 8 - Appendices W through AA
Part III	-	Interim Measure/Interim Remedial Action Design Analysis
Part IV	-	Recommended Interim Measure/Interim Remedial Action Alternative
Part V	-	Post-Closure Monitoring and Assessment Plan

OPERABLE UNIT 4 SOLAR EVAPORATION POND
INTERIM MEASURES/INTERIM REMEDIAL ACTION-ENVIRONMENTAL ASSESSMENT DECISION DOCUMENT

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OPERABLE UNIT NO. 4
LIST OF ACRONYMS AND ABBREVIATIONS

ADT	Average Daily Traffic
AG	aboveground
AIP	Agreement in Principle
ANOVA	analysis of variance
APEN	Air Pollution Emission Notice
AR	Treatability Studies Annual Reports
ARAR(s)	Applicable or Relevant and Appropriate Requirement(s)
ARF	Airborne Release Fraction
ASTM	American Society for Testing and Materials
ATM-m^3/mole	Atmospheres per cubic meter per mole
ATSDR	Agency for Toxic Substance and Disease Registry
BDL	Below (analytical) Detection Limit
bgs	below ground surface
BRA	Baseline Risk Assessment
BTEX	benzene, toluene, ethylbenzene, and xylene
CAD/FAD	Corrective Action Decision/Final Action Decision
CAMU	Corrective Action Management Unit
CAP	Cement Asbestos Pipe
CCR	Colorado Code of Regulations
CD	Consolidated-Drained
CDH	Colorado Department of Health
CDOT	Colorado Department of Transportation
CEC	Cation Exchange Capacity
CE	Cognizant Engineer
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHWA	Colorado Hazardous Waste Act
CI	Cast Iron
CLP	Contract Laboratory Program
CLT	Comprehensive list of technologies/process options
cm^2	square centimeters
cm/day	centimeters per day
cm/sec	centimeters per second
CMP	corrugated metal pipe
CMS/FS	Corrective Measures Study/Feasibility Study
COC(s)	contaminants of concern
COEM	Conduct of Engineering Manual
COL	colluvium
cpm	counts per minute
CRDL	contract-required detection limit

CRQL	contract-required quantitation limit
CSI	Construction Specified Institute
CU	Consolidated-Undrained
DCF	Dose Conversion Factor
DCG	Derived Concentration Guide
DCN	document change notice
°C	degrees Celsius
DOE	United States Department of Energy
DOT	U S Department of Transportation
dpm	disintegrations per minute
dpm/kg	disintegrations per minute per kilogram
DQO	data quality objective
DQR	data quality requirement
EA	environmental assessment
ECD	electron capture detector
EE	Environmental Evaluation
EIS	Environmental Impact Statement
EM	Electromagnetic
EMD	Environmental Management Division
EPA	United States Environmental Protection Agency
EPRI	Electric Power Research Institute
ES&H	Environmental Safety and Health
°F	degrees Fahrenheit
FDC	Frequency domain capacitance
FFCA	Federal Facilities Compliance Agreement
FID	Flame Ionization Detector
FIDLER	Field Instrument for the detection of low energy radiation
FML	flexible membrane liner
FO	field operations
FR	Federal Register
FRP	Fiberglass Reinforced Plastic
FS	Feasibility Study
FSP	Field Sampling Plan
ft/ft	feet per foot
ft msl	feet above mean sea level
ft/yr	feet per year

g/cm^3	grams per cubic centimeter
GC/FID	gas chromograph/flame ionization detector
GCL	geosynthetic clay liners
GIS	Geographic Information System
gpm	gallons per minute
GPR	ground-penetrating radar
GRA	General Response Action
GRRASP	General Radiochemistry and Routine Analytical Services Protocols
HEAST	Health Effects Assessment Summary Table
HELP	Hydrologic Evaluation of Landfill Performance
HEPA	High-Efficiency Particulate Air
HHEM	Human Health Evaluation Manual
HHRA	Human Health Risk Assessment
HHS	Human Health Standard
HM	hot measurement
HQ	hazard quotient
HSU	hydrostratigraphic unit
IAG	Interagency Agreement
ICP	Inductively Coupled Plasma Arc Method
ICR	Incremental Cancer Risk
IDL	instrument detection limit
IDM	Investigation-Derived Material
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IRIS	Integrated Risk Information System
ITPH	interceptor trench pump house
ITS	interceptor trench system
K	hydraulic conductivity
KAL	Cretaceous Arapahoe/Laramie
KS	Kolmogorov-Smirnov
LDR	land disposal restriction
LHSU	lower hydrostratigraphic unit
LOEL	Lowest Observed Effect

m	meter
MCL	maximum contaminant level
MEPAS	Multimedia Exposure Pathway Asessment System
mg/kg	milligrams per kilogram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
mg/L	milligrams per liter
m/yr	meters per year
MHz	megahertz
mph	miles per hour
MTR	Minimum Technology Requirement
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOEL	No Observed Effect
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NSC	Non-safety Class
NTGS	National Technical Guidance Series
NTS	Nevada Test Site
O&M	operations & maintenance
OPWL(s)	original process waste line(s)
OU	Operable Unit
OU4	Operable Unit 4
PA	Protected Area
PAH	Polynuclear or Polycyclic Aromatic Hydrocarbon
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCBs	polychlorinated biphenyls
pCi/L	picocuries per liter
PCOC(s)	potential contaminant(s) of concern
PCE	Tetrachloroethene
pH	negative log hydronium ion concentration moles per liter (potential of hydrogen)
PID	Photoionization Detector
PM10	particulate matter less than 10 microns
PMR	Power Modification Request
PNA	polynuclear aromatic hydrocarbons

PNL	Pacific Northwest Laboratory
PP	proposed plan
PPCD	DOE's Plan for Prevention of Contaminant Dispersion
PPE	personal protective equipment
PQAP	Project Quality Assurance Program Plan
PRG(s)	preliminary remediation goal(s)
PSZ	Perimeter Security Zone
PVC	polyvinyl chloride
QA	quality assurance
QAA	Quality Assurance Addendum
QAP	Quality Assurance Plan
QAPjP	Quality Assurance Project Plan
QC	quality control
QHA	Quality Assurance Addendum
RA	remedial action
RAAMP	Radiological Ambient Air Monitoring Program
RAGS	Risk Assessment Guidance for Superfund
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
RF	Respirable Fraction
RFA	Rocky Flats Alluvium
RfC	reference concentration
RfD	reference dose
RFEDS	Rocky Flats Environmental Database System
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RL	reporting limit
ROD	Record of Decision
ROI	Radiological operating instruction
RQD	Rock Quality Designation
RSP	Respirable Suspended Particulates
SAP	Sampling and Analysis
SAS	Special Analytical Service
SCS	Soil Conservation Service
SEP(s)	Solar Evaporation Pond(s)
SF	slope factor

SOP	Standard Operating Procedure
SOW	Statement of Work
SPT	Standard Penetration Test
SS	Stainless Steel
SSH&SP	Site-Specific Health and Safety Plan
STL	Steel
STP	Sewage Treatment Plant
SVOC	semivolatile organic compound
SWMU	Solid Waste Management Unit
TAL	Target Analyte List
TBC	to-be-considered documents
TCA-1,1,1	Trichloroethane
TCE	Trichloroethene
TCL	Target Compound List
TCLP	toxicity characteristic leaching procedure
TDR	Time domain reflectometry
TDS	total dissolved solids
TICs	tentatively identified compounds
TMTS	Temporary Modular Tank System
TOC	total organic carbon
TSDF	Treatment, Storage, or Disposal Facility
TSP	Treatability Studies Plan
TSS	total suspended solids
UCL	upper confidence level
UG	underground
UHSU	upper hydrostratigraphic unit
UITS	Upgradient Interceptor Trench System
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
UTL	upper threshold limit
UV	ultraviolet
VCP	Vitrified Clay Pipe
VFA	Valley Fill Alluvium
VOC	volatile organic compound

WARP	Well Abandonment and Replacement Program
WCS	weathered bedrock
WQPL	water quality parameters list
WRS	Wilcoxon Rank Sum
ZPA	Zero Period Acceleration

PART IV RECOMMENDED IM/IRA ALTERNATIVE

Part IV provides the conceptual design of the proposed general response action (GRA) to close/remediate the Solar Evaporation Ponds (SEPs), also known as Operable Unit 4 (OU4) and Individual Hazardous Substance Sites (IHSSs) 101 and 176 Part IV also presents the strategy to close Building 788 (Resource Conservation and Recovery Act (RCRA) Units 21 and 48) and Building 964 (RCRA Unit 24) Section IV 1 contains a general programmatic summary of the project activities that will be performed Section IV 2 provides the functional design requirements and the specific design criteria that must be complied with in order for the SEP closure/remediation system to achieve the established goals and objectives Section IV 3 presents the conceptual design for the closure/remediation system which is summarized in Section IV 1 Section IV 4 provides a waste management plan identifying the wastes that will be generated as the project is implemented A list of the specifications that will be prepared during the detailed design period is presented in Section IV 5 Section IV 6 provides work plans for engineering optimization studies that will be implemented during the detailed design period to provide the information which is required for design completion This section also contains a conceptual-level construction schedule to implement the design Section IV 7 presents a conceptual-level construction cost estimate A construction quality assurance plan is presented in Section IV 8 Section IV 9 discusses health and safety considerations for the construction activities Section IV 10 assesses the risks associated with the proposed GRA, identifies any environmental impact, and compares the environmental impact from the proposed GRA to the no-action GRA Section IV 11 presents how the design will comply with the identified Applicable or Relevant and Appropriate Requirements (ARARs) and proposes to establish a Corrective Action Management Unit (CAMU) as necessary to administratively implement the proposed action Section IV 11 also proposes to establish a temporary unit (TU) for the processing of OU4 sludge and pondcrete

IV.1 GENERAL PROJECT DESCRIPTION

The following section provides a general description of the activities that will be performed as part of the OU4 Interim Measure/Interim Remedial Action (IM/IRA) closure/remediation plan The vadose zone as defined for the closure/remediation activities is the soil interval from three inches below ground surface (bgs) to the elevation of the mean seasonal high ground water elevation This definition was adopted so that the closure/remediation activities would not address soils that are expected to be seasonally saturated The Phase II RCRA facility investigation/remedial action (RFI/RI) will focus on investigating the phreatic zone (saturated zone), and will determine if ground water remediation is required A detailed engineering description of the closure/remediation design is presented in Section IV 3

IV.1.1 Description of the Selected Alternative

DOE will utilize a combination of the various alternatives that were proposed and described in Part III of this document under General Response Action II to close/remediate the OU4 SEPs Although the no action alternative was eliminated in Part III of this document, it will be carried throughout Part IV for comparison to the selected remedial alternative The location of the final engineered cover and reclaimed areas are shown on Figure IV 1-1 Contaminated remediation waste from within OU4 and IHSS 176 will be consolidated beneath the final engineered cover In addition, the SEP sludge and pondcrete remediation wastes and debris from the demolition of Buildings 788 and 964 will be dispositioned beneath the final engineered cover The closure will comply with all the identified ARARs (Section IV 11 2) Section IV 11 4 presents the justification to establish a CAMU to facilitate the consolidation and closure Section IV 11 5 provides a justification to establish a TU for processing sludge and storing processed sludge and pondcrete prior to their disposition beneath the final engineered cover All SEP liners, berms, and contaminated vadose zone soils beneath IHSS 101 and a portion of IHSS 176 will be excavated to the mean seasonal high ground water elevation as calculated from historical data collected at wells surrounding the SEPs The liners will be crushed after excavation and mixed with excavated contaminated soil, and OU4 sludge and pondcrete to produce a homogenous waste form that will equally settle over time and comply with the construction compaction requirements Contaminated surficial soils and vadose zone soils within OU4 and surface soils in IHSS 176 at concentrations exceeding the Preliminary Remediation Goals (PRGs) will also be excavated The waste mixture, along with debris from RCRA Units 21, 48, and 24 that cannot be decontaminated, will be consolidated above a subsurface drainage layer since vadose zone soil contaminants found beneath the SEPs and other material/debris contaminants have the potential to impact ground water quality This homogeneous waste mixture and debris will be consolidated within the area of the existing SEP 207-A, 207-B Series SEPs and IHSS 176 Section IV 3 1 1 provides details concerning the areas that will be excavated and presents maps depicting the mean seasonal high ground water elevation and the vadose zone thickness A subsurface drainage layer will be constructed just

above the elevation of the mean seasonal high ground water elevation The subsurface drainage layer is a mitigative measure that will provide a means to prevent any future rising ground water from contacting the consolidated hazardous liners, sludge, pondcrete, debris and contaminated soil

Engineered Cover Alternative 6, as described in Section III 3 2 1 (Figure III 3-8), will be constructed over the consolidated materials Engineered Cover Alternative 6 was selected for the final engineered cover because it has the highest potential to prevent infiltration of precipitation into the consolidated contaminated materials during the specified 1,000-year period The final engineered cover system, in conjunction with the physical site characteristics, must protect human health and the environment from the contaminants in the hazardous waste materials for 1,000 years as required by the State of Colorado hazardous waste landfill siting criteria (6 CCR 1007-2) Engineered Cover Alternative 6 is best suited to meet the 1,000-year design criteria because it utilizes all naturally occuring materials and is expected to maintain the longest integrity of all of the final engineered cover alternatives

The liners and contaminated media from SEP 207-C will be excavated, crushed, and consolidated beneath the final engineered cover and above the subsurface drainage system The excavated area within SEP 207-C will be clean-closed since the closed area will not be beneath the final engineered cover The soils beneath Building 788, located between SEP 207-C and SEP 207-A, will be excavated and consolidated beneath the final engineered cover The soils from IHSS 176 will also be excavated and consolidated beneath the final engineered cover The depth of the excavation will not extend deeper than the mean seasonal high ground water elevation Soil samples will be collected during the excavation of SEP 207-C and the areas adjacent to the SEPs undergoing remediation and analyzed to aid in the determination of the optimum extent of soil removal Samples will not be taken from excavations beneath the final engineered cover since all the material will be excavated to the mean seasonal high ground water elevation Section IV 8 provides the details for the sampling and analysis program Excavation may be terminated when the mean seasonal high ground water elevation is encountered This document assumes that all the soils beneath the configuration of the final engineered cover will be excavated to the elevation of the mean seasonal high ground water elevation and consolidated above the subsurface drain Contaminated soils beneath this elevation will not be remediated as part of the OU4 IM/IRA Remediation of these saturated soils will be deferred until after the Phase II RFI/RI is conducted and it is determined if ground water remediation is required

Engineered Cover Alternative 1, as described in Section III 3 2 1 (Figure III 3-3), will be constructed over SEP 207-C, areas that are remediated adjacent to the SEPs, and over the portions of the SEPs not covered by the full extent of the final engineered cover (the toe of the final engineered cover) A more protective final engineered cover will not be required for these areas because all of the SEP materials and contaminated media with Contaminant of Concern (COC) concentrations exceeding PRGs will be removed Engineered Cover Alternative 1 will also be constructed over other areas in OU4 and IHSS 176 where contaminated surface soils are excavated for consolidation under the final engineered cover Sampling and analysis will be conducted to verify that all of the contamination has been removed such that only the allowable concentrations remain within the reclaimed areas Engineered Cover Alternative 1 will be used

essentially to re-establish grade and prevent erosion over areas where all contamination has been removed Figure IV 1-1 depicts the areal extent of the final engineered cover and the reclaimed area The location of the final engineered cover has been configured to address the different types of contaminated media and the physical constraints of the site (i e , the hillside to the north, other RFETS facilities, and the potential for a high ground water elevation in the southeastern area of the site)

The RFI/RI results indicate that surficial soils and vadose zone soils adjacent to the SEPs (northern areas) have COC concentrations which exceed the applicable target level concentrations (PRGs or background concentrations) Surface soils immediately south of SEP 207-A with COC concentrations exceeding the PRGs will be excavated and consolidated under the final engineered cover

Hillside soils with the COC concentrations exceeding the surface and vadose zone soil PRGs will be excavated from the area between the SEP northern berms and the intersection of the piezometric surface and the topographical surface (Figure IV 1-2) will be excavated and consolidated beneath the final engineered cover The soils downgradient from the intersection of the piezometric surface with the topographic surface have both surface and vadose zone soil contamination These soils may not be excavated for remediation since the source of the contamination is likely to be the ground water that seeps to the surface The Phase I IM/IRA does not formally require the remediation of these soils that may be impacted by ground water, however, surface soils in this region may be excavated since the north hillside will be regraded as a function of constructing the final engineered cover The closure of the SEPs does not address the ground water and the seep areas The ground water seeps and downgradient soil media will be addressed during the Phase II RFI/RI Remediation of these areas (as required) will be conducted as a separate project In addition, remediation of the areas surrounding RFETS Buildings 783, 780, 780B, and 786 will be deferred because of existing operations in these areas Remediation of this industrial area, including soil and ground water, will be addressed when the industrial area operable unit is closed It should be noted that the industrial area operable unit will provide a mechanism to decide whether remediation will occur under the closure of the buildings or on a yet-to-be-determined expedited schedule Remediation of the OU4 area between the security fences will also be deferred This area will be addressed in the future when the security area is closed

Surface soils north of the perimeter security fence (buffer zone) that are within the OU4 boundary and have COC concentrations exceeding the surficial soil PRGs will be excavated and consolidated beneath the final engineered cover The excavated soils will be replaced with clean imported backfill Contamination of the surface soils within this region of OU4 is not likely to be from ground water seeps because the Interceptor Trench System (ITS) and drainage ditches exist along the access roads to intercept seepage flows There are no seep areas in this region In addition, the contaminants in this region are not all the same as those detected in the vicinity of the SEPs The clean backfill is not likely to become contaminated from the ground water seeps because the peviously mentioned ITS and drainage ditches separate the seep areas from the areas north of the site perimeter fence No vadose zone contamination has been identified

north of the security fence If vadose zone contamination is discovered during the verification sampling, the soils will not be remediated as a function of the Phase I IM/IRA These soils will not be remediated due to the presence of the ITS within this area which could be impacted if vadose zone soils were excavated The ITS is currently collecting ground water and is expected to continue to be used in the future for a ground water collection system The effectiveness of the ITS will be evaluated as part of the Phase II RFI/RI Therefore, any contaminated vadose zone soils will be remediated (if necessary), at the completion of the Phase II RFI/RI The surface soil excavation/remediation and reclamation of this buffer zone area is proposed in the IM/IRA to provide a means to protect human health and the environment from the upward exposure pathways since the final remediation of this area will occur after the Phase II RFI/RI

The vadose zone soil in the area immediately south of SEP 207-C is contaminated, but its remediation will be deferred because it is adjacent to Buildings 783, 784, 786, and 787 where ongoing RFETS operations will restrict access, however, any contaminated vadose zone soils in this region that lie within the limits of excavation will be excavated and consolidated beneath the final engineered cover Therefore, excavation of the vadose zone soils from the area south of SEP 207-C will begin approximately 15 feet from the existing industrial area fence line The 15-foot area will allow room for excavation without impacting the fence line or the RFETS industrial operations There is also vadose zone soil contamination just south of the SEP 207-A adjacent to the berm This material will be excavated and consolidated beneath the final engineered cover

Contaminated surface soils within IHSS 176 east of the B series SEPs, but not beneath the final engineered cover, will be excavated and consolidated beneath the final engineered cover Engineered cover Alternative 1 will be constructed over areas where soils have been excavated for remediation to establish a final grade and vegetative cover Vadose zone soils within IHSS 176 beneath the final engineered cover shall be excavated to the elevation of the mean seasonal high ground water elevation OU4 sludge and pondcrete currently being stored in tanks and tents, respectively, will be processed and consolidated beneath the final engineered cover

Samples will be collected for COC analysis to verify that all the contaminated soils that exceed their respective PRG levels have been removed from areas outside the footprint of the final engineered cover that are being remediated Section IV 8 provides a methodology for conducting the conformational sampling and identifies the COCs for analysis Excavated areas will be regraded with imported clean topsoil (as required) and seeded (Engineered Cover Alternative 1) as presented in Section III 3 2 1

DOE will consolidate the OU4 investigation-derived material (IDM), which consists of drill cuttings from the OU4 borings, beneath the final engineered cover to help establish the grade for the construction of the final engineered cover There are approximately 200 drums (30-gallon capacity) of drill-cutting soils resulting from the OU4 RFI/RI program There will also be IDM generated from the Phase II program that may be consolidated beneath the final engineered cover if it is generated prior to the construction of the final engineered cover

components It will not be necessary to sample and analyze the drill cuttings because this material results from the OU4 RFI/RI sampling Therefore, the COC concentrations in the drill cuttings are similar or equal to the concentrations in the soils that are being consolidated beneath the final engineered cover Only OU4 IDM will be consolidated beneath the final engineered cover The drums will be decontaminated (if necessary as determined by RFETS Standard Operating Procedure FO 03) and returned to the waste management program for re-use

The debris from the excavated and removed utilities will be size-reduced and depositioned beneath the final engineered cover These materials will consist of segments of excavated piping, excess soils from the excavation of the utilities, and debris from the foundations of Buildings 788 and 964, and other OU4 subgrade structures adjacent to the SEPs (i e , concrete caissons and footers) These materials will be size-reduced and positioned as necessary to ensure that they will not cause unequal subsidence of the final engineered cover In addition, contaminated remediation waste from Buildings 788 (RCRA Units 21 and 48) and 964 (RCRA Unit 24) will be consolidated beneath the final engineered cover if it cannot be effectively decontaminated

DOE performed a geotechnical evaluation to determine if it is necessary to stabilize the northern hillside to prevent landsliding that could occur as a result of natural slope stability conditions and the additional load of the final engineered cover The results of the geotechnical investigation of the hillside, in conjunction with slope stability modeling are discussed in Section IV 6 1

The remaining sections of Part IV present the conceptual design details and a description of the design In addition, modeling results are presented that demonstrate that the closure system will be protective of human health and the environment for 1,000 years

IV.1.2 Classification of the Selected Alternative

Per DOE Order 6430 1A, United States Department of Energy General Design Criteria, a nuclear facility (special facility) is defined as, "A facility whose operations involve radioactive materials in such form and quantity that a significant nuclear hazard potentially exists to the employees or the general public Included are facilities that (1) produce, process, or store radioactive liquid or solid waste, fissionable materials, or tritium, (2) conduct separation operations, (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations, or, (4) conduct fuel enrichment operations " The remediated SEPs will be classified as a nuclear facility because they will ultimately store solid radioactive waste materials As discussed in Division 13, 1300-1 2 of the General Design Criteria, 20 different types of special facilities have been designated The most appropriate designation for the SEPs is that of a Radioactive Solid Waste Facility A more detailed discussion of the special facility applicability and its effects on the design of the remedial alternative for the SEPs is provided in Appendix IV A

The Rocky Flats Environmental Technology Site Conduct of Engineering Manual (COEM), 2-DOS-COEM-6 3 6, "Classification of Systems, Components, and Parts," provides a method and criteria for the classification of systems, components, and parts to provide a level of design, procurement, and quality assurance commensurate with the safety function of the system The classification of systems, components, and parts at the RFETS invokes a graded approach of ensuring that all phases of design, construction, and repair work are subject to levels of review and control commensurate with the safety function of the system, component, or part Four system categories have been designated at the RFETS System Category 1 is composed of those systems, components, or structures, including portions of systems, whose failure could adversely affect the environment or the safety and health of the public System Category 2 is defined as systems, components, or structures, including portions of systems, whose failure could reasonably be expected to inhibit or prevent a Category 1 system, component, or structure from performing its intended vital function System Category 3 includes those systems, components, or structures, including portions of systems, which provide a margin of protection for personnel or the environment, but which do not perform vital safety functions as defined in the basis for Category 1 and Category 2 items Lastly, System Category 4 is defined as those systems, components, or structures, including portions of systems, that do not meet any of the criteria for classification in Category 1, 2, or 3

An example of a System Category 3 includes, "Systems providing containment for radioactive contamination or material as defined in HSP 18 02 " Based on this example, the remediated SEPs have been designated as a System Category 3 Systems, components, and parts that have been designated as System Category 3 and 4 are, by definition, classified as Non-Safety Class (NSC) NSC is defined as any system, component or part which is not required to ensure a System Category 1 or 2 system performs its vital safety function(s) All NSC items may be purchased as commercially available without procurement specifications The DOE cognizant engineer may specify additional inspection and/or testing requirements for NSC items and impose select additional inspection and/or testing requirements through the use of procurement specifications, in accordance with COEM 6 5 14, "Engineering Standards for the Procurement, Receipt, and Control of Safety Related Items " The additional inspection and/or testing requirements may be imposed to ensure a particular level of quality commensurate with engineering design, DOE, or other regulatory requirements

IV.2 DESIGN BASIS FUNCTIONAL REQUIREMENTS

The following section addresses the functional objectives of the proposed alternatives and presents the detailed design requirements which the final engineered cover systems must meet or exceed The design codes, standards, and DOE Orders that must be adhered to are identified in this section In addition, assumptions and constraints or limitations that may have an impact on the design are specified The design basis will be used to guide the detailed design of the SEP closure/remediation IM/IRA

IV.2.1 Functional Objectives

IV 2 1 1 The overall OU4 closure/remediation design shall mitigate surface soils, subsurface soils, and hazardous waste COCs such that established PRGs are met

IV 2 1 2 The SEP facility shall be closed such that it will control, minimize, or eliminate, to the extent necessary to protect human health and the environment, the release of hazardous waste, hazardous constituents, leachate, or contaminated runoff to the ground water, surface waters, or the atmosphere

IV 2 1 3 Contaminated media and OU4 remediation wastes that can be remediated by this IM/IRA shall be consolidated within the CAMU to the maximum extent practicable

IV 2 1 4 The construction of the OU4 closure/remediation IM/IRA shall be conducted in a manner which minimizes exposure to environmental hazards

IV 2 1 5 The OU4 facility shall be closed with a cover system designed to

- Provide long-term minimization of the migration of liquids through the cover and the underlying material,
- Function with minimal short-term maintenance and no long-term maintenance,
- Promote surface drainage of precipitation away from the final engineered cover,
- Minimize damage to the cover from erosion or abrasion,
- Accommodate settling and subsidence so that the integrity of the cover and the subsurface drain is maintained, and
- Have a permeability less than or equal to the permeability of existing natural subsoils

IV 2 1 6 Any hazardous wastes (liners, contaminated media, soils, utilities, or Building 788 and 964 debris) in the SEP facility must be kept isolated from the ground water to be protective of human health and the environment for 1,000 years Constructed hydraulic barriers or subsurface drains should be considered in addition to the cover system for control of shallow ground water migration through the SEP facility area where the hazardous wastes and contaminated media are consolidated and to prevent a rising ground water elevation from contacting the consolidated hazardous wastes.

IV 2 1 7 The overall SEP facility closure/remediation design shall be demonstrated via modeling and qualitative assessment to be protective of human health and the environment from contaminated media for 1,000 years

IV 2 1 8 The overall IM/IRA closure/remediation will meet the clean-closure requirements for the RCRA Units 21, 48, and 24

IV.2.2 Design Requirements

IV 2 2 1 The SEP facility cover system shall

- Minimize the migration of liquids through the cover and the subsurface with a system of evaporation, transpiration, lateral drainage pathways, and hydraulic barriers that will resist infiltration through the cover system and divert any external or infiltrated liquids away from the closed SEPs,

- Function with minimal maintenance by providing the following

  - An optimal slope to the cover system that shall promote drainage while minimizing erosion The cover system maximum erosion rate shall not exceed 2 tons/acre/year, in accordance with U S Environmental Protection Agency (EPA) guidance (EPA, 1989b),

  - A biotic barrier to deter plant and animal intrusion into the underlying contaminated media, and

  - A final vegetated surface of native species that are drought resistant, do not require maintenance, are the dominant species to grow after a brush fire, and provide a dense, uniform cover,

- Provide a stormwater management system that shall accommodate a 25-year, 6-hour storm event during construction of the final engineered cover (DOE Order 6430 1A, Chg 001),

- Promote drainage of precipitation by providing a side slope not greater than 20 percent (Side slopes may be steeper where the cover construction area is constrained, but additional erosion control and slope stability measures shall be considered)

- Accommodate settling and subsidence such that the side slope shall remain between 18 and 20 percent after subsidence,

- Have a hydraulic barrier with a hydraulic conductivity that shall not exceed the average subsurface soil hydraulic conductivity, and

- Meet all applicable requirements of the State of Colorado hazardous waste regulations

IV 2 2 2 All contaminated media that will be placed under the final engineered cover, and that could have an adverse impact on ground water quality as demonstrated by leaching models, shall be protected from contact with ground water

IV 2 2 3 All contaminated media beneath the SEPs and the portion of IHSS 176 where the cover will be situated shall be excavated to the mean seasonal high ground water elevation, if necessary, and consolidated beneath the final engineered cover

IV 2 2 4 All remediation waste from the clean-closure of the RCRA Units 21, 48, and 24 that is not practicable to be decontaminated for free-release shall be consolidated beneath the final engineered cover

IV 2 2 5 The overall SEP facility closure/remediation design shall

- Be demonstrated to be protective of human health and the environment for 1,000 years using qualitative assessment and results from computer models such as

  - HELP, Version 2 05 (EPA code for infiltration assessment)
  - VLEACH, Version 1 02 (EPA code for vadose zone transport)
  - MYGRT, Version 2 0 (Electric Power Research Institute (EPRI) code for ground water impact)
  - VS2DT, Version 2 0 (U S Geological Survey Code for predicting the extent of contaminant leaching from a volume of unsaturated porous material)
  - XSTABL, Version 4 10 (Proprietary code for slope stability modeling)
  - Soil Prop, Version 2 1 (Environmental Systems and Technology, Inc code for estimation of unsaturated soil hydraulic properties from particle size distribution data)

- Meet all applicable requirements of the

  - Interagency Agreement (IAG) for the RFETS,
  - Federal regulations,
  - State of Colorado hazardous waste regulations,
  - DOE Orders and Directives, and
  - RFETS standards and design criteria

IV 2 2 6 The SEP facility will be closed with the existing SEP liners relocated and consolidated under the cover system The SEP liners shall be crushed to a minimum appropriate size range and mixed with contaminated soils as necessary, to provide a compacted layer under the final engineered cover system of uniform average composition and thickness

IV 2 2 7 The SEP facility will be closed with the OU4 sludge (currently stored in tanks) processed and consolidated under the final engineered cover system The sludge will be processed and mixed with contaminated soils as necessary, to provide appropriate compaction for disposition beneath the final engineered cover system

IV 2 2 8 The SEP facility will be closed with the OU4 pondcrete (currently stored on the 704 pad) relocated and consolidated under the final engineered cover system The SEP pondcrete will be processed, crushed to a minimum appropriate size range, and mixed with contaminated soils, as necessary, to provide appropriate compaction for disposition beneath the final engineered cover system

IV 2 2 7 Contaminated OU4 soils from the hillsides north and east of the SEP facility between the berms and the intersection of the piezometric surface the the topographic surface and from the buffer zone shall be excavated to remove all soils with COCs above PRGs These soils will be consolidated and compacted beneath the final engineered cover system boundary to adequately support the cover system Contaminated surface soils from the OU4 buffer zone and surface soils from IHSS 176, shall be excavated and consolidated beneath the final engineered cover or as vadose zone soils under SEP 207-C (as appropriate) Verification sampling will be required to demonstrate that the remediation excavation is complete

IV 2 2 8 The hillsides north and east of the SEP facility shall be considered with respect to landsliding and surface erosion If necessary, the hillsides will be stabilized to mitigate the potential for degradation of the structural integrity of the cover system

IV 2 2 9 Underground utilities, aboveground utilities, and structures and equipment (RCRA Units 21, 48 and 24) within the boundary of the SEP facility cover system shall be either abandoned and closed in place, removed, relocated, decontaminated (if

practicable), or consolidated under the final engineered cover Locations of utilities to be removed shall be verified, as necessary, to effect removal Any excavated utilities, structures, or equipment will be considered remediation waste Removed utilities, structures, or equipment will be surveyed for contamination, and segregated as contaminated and non-contaminated materials Contaminated materials shall be decontaminated, as practicable, for free-release Any materials that cannot or will not be decontaminated shall be consolidated under the final engineered cover Underground utilities and other structures and equipment within the boundary of the SEP final engineered cover system shall be managed as follows

IV 2 2 9 1 The underground utilities may be abandoned and closed in place if the utility will no longer be required after the cover system has been installed and will not impede construction or implementation of the engineered cover system Abandonment in-place will include the following actions

- The soils surrounding the underground utilities will be excavated as necessary to provide access for in-place closure equipment and materials

- Utilities, and/or excavated soils shall be monitored for radioactive contamination, and dispositioned and handled in accordance with appropriate DOE Orders and Directives and RFETS standards and procedures Excavated soils shall be sampled and analyzed to ensure that all contaminated soils have been removed

- Grout may be pumped into underground utility lines to minimize the void spaces or open areas

IV 2 2 9 2 The underground utilities' structures, and equipment (RCRA Units 21, 48 and 24) will be removed if the utility, structure, or equipment shall no longer be required after the cover system has been installed and causes an impediment to construction or implementation of the cover system Removal shall include the following actions

- The soils surrounding the utilities shall be excavated, as necessary, to allow their removal

- Utilities, structures, equipment, and/or excavated soils shall be monitored for radioactive contamination and dispositioned and handled in accordance with appropriate

DOE Orders and Directives and RFETS standards and procedures

- Utilities, structures, and equipment shall be removed, segregated, decontaminated and, if non-decontaminable, size-reduced and placed under the final engineered cover system

- Excavation areas that are outside the full extent of the final engineered cover shall be backfilled with clean materials

IV 2 2 9 3 Utilities will be relocated if they will be required to be in service after the final engineered cover system has been installed Relocation shall include the following actions

- Utilities, and/or excavated soils shall be monitored for radioactive contamination and dispositioned and handled in accordance with appropriate DOE Orders and Directives and RFETS standards and procedures If closed portions of utilities to be relocated are deemed to be left in place, then procedures outlined in Section IV 2 2 9 1 shall apply If closed portions of utilities to be relocated are deemed to be excavated, then the procedures outlined in Section IV 2 2 9 2 shall be applied

- Excavation areas beyond the footprint of the final engineered cover shall be backfilled with clean materials

- Construction for relocated utilities shall be performed in accordance with applicable federal, state, and RFETS requirements

IV 2 2 10 Monitoring wells required for the SEP facility post-closure plan shall be installed prior to completion of the closure/remediation Some wells may be required prior to completion of the final engineered cover Other wells may be required after the final engineered cover system has been installed

IV 2 2 11 The SEP facility post-closure monitoring system design shall be integrated with the SEP facility closure/remediation design The post-closure monitoring system shall be installed prior to completion of closure/remediation

IV 2 2 12 The closed SEP facility shall be provided with access roads to allow maintenance vehicles and equipment access to the facility to perform required maintenance and

monitoring activities The roads shall be designed in accordance with appropriate DOE Orders and Directives, and RFETS procedures and standards

IV 2 2 13 The closed SEP facility shall have a fence installed around the overall perimeter of the final engineered cover system with appropriate gated accessways for future inspections of the facility The fence shall be designed in accordance with appropriate DOE Orders and Directives, and RFETS procedures and standards Appropriate signs shall be attached to the fence to notify workers that the contained area is a Corrective Action Management Unit

IV 2 2 14 The design for the closure/remediation of the SEPs shall include specification of procedures to prevent the spread of contaminants to soil, water, or air during construction The closure/remediation design shall include the following

- Mitigation techniques to prevent airborne dust contamination during earth-moving, demolition, waste transfer, and other construction activities,
- Drainage control, stockpile coverage, and other measures, if required, including collection and treatment of stormwater, to prevent surface water contamination, and
- Careful planning of stockpile management, earth-moving, demolition, and waste transfer to prevent soil contamination

IV 2 2 15 New and/or relocated utilities for the SEP facility shall be designed in accordance with appropriate federal and state regulations, DOE Orders and Directives, and RFETS procedures, and standards

IV.2.3 Waste Acceptance Criteria

OU4 SEP sludge and pondcrete is currently in storage at RFETS and shall be processed for consolidation beneath the final engineered cover These wastes shall meet the following criteria prior to acceptance for consolidation beneath the cover

- The waste form shall not, prior to placement, contain free liquids Lack of free liquids shall be demonstrated with the Paint Filter Test
- The waste shall be delivered in either monolithic or particulate form In the event that the producer intends to deliver the waste as a mixture of both forms, the producer shall identify, at the completion of the treatability study, the ratio of one form with respect to the other and/or the expected order of delivery, i e , consistent mixture or batches of one form followed by the other

If the delivered waste form is monolithic, the following criteria shall apply

- Each monolith shall fit entirely within a rectilinear envelope which is a maximum of 12 inches high by 24 inches wide by 48 inches long

- Compressive strength of the form shall not exceed 3000 pounds per square inch (psi) Shear and tensile strengths shall not exceed those of 3000 psi non-reinforced structural concrete

- The monoliths shall not be reinforced

- The monolith shall not be delivered in molds, containers, or packaging of any kind that cannot be returned to the producer

If the delivered waste form is particulate, the following criteria shall apply

- All waste form particles shall pass a 3-inch mesh screen

- The waste form particles shall not agglomerate during storage after production such that particles larger than allowed above are formed, unless such oversized particles meet all criteria identified above for a monolithic waste form and the producer explicitly states that such agglomeration is likely

- There is no specific criteria for particle size distribution

- The waste form as received (if particulate) or as size-reduced (if monolithic or agglomerated particles) shall be capable of being mixed with the site soils such that all formed agglomerates pass a 3-inch screen

- The waste form shall be maximally resistant to dispersion by wind Dispersion resistance can be accomplished through the control of moisture content of the as-delivered form, through the control of the particle size of the form, or through acceptable control of other intrinsic waste form characteristics

- Delivery of the waste form to the remediation site shall be accomplished "just in time" so that the placement of a homogeneous soil/waste mixture is not interrupted and so that storage of the waste form on the construction site is minimized Relief from this requirement is possible if it can be demonstrated that, storage of the waste form in small piles at the remediation site will not produce dust or dispersible fines, will not degrade upon wetting, and that the waste form can be transported without generation of dispersible fines from pile to point of placement, mixing, or size reduction using existing site remediation construction equipment

- The waste form shall contain no additional materials that, either because of quantity or character of the materials cause existing assessment or modeling of health effects, contaminant migration, or ground water protectiveness to become invalid, or that cause the currently proposed remedy to fail to adequately protect human health and the environment

- The waste form shall be treated or prepared such that pathogens are removed or rendered innocuous to the extent that workers exposed to the material, and not wearing protective equipment, will be protected from the effects of such pathogens

- The waste form shall be treated or prepared such that gas production from the form, in type, rate, and volume, shall be no greater than such production from an equivalent volume of natural soil from the site

- The total volume of the waste form shall not exceed 20,000 cubic yards

- Leachate from the waste form, when modeled through the HELP and VS2DT codes, shall not exceed the concentrations specified for protectiveness of human health and the environment at the toe of the engineered barrier Specification of leachate levels shall be developed from the estimated parameters resulting from early modeling and confirmed with empirical data from the treatability studies

IV.2.4 Applicable Codes, Standards, and References

The following is a list of the national codes and standards, DOE Orders, RFETS procedures, and reference documents to be considered during the design of the SEP closure/remediation Particular standards and testing requirements are identified in specific construction specifications

American Concrete Intitute (ACI)

American National Standards Institute (ANSI)

American Society of Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

American Water Works Association (AWWA)

American Wire Gage (AWG)

American Wood Preservers Association (AWPA)

Code of Federal Regulations Title 29, Parts 1910 and 1926 (29 CFR 1910 and 1926) Occupational Exposure to Asbestos, Tremolite, Anthophylite, and Actinolite

Code of Federal Regulations Title 40, Part 122 26 (40 CFR 122 26) - National Pollutant Discharge Elimination System, Stormwater Discharges

Code of Federal Regulations Title 40, Part 61 (40 CFR 61) Subpart M National Emission Standards for Hazardous Pollutants

Code of Federal Regulations Title 40, Part 265 (40 CFR 265) - Interim Status Standard for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, July 1990

COEM - DES - 5, Rev 4, "Specification for Procurement and Construction," 6/17/91

COEM - DES - 12, Rev 3, "Power Distribution Systems Management," 6/17/91

COEM - DES - 13, Rev 1, "Illumination Engineering Design and Review Procedure," 6/17/91

COEM - DES - 19, Rev 2, "Drafting Practices," 6/17/91

COEM - DES - 25, Rev 2, "Facility CADD System," 6/17/91

COEM - DES - 27, Rev 3, "Operational Requirements Document," 6/17/91

COEM - 6 1 5, Rev 0, "Title I Design Summary/Review," 4/30/92

COEM - 6 3 6, Rev 0, "Classification of Systems Components and Parts," 7/30/93

COEM - 6 4, Rev 0, "Design Calculations," 3/31/92

COEM - 6 6 2, Rev 0, "Engineering Drawing Control," 1/31/92

DOE/EH - 0256T, Radiological Control Manual, 6/92

DOE Order 4010 1A, "Value Engineering," 5/14/92

DOE Order 4700 1, Change 001, "Project Management System," 6/2/92

DOE Order 5400 1, Change 001, "General Environmental Protection Program," 6/29/90

DOE Order 5400 3, "Hazardous and Radioactive Mixed Waste Program," 2/22/89

DOE Order 5400 4, "Comprehensive Environmental Response, Compensation, and Liability Act

Requirements," 10/6/89

DOE Order 5400 5, Change 002, "Radiation Protection of the Public and the Environment," 2/8/90

DOE Order 5480 4, Change 004, "Environmental Protection Safety and Health Protection Standards," 1/7/93

DOE Order 5480 11, Change 003, "Radiation Protection for Occupational Workers," 6/17/92

DOE Order 5700 2D, "Cost Estimating, Analysis, and Standardization," 6/12/92

DOE Order 5700 6C, "Quality Assurance," 8/21/91

DOE Order 5820 2A, "Radioactive Waste Management," 9/26/88

DOE Order 6430 1A, Change 001, "General Design Criteria," 4/6/89

DOE, Rocky Flats Plant, *Draft Integration of NEPA, CERCLA and RCRA for Activities Under the Interagency Agreement at Rocky Flats Plant,* June 1992

DOE, *Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards,* UCRL-15910, June 1990

EG&G Rocky Flats, Inc , Annual Report *Sitewide Treatability Studies,* March 1992

EG&G Rocky Flats, Inc , *Background Geochemical Characterization Report,* September 1992

EG&G Rocky Flats, Inc , *Design Criteria for Engineering and Architectural Services,* March 1985

EG&G Rocky Flats, Inc , *Draft Environmental Evaluation Working Document for Phase I RFI/RI Work Plan, OU4,* January 1993

EG&G Rocky Flats, Inc , Environmental Restoration Technical Support Document *A NEPA Support Document for the Rocky Flats Plant,* June 1992

EG&G Rocky Flats, Inc , *Final Phase I RFI/RI Work Plan for OU4, Solar Evaporation Ponds,* Vol I and II, January 1992

EG&G Rocky Flats, Inc , *Historical Release Report for the Rocky Flats Plant,* June 1992

EG&G Rocky Flats, Inc , *Proposed Interim Measure/Interim Remedial Action Decision Document for the Solar Evaporation Ponds Operable Unit No 4* ,April 1992

EG&G Rocky Flats, Inc , *RFETS Standard No SC-106, Standard for Equipment Qualification,* June 14, 1990

EG&G Rocky Flats, Inc , *Technical Memorandum No 1 to Final Phase I RFI/RI Work Plan, Vadose Zone Investigation, OU4,* December 1992

EPA, *Data Quality Objectives for Remedial Response Activities, Development Process,* EPA/540/G-87/003, March 1987

EPA, *Data Quality Objectives for Remedial Response Activities, Example Scenario,* March 1987

EPA, *Ecological Assessments of Hazardous Waste Sites A Field and Laboratory Reference,* EPA/600/3-89/013, March 1989

EPA, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final,* EPA/540/G-89/004, October 1988

EPA, *Guidance for Data Usability in Risk Assessment,* October 1990

EPA, *Guideline for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* EPA/540/2-058, December 1989

EPA, *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A), Interim Final,* EPA/540/1-89-002, December 1989

EPA, *Risk Assessment Guidance for Superfund, Volume II, Environmental Evaluation Manual, Interim Final,* EPA/540/1-89-001, March 1989

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

Facilities & Engineering Manual 009, *Architect-Engineer's Guide to Construction Cost Estimating for Rocky Flats Plant,* July 1992

Federal Facility Agreement and Consent Order, USEPA Region VIII and The State of Colorado in the Matter of US DOE Rocky Flats (Colorado) Site, January 1991

Institute of Electrical and Electronic Engineers (IEEE)

Jefferson County Health Department

National Electrical Code (NEC)

National Safety Code (NESC)

National Sanitation Foundation (NSF)

State Department of Highways, Division of Highways, State of Colorado Standard Specifications for road and Bridge Construction

State of Colorado Department of Health, *Draft Interim Final Policy and Guidance on Risk Assessment for Corrective Action at RCRA Facilities*, October 25, 1993

State of Colorado Hazardous Waste Regulations, 6 CCR 1007-6, Part 265

Underwiters Laboratory (UL)

Uniform Building Code, 1988

UCRL - 15910

United States Army Corp of Engineers (USACE)

IV.2.5 Constraints and Limitations

Closure/remediation of the OU4 SEPs will be designed and implemented within the following constraints and limitations

IV 2 5 1 Other RFETS facilities are located in the vicinity of the SEPs that shall be impacted by the final engineered cover system These facilities include

- Building 910 south of SEP 207-B South,
- Distillate Tanks south of SEP 207-A,
- Cooling towers south of SEP 207-C and west of SEP 207-A, and
- Buildings 783, 784, 786, and 787

IV 2 5 2 The OU4 SEP closure shall not adversely impact ongoing or planned activities in other operable units

IV 2 5 3 Use of some areas for construction-related activities may be constrained by the presence of the protected area (PA) security systems

IV 2 5 4 For implementation of the IM/IRA, the vadose zone is defined as the unsaturated soil region from three inches bgs to the mean of the seasonal high ground water elevation in order to define soil remediation boundaries (The mean seasonal high ground water elevation is approximately 1 foot higher than the mean seasonal ground water elevation)

IV 2 5 5 Buildings 788 and 964 will be removed and RCRA Units 21, 48 and 24 shall be clean closed during the closure/remediation activities at the OU4 SEPs

IV.2.6 Design Basis Assumptions

Closure/remediation of the OU4 SEPs is based on the following assumptions

IV 2 6 1 The OU4 SEP liners, sludge, and pondcrete are considered hazardous waste by the Colorado Department of Public Health and the Environment (CDPHE)

IV 2 6 2 The OU4 SEP sludge, currently stored in tanks, shall be processed and consolidated beneath the final engineered cover

IV 2 6 3 The OU4 SEP pondcrete, currently stored under tents, shall be processed and consolidated beneath the final engineered cover

IV 2 6 4 The consolidated OU4 SEP liners, sludge and pondcrete shall be elevated, at a minimum to the level above the subsurface drain to prevent contact of the liners, sludge, and pondcrete with the ground water

IV 2 6 5 The SEP facility waste liquids and sludges, shall be removed from the SEPs prior to the commencement of the closure/remediation project

IV 2 6 6 Buildings 788 and 964 (RCRA Units 21, 48 and 24) shall be removed as required by the SEP facility closure activity and closed in accordance with RCRA requirements

IV 2 6 7 Equipment associated with draining the SEPs and processing sludge and pondcrete shall be removed prior to the closure/remediation activities This activity shall be addressed through a separate project

IV 2 6 8 The CDPHE shall grant a CAMU which will allow the consolidation of remediation wastes beneath the final engineered cover without the need for treatment to comply with the Land Disposal Restrictions (LDRs)

IV 2 6 9 The CDPHE shall grant two TUs which will allow the processing of the sludge and pondcrete remediation wastes

IV 2 6 10 Field- or bench-scale testing shall not be required to demonstrate that the SEP facility cover system will meet the Colorado hazardous waste regulations

IV 2 6 11 All of the contaminated vadose zone soil beneath the SEPs shall be excavated and consolidated above the subsurface drain beneath the final engineered cover

IV 2 6 12 The SEP facility closure is classified as System Category 3 NSC in accordance with COEM 6 3 6

IV 2 6 13 The SEP facility design basis wind speed (fastest mile speed at 10m height) is 109 miles per hour The annual wind speed exceedance probability is 0 02 (UCRL-15910)

IV 2 6 14 The SEP facility is located within Seismic Zone 1 (Uniform Building Code 1988) A Zero Period Acceleration (ZPA) of 0 15 gravity will be used for slope stability modeling (EG&G, 1990)

IV 2 6 15 The SEP facility design frost depth is 36 inches

IV 2 6 16 The minimum stormwater culvert diameter is 15 inches (DOE Order 6430 1A, Chg 001)

IV.3 CONCEPTUAL DESIGN

This section provides an engineering description of the closure/remediation system proposed for the OU4 SEPs The section is divided into four components The first component addresses closure of the SEPs and soil remediation The second component addresses the closure/removal of RCRA Units 21, 48 and 24 (Buildings 788 and 964) The third component addresses closure or relocation of utilities in the vicinity of the SEPs The fourth component provides a power modification plan to support changes to the site electric supply system from the removal of the buildings and the installation of the final engineered cover The fifth component addresses the sludge and pondcrete processing Appendix IV B contains a set of conceptual design drawings for the final engineered cover and the post-closure monitoring system

IV.3.1 Site Layout and Final Engineered Cover

Drawing 51045-110 depicts an overall site layout of OU4 and Drawing 51045-112 provides a final site plan Drawing 51045-121 presents the topographic area/extent of the final engineered covers Drawings 51045-122 and 51045-123 provide cross-sections and details of the final engineered cover Drawing 51045-130 presents the drainage plan for surface water runoff

IV.3.1.1 Site Layout

<u>Location of the Final Engineered Cover</u>

A final engineered cover will be built over most of SEP 207-A, the 207-B Series SEPs, and a portion of IHSS 176 east of the B-Series SEPs This cover is described in Section III 3 2 1 and is identified as Engineered Cover Alternative 6 An illustration of the final engineered cover and backfilled area site layout is presented as Figure IV 1-1

Soils beneath the footprint of the final engineered cover will be excavated to the mean seasonal high ground water elevation These areas are portrayed as Zone "A" on Figure IV 3-1 Figure IV 3-2 provides an excavation contour map for Zone "A" The depth of the excavation will range from 0 to 27 feet The excavated volume will be approximately 129,200 cubic yards Zone "A" includes soils excavated from beneath SEPs 207-A, 207-B series, and SEP 207-C

Soils with COC concentrations exceeding surface and vadose zone soil PRGs will be excavated from the hillside north of the SEPs to the downhill intersection of the piezometric surface and the topographic surface It is anticipated that this excavation will include a vegetated area totaling approximately 168,000 square feet Surface soils will be excavated to a depth of 6 inches from the SEP berms to the intersection of the piezometric surface and the topographic surface Additionally, vadose zone soils contaminated with Radium-226 will be excavated from locations close to the SEP berms The anticipated volume of this material is 3,100 cubic yards

This material will be consolidated with the liners, sludge, and pondcrete above the subsurface drainage layer beneath the final engineered cover This area is identified as Zone "B" on Figure IV 3-1

OU4 surface soils with COC concentrations exceeding surface soil PRGs will be excavated north of the perimeter security fence (buffer zone) The vegetated excavation area will total approximately 290,600 square feet and extend to a depth of approximately 6 inches below ground surface (bgs) The anticipated volume of this material is 5,400 cubic yards This material will be consolidated above the subsurface drainage layer under the final engineered cover This area is identified as Zone "C" on Figure IV 3-1 There have not been any contaminated vadose zone soils located north of the perimeter security fence (within OU4) at concentrations exceeding the vadose zone PRGs If vadose zone soil contamination is discovered during the verification sampling, the soils will not be remediated as a function of the Phase I IM/IRA These soils will not be remediated due to the presence of the ITS within this area which could be impacted if vadose zone soils were excavated The ITS is currently collecting ground water and it is expected to contiued to be used in the future for a ground water collection system The effectiveness of the ITS will be evaluated as part of the Phase II RFI/RI Therefore, any contaminated vadose zone soils discovered during verification sampling will be remediated (if necessary), at the completion of the Phase II RFI/RI The surface soil excavation/remediation and reclamation of this buffer zone area is proposed in the IM/IRA to provide a means to protect human health and the environment from the upward exposure pathways since the final remediation of this area will occur after the Phase II RFI/RI

Site layout will be impacted by the consolidation of materials from several areas The excavated soil and materials will be transferred to SEP 207-A and the 207-B Series SEPs prior to the construction of the final engineered cover The liners from all the SEPs and monolithic processed pondcrete will be crushed to achieve material uniformity Processed OU4 sludge and particulate processed pondcrete will be transported to the SEP area Pondcrete, sludge and liners will be mixed with excavated soils from under the SEP 207-A and 207-B areas to produce a homogeneous waste material with adequate compaction characteristics The homogeneous waste mixture will be placed in lifts and be compacted to form a specified grade for construction of the final engineered cover The waste materials may require size-screening prior to placement beneath the final engineered cover to ensure that the materials have the ability to be adequately compacted

A subsurface drainage system will be constructed beneath the final engineered cover because there are significant seasonal fluctuations in the ground water elevation Historical records from 1986 to 1993 indicate that a seasonally high ground water elevation has contacted the SEP 207-B Series liners The records also indicate that the ground water elevation has risen above portions of the liners in the 207-B Series SEPs Given the historically high ground water elevation, and the fact that the vadose zone soils beneath the SEPs provide a potential source of ground water contamination (Appendix III D), a subsurface drainage layer will be installed beneath the contaminated consolidated materials and the final engineered cover Vadose zone soils beneath the SEPs will be excavated to the elevation of the mean seasonal high ground water

elevation The subsurface drainage layer will be installed just above the elevation of the mean of the seasonal high ground water elevation The subsurface drainage layer will be constructed of layers of sand and gravel The excavated vadose zone contaminated media will be returned to the excavation above the subsurface drainage layer The crushed SEP liners will be combined with contaminated soil media from beneath SEP 207-A and 207-B areas, processed sludge and processed pondcrete for placement above the subsurface drainage layer The subsurface drainage layer will minimize the potential for a future rising ground water elevation from contacting the consolidated hazardous wastes and contaminated media

The subsurface drainage system will cause potentially rising ground water to flow away from the consolidated contaminated material The subsurface drainage system will tie-in to the ITS via a subsurface drainage trench This will prevent the consolidated contaminated material from becoming saturated if the ground water elevation rises, and will prevent the generation of leachate that could exceed the applicable ground water protection standards at the Phase I IM/IRA Point of Compliance (toe of the final engineered cover) Appendix III D presents the predicted leachate results from the OU4 soils under saturated conditions Under saturated conditions, leachate could be generated having concentrations exceeding levels considered to be protective of human health and the environment Construction of a subsurface liner and collection system below the consolidated contaminated materials for the collection of leachate could produce saturated conditions during the 1000-year period of performance Since a leachate detection/removal system could not be expected to operate for 1000 years without maintenance and replacement of mechanical parts, human operation would be required In addition, an impermeable liner in the subsurface may be damaged by uplift forces and heaving caused by a potentially rising ground water elevation Since the period of performance is 1000-years, the DOE considers that it is important that the closure system be designed to function passively The subsurface drain is the preferred ground water control method since it is passive and will not require maintenance over the 1000-year period of performance The passive subsurface drain system could also act as a leachate collection system if precipitation infiltrated through the final engineered cover and contacted the consolidated contaminated materials Conservative VLEACH modeling, presented in Section IV 10 4, demonstrates that under unsaturated conditions the leachate produced would be innocuous The DOE considers that it is better to allow the potential for a release of innocuous leachate through the closure system (via a passive subsurface drain) than to design a condition where saturated conditions could occur and result in leachate that would not be protective of human health and the environment (subsurface liner) An evaluation of specific methods to prevent ground water contamination is presented in Appendix III E The proposed final engineered cover and subsurface drain system are designed to isolate the consolidated contaminated materials from the groundwater by a reduction in the amount of precipitation infiltration, and by preventing potentially rising ground water from contacting the consolidated materials

OU4 SEP sludge currently stored in tanks at the RFETS will be processed for disposition beneath the final engineered cover Approximately 5,000 cubic yards of processed sludge will be dispositioned beneath the final engineered cover OU4 SEP pondcrete currently stored in tents on the RFETS will be processed and crushed for dispositioning beneath the final engineered

cover Approximately 10,000 cubic yards of pondcrete will be dispositioned beneath the engineered cover Approximately 11,800 cubic yards of liners will be dispostioned beneath the final engineered cover

Approximately 30 cubic yards of IDM are present in the OU4 area which was produced during the RFI/RI drilling operations These soils will be dispositioned beneath the final engineered cover Approximately 700 cubic yards of Buildings 788 and 964 debris and concrete will be dispositioned beneath the final engineered cover

Table IV 3-1 presents the approximate quantity of material for each remediation zone and waste type The depth of excavation is based on Figure IV 3-3 which provides a summary of the COCs that have vadose zone concentrations which exceed the vadose zone PRGs and Figure IV 3-4 which shows the vadose zone thickness based on the mean of the seasonal high ground water elevation Figure IV 3-5 presents a phreatic surface map of the mean seasonal high ground water elevation Figure IV 3-6 presents a 3-dimensional portrayal of the SEPs that depicts cross-sections Figures IV 3-7 and IV 3-8 depict the cross-sections that show the site topography, the depth of contamination, and the mean seasonal high ground water elevation Appendix C provides cross-sections through the SEPs that depict the ground surface elevation, the depth of contamination for specific COCs, and the elevation of the mean seasonal high ground water elevation Appendix C also provides summary maps for surficial soil contamination

Mass of Contaminants

Mass estimates of the primary COCs consolidated beneath the final engineered cover were calculated using the mean contaminant concentrations for soils, liners, sludge, and pondcrete in addition to the total volume of the specific material It should be noted that contaminant masses in soil include concentrations from both OU4 contamination and natural background concentrations The results of these calculations are provided in Table IV 3-2 Table IV 3-2 also provides the total mass of the primary COCs based on the total mass of the consolidated materials The total mass of consolidated materials is 2 3 x 10^{+8} kilograms (kg) The total mass of the primary COCs are

Arsenic	47 1 kg
Beryllium	15 kg
Cadmium	5,497 kg
Chromium	1,768 kg
Americium-241	5 9E-06 kg
Plutonium-239/240	0 027 kg
Uranium-233/234	0 1 kg
Uranium-235	11 0 kg
Uranium-238	2,174 kg

TABLE IV.3-1

QUANTITY OF WASTE DEPOSITION

ZONES OF EXCAVATION	
Zone	**Quantity**
Zone A Soils	129,200 yd^3 [a]
Zone B Soils	3,100 yd^3
Zone C Soils	5,400 yd^3
Investigative Derived Material (IDM)	30 yd^3
Liners	11,800 yd^3
Sludge	5,000 yd^3
Pondcrete	10,000 yd^3
Building 788 and 964 debris and Concrete Entombment	700 yd^3

[a] yd^3 = cubic yards

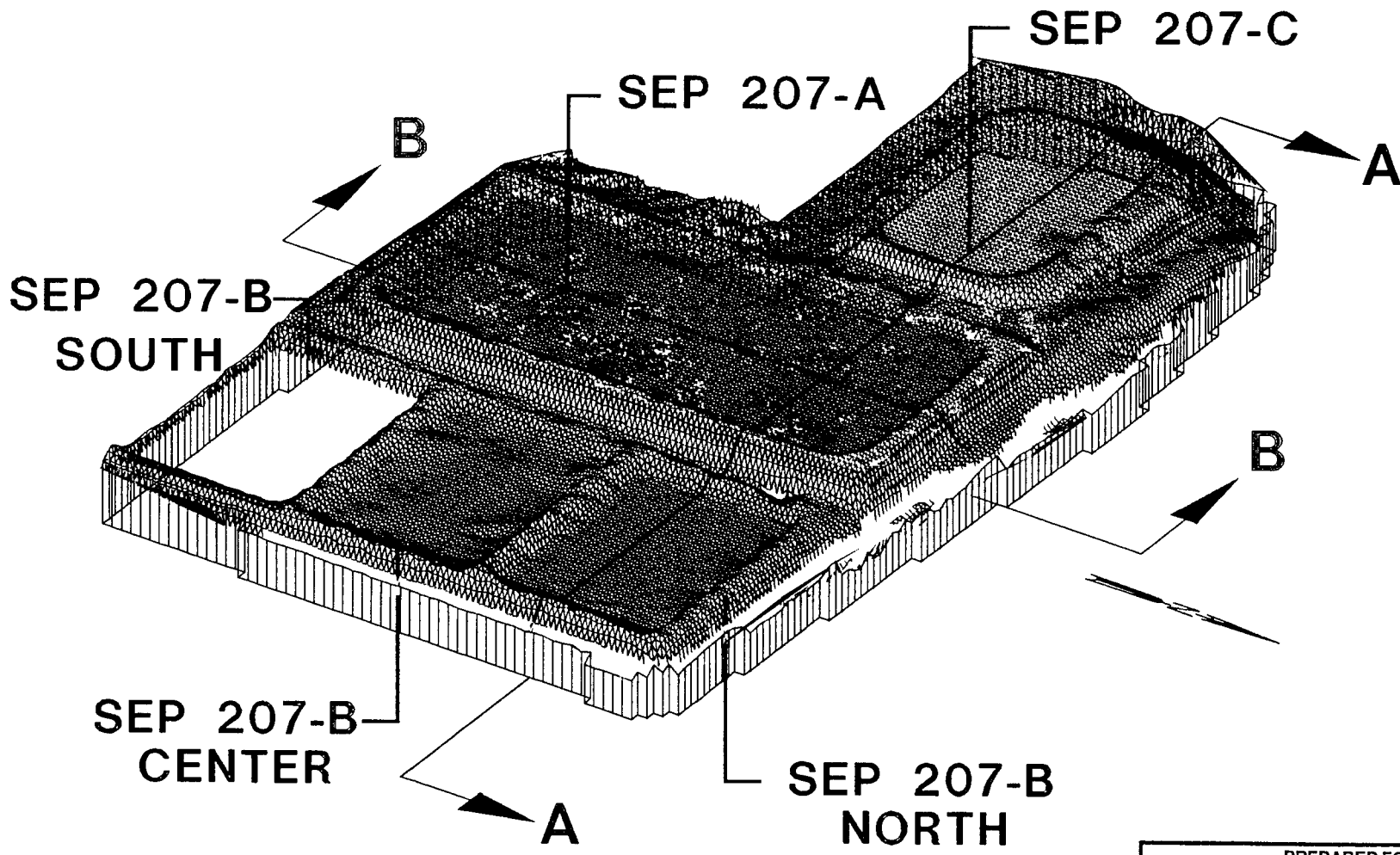

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Figure IV 3 6

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Location of Cross Sections

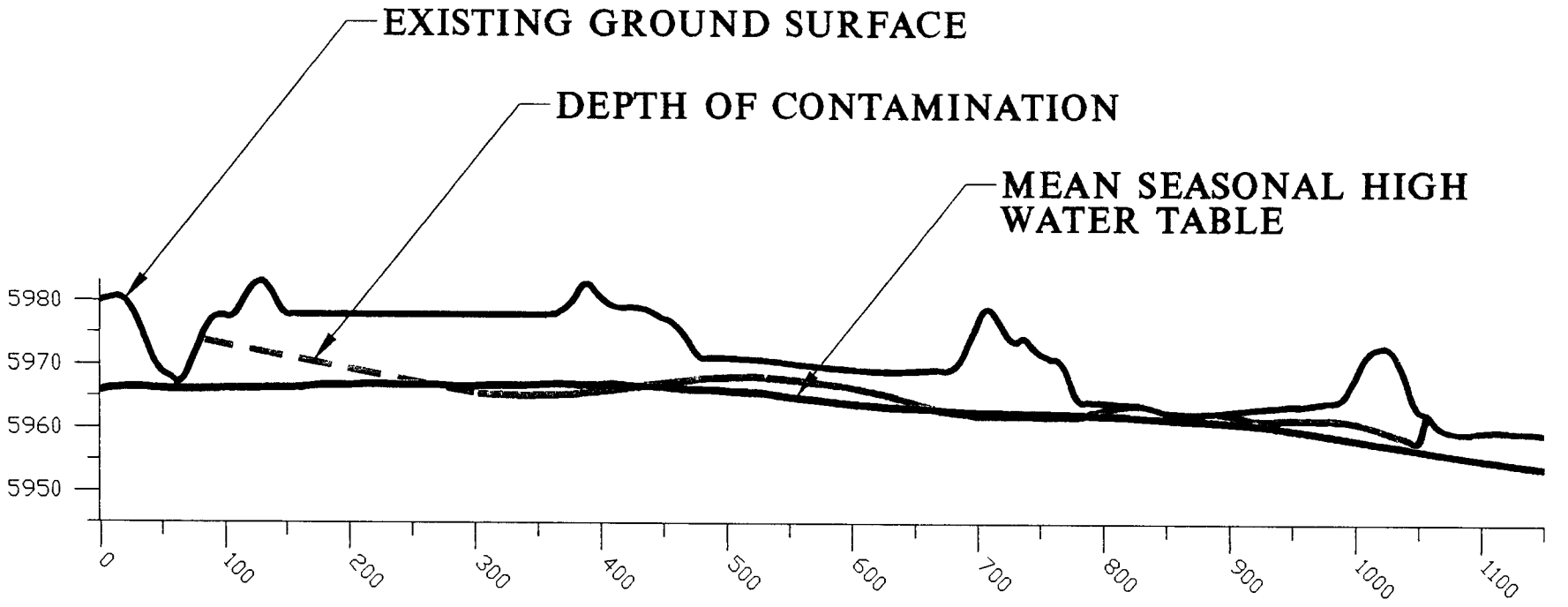

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Figure IV 3 7

Solar Evaporation Ponds
Operable Unit No 4 IM/IRA EA DD
East West Cross Section

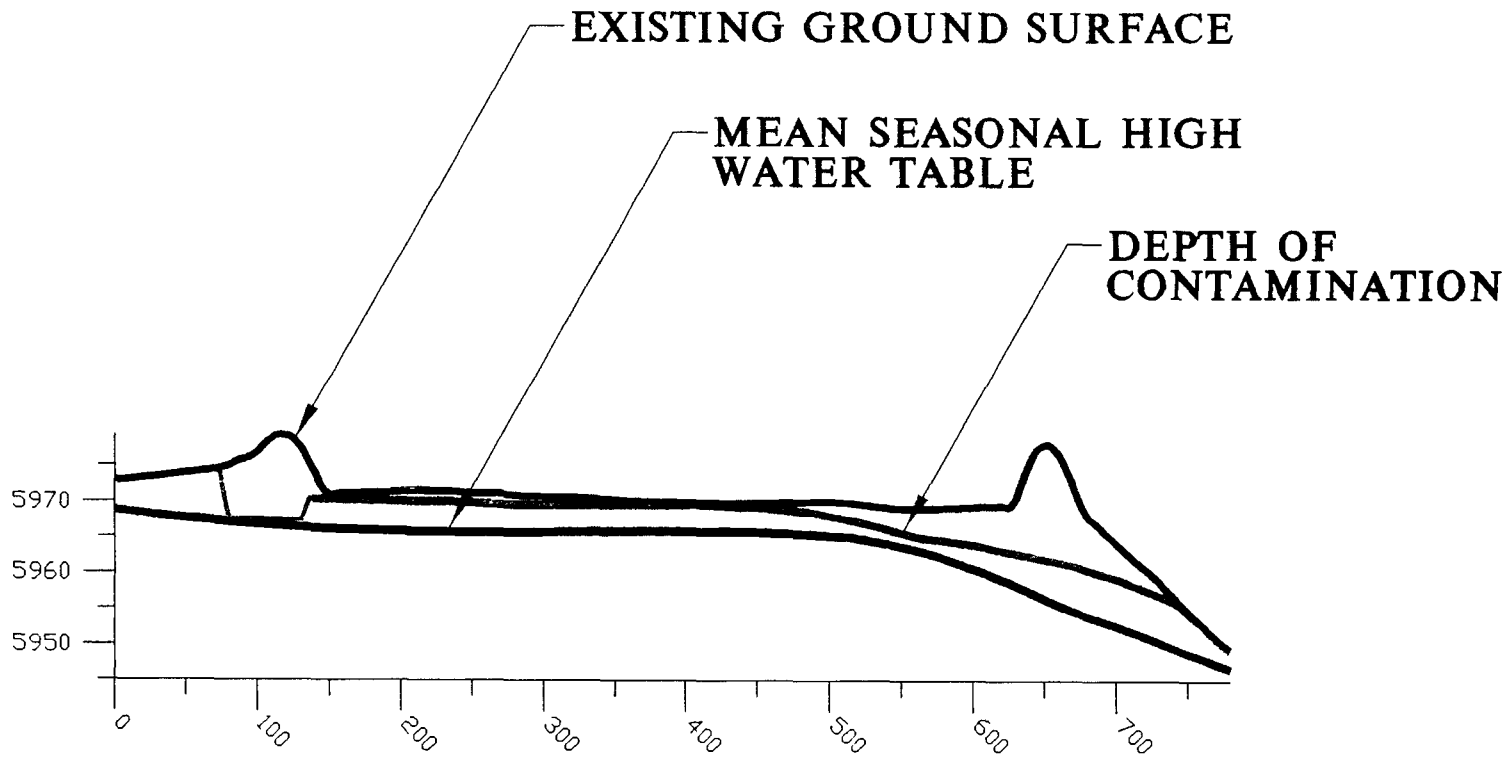

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Figure IV 3 8

Solar Evaporation Ponds
Operable Unit No 4 IM/IRA EA DD
North South Cross Section

TABLE 3-2
CONTAMINANT QUANTITIES

PONDCRETE UNDER ENGINEERED COVER
CONTAMINANT QUANTITIES

Note 1 Volume of inventory pondcrete based on 8,200 tri-walls with an average pondcrete volume of 13 7 cu ft
2 Radionuclide concentrations were measured on a dry pondcrete basis Pondcrete % moist 60 8
3 Radionuclide concentrations taken from "Analysis of Inventory Pondcrete - Final Report", Apdx D, June 3, 1991
4 Chemical concentrations taken from Pond and Sludge Waste Characterization Report, HNUS, March 1992

Volume of Inventory Pondcrete= 4,161 CUBIC YARDS
Mass of Inventory Pondcrete= 4,586 TONS= 4 16E+06 kg

Contaminant	Mean Activity Concentration (pCi/g dry)	Mass/Activity Relationship (mg/pCi)	Mean Mass Concentration (mg/kg)	Quantity	Units
Arsenic			7 12	11 6	kg
Beryllium			0	0	kg
Cadmium			1 41E+03	2,292	kg
Chromium			8 41E+02	1,372	kg
Americium-241	0	2 911E-10	0 00E+00	0	mg
Plutonium-239/240 (239)	9 95E+02	1 609E-08	1 60E-02	26 1	g
Uranium-233/234 (234)	1 55E+02	1 605E-07	2 48E-02	40 5	g
Uranium-235	4 76E+00	4 622E-04	2 20E+00	3 59	kg
Uranium-238	1 82E+02	2 972E-03	5 42E+02	883	kg

LINERS UNDER ENGINEERED COVER
CONTAMINANT QUANTITIES

Note 1 Chemical and radiological data taken from "Analytical Reports for Requisition 11859", Chem-Nuclear Geotech, August 16, 1993
2 Density of in-place liner assumed equal to in-place asphalt concrete pavement = 137 lbs /cu ft

Volume of Liners= 11,800 CUBIC YARDS
Mass of Liners= 21,824 TONS= 1 98E+07 kg

Contaminant	Mean Activity Concentration (pCi/g)	Mass/Activity Relationship (mg/pCi)	Mean Mass Concentration (mg/kg)	Quantity	Units
Arsenic			1 35	26 7	kg
Beryllium			0 1	1 98	kg
Cadmium			2 87	56 8	kg
Chromium			9 49	188	kg
Americium-241	2 20E-03	2 911E-10	6 40E-10	0 013	mg
Plutonium-239/240 (239)	6 20E-02	1 609E-08	9 98E-07	0 020	g
Uranium-233/234 (234)	1 48E+00	1 605E-07	2 37E-04	4 69	g
Uranium-235	1 14E-01	4 622E-04	5 28E-02	1 05	kg
Uranium-238	1 45E+00	2 972E-03	4 29E+00	85 0	kg

SLUDGES UNDER ENGINEERED COVER
CONTAMINANT QUANTITIES

Weight of Dry Sludge= 434 TONS= 3 94E+05 kg

Note Weight based on dry sludge and salt quantities provided by EG&G

Contaminant	Mean Activity Concentration (pCi/g)	Mass/Activity Relationship (mg/pCi)	Mean Mass Concentration (mg/kg)	Quantity	Units
Arsenic			2 23E+01	8 8	kg
Beryllium			0 00E+00	0	kg
Cadmium			3 46E+02	136	kg
Chromium			5 31E+02	209	kg
Americium-241	6 37E-01	2 911E-10	1 85E-07	0 073	mg
Plutonium-239/240 (239)	5 98E+00	1 609E-08	9 62E-05	0 038	g
Uranium-233/234 (234)	1 83E+01	1 605E-07	2 93E-03	1 153	g
Uranium-235	6 38E-01	4 622E-04	2 95E-01	0 12	kg
Uranium-238	2 33E+01	2 972E-03	6 92E+01	27	kg

SOILS UNDER ENGINEERED COVER
CONTAMINANT QUANTITIES

Volume of Surficial Soil=	8,500 C Y	
Mass of Surficial Soil=	13,770 TONS=	1 25E+07 kg
Volume of Vadose Zone Soil	129,200 C Y	
Mass of Vadose Zone Soil=	209,304 TONS=	1 90E+08 kg
Total Mass Soil=	223,074 TONS=	2 02E+08 kg

Contaminant	Mass/Activity Relationship (mg/pCi)	Mean Activity Concentration (pCi/g)	Mean Mass Concentration (mg/kg)	Quantity	Units
Surficial Soil					
Beryllium			1 03E+00	12 9	kg
Cadmium			1 93E+01	241	kg
Americium-241	2 911E-10	7 36E-01	2 14E-07	2 68	mg
Plutonium-239/240 (239)	1 609E-08	6 90E-01	1 11E-05	0 139	g
Uranium-233/234 (234)	1 605E-07	2 62E+00	4 21E-04	5 26	g
Uranium-235	4 622E-04	7 06E-02	3 26E-02	0 408	kg
Uranium-238	2 972E-03	2 04E+00	6 07E+00	75 8	kg
Vadose Zone Soil					
Beryllium			0	0	kg
Cadmium			1 46E+01	2,771	kg
Americium-241	2 911E-10	5 81E-02	1 69E-08	3 21	mg
Plutonium-239/240 (239)	1 609E-08	8 02E-02	1 29E-06	0 245	g
Uranium-233/234 (234)	1 605E-07	1 63E+00	2 61E-04	49 6	g

Uranium-235	4 622E-04	6 67E-02	3 08E-02	5 86	kg
Uranium-238	2 972E-03	1 95E+00	5 81E+00	1,103	kg

Soil Contaminant Totals	Quantity	Units
Beryllium	12 9	kg
Cadmium	3,012	kg
Americium-241	5 89	mg
Plutonium-239/240 (240)	0 384	g
Uranium-233/234 (233)	54 8	g
Uranium-235	6 26	kg
Uranium-238	1,178	kg

TOTAL ESTIMATED CONTAMINANT QUANTITIES UNDER ENGINEERED COVER

Total volume all contaminated media= 164,500 CUBIC YARDS

Total mass all contaminated media= 261,430 TONS= 2 37E+08 KILOGRAMS

Note Volumes of treated sludge and re-treated pondcrete are estimated to be 5,000 C Y and 10,000 C Y , respectively
Note Specific gravities of treated sludge and re-treated pondcrete are assumed=inventory pondcrete 1 31
Density of these materials is therefore = 1 10 TONS/CUBIC YARD

Contaminant	Quantity	Units
Arsenic	47 1	kg
Beryllium	15	kg
Cadmium	5,497	kg
Chromium	1,768	kg
Americium-241	5 98	mg
Plutonium-239/240 (239)	26 5	g
Uranium-233/234 (234)	101	g
Uranium-235	11 0	kg
Uranium-238	2,174	kg

The results of these calculations indicate that the total mass of the primary COCs is very small with respect to the total mass of material consolidated beneath the final engineered cover

Location of Reclaimed Areas

Reclaimed areas will be constructed over SEP 207-C (Zone A), the hillside north of the SEPs to the intersection of the piezometric surface with the topographic surface (Zone B) and north of the security fence (buffer zone) (Zone C) The chosen cover design is described in Section III 3 2 1 and is identified as Alternative 1 A drawing of the reclaimed areas and the final engineered cover site layout is presented as Figure IV 1-1

Rationale for Site Layout

The excavation, transfer of materials, and relocation of stored wastes (IDM, sludge, and pondcrete) allows for the consolidation of the waste materials formerly and presently existing in the OU4 SEPs location Consolidation of the waste materials balances the wastes and reduces the contaminant area, thereby reducing construction and materials costs and operation and maintenance requirements The area reduction also facilitates a decrease in control and monitoring requirements

The mean of the seasonal high ground water elevation under the 207-B Series SEPs in conjunction with the fact that contaminants in the vadose zone provide a potential source of ground water contamination, has precluded the option of leaving liners, berms, and contaminated soils at their *in situ* elevations beneath the SEPs A subsurface drainage layer will be installed as an additional preventive measure to prevent groundwater contact with the consolidated materials This system will be installed just above the elevation of the mean of the seasonal high ground water elevation This system will reduce the potential for a future rise in the ground water elevation from contacting the hazardous waste and contaminated media This subsurface drain will consist of layers of sand and gravel The position of this system is depicted on Drawing 51045-122

Selection of adequate backfill materials, vegetation, gravel, armor, grading, and slope will minimize surface water and wind erosion, and promote runoff away from the final engineered cover The potential for slope instability will be reduced by constructing the final engineered cover away from the crest of the north hillside Additional measures that will be implemented to increase stability include backfilling and grading the north hillside

IV.3.1.2 Closure System Details

The chosen design for the final engineered cover is based on research underway at the DOE Hanford Site in eastern Washington State and the Los Alamos National Laboratory near Los Alamos, New Mexico This research provides engineering cover design criteria for semi-arid to subhumid climates, similar to those at the RFETS The design uses natural earthen materials with proven long-term durability The natural materials chosen for the final engineered

cover design are best suited to protect human health and the environment for a period of 1,000 years

The goals of the final engineered cover include the isolation of consolidated wastes from transport pathways by controlling water infiltration, plant and animal intrusion, and wind and water erosion The final engineered cover will have the ability to provide long-term passive performance The design criteria meet state and federal regulations as presented in Section III 5 2

The goals of the backfilled reclaimed areas identified as Zones A, B, and C on Figure IV 3-1 include removing contaminated materials from the areas and creating a final grade with a consistent slope for positive drainage and erosion control The reclaimed areas will be designed to direct runoff away from the final engineered cover

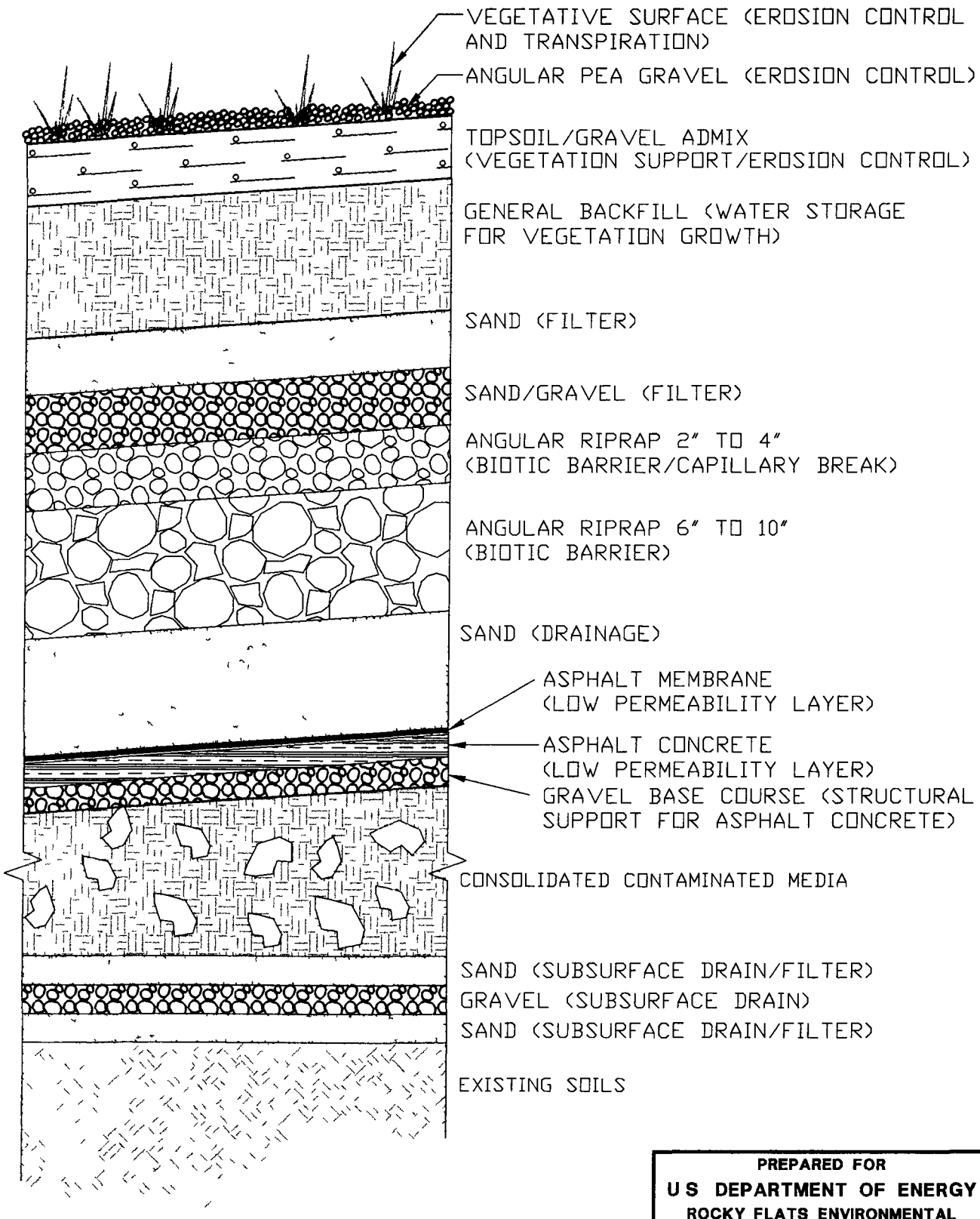
Final Engineered Cover

The final engineered cover will be constructed of several layers placed above the consolidated contaminated materials to form an abovegrade mound The layers will be constructed of different materials, each with its own function All the materials used in the final engineered cover design can be obtained locally outside of the RFETS boundaries The layers used to construct the final engineered cover include the following

- Vegetation,
- Angular Pea Gravel,
- Topsoil,
- General backfill,
- Sand filter,
- Gravel filter,
- Angular riprap,
- Drainage/cushion Sand,
- Asphalt membrane,
- Asphalt concrete, and
- Gravel base course

Figure IV 3-9 illustrates the cross-section of the proposed final engineered cover Drawing 51045-123 provides a drawing of the cross-section specifying the thickness of each layer

Several layers of the final engineered cover have been chosen based on research conducted at the DOE Hanford Reservation and the research of Dr Hakonson at the DOE Los Alamos National Laboratory The information collected from research performed at the DOE Hanford Site is very beneficial for application to the RFETS The similarities between Hanford and RFETS include the climate, waste materials, long-term goals and the use of asphaltic



NOTE:

THE DEPTH OF THE GENERAL BACKFILL WILL VARY WITH RESPECT TO THE DEPTH OF THE EXCAVATION AND DESIRED FINAL GRADE

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Figure IV 3 9

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Final Engineered Cover

materials for the low permeability layer, however, some selected materials used in the RFETS final engineered cover design (e g , angular riprap layer) were based on computer modeling and the evaluation of information and materials specific to the RFETS

An important component of the final engineered cover is the vegetated surface Plant cover can reduce soil loss and may enhance deposition of wind transported particles (Waugh, 1989) The addition of organic matter over the years binds soil particles Higher plants also feed and are fed by soil microorganisms that help drive plant succession, secondary mineralization, soil aggregation and hence moisture retention and soil stability

Over time, regardless of what is initially planted on a barrier, the plant community will likely converge with the community that would have developed naturally through the process of succession (Waugh, 1989) Natural succession or recovery of a plant community following a disturbance leads to greater biomass (and initially, greater transpiration), slower rates of nutrient cycling, damped effects of macroenvironmental extremes (such as buttering of extreme precipitation or soil water movement), and overall greater site stability

A reduction in plant growth associated with higher global temperatures may be balanced partly by an increase in growth attributable to the higher CO_2 concentrations A doubling of atmospheric CO_2, for example, could lead to a greater than 80% increase in biomass yield and, simultaneously, as much as a 10% decrease in the per-unit-leaf-area transpiration rate (Petersen et al, 1993)

Lysimeter tests were performed at the Hanford Site to research water infiltration due to animal burrowing (Landeen, 1991) These tests indicated a lack of significant water infiltration at depth and an overall water loss in the lysimeters These occurrences were taking place despite the following worst case conditions, which were imposed on the lysimeters

- no vegetative cover (no transpiration),
- no water runoff (all water contained),
- higher than normal animal and burrow densities,
- supplemental precipitation added at rates not expected to happen normally, and
- animals always burrow to the bottom of the lysimeters

The overall water loss appears to be caused by a combination of constant soil turnover and subsequent drying, ventilation effects from open burrows, and high ambient temperatures

The first soil layer will be composed of a topsoil/gravel admix This layer will control erosion, facilitate evaporation, and support vegetation The thickness of this layer will be based on the estimated amount of soil loss due to wind and water erosion and on the rooting characteristics of the selected vegetation species Characteristics examined to determine the most effective transpiration rate include plant size, soil type, availability of water, rooting characteristics, and atmospheric factors Transpiration is a function of the supply of water to roots, plant liquid water conductance, stomatal conductance, and leaf area (Petersen et al, 1993)

The incorporation of a gravel admix (pea gravel size) into the surface of the topsoil layer is intended to mimic conditions that led to the formation of desert pavements that have remained stable for thousands of years (Waugh, 1990) Pea gravel has a higher surface area-to-volume ratio than larger gravel or cobble and thus may provide greater soil protection with less impact on soil hydraulic properties

The use of pea gravel to prevent wind erosion has been researched for the Hanford Site final engineered cover (Ligotke et al, 1990) The wind conditions at Hanford are similar to those found at the RFETS Results of these studies indicated that the addition of 0 11 to 0 26 inch diameter gravels as admixtures to the silt-loam soil at the Hanford Site provided 54 to 32 times less surface deflation respectively, than soil only in normal wind conditions Inclusion of the fine-grained gravels reduced erosion rates ranging from 2 3 to 1 5 percent of those rates occurring from unprotected soil-only surfaces Wind tunnel tests for varying wind speeds, have produced results indicating that the best gravel choice for protective barriers exposed to extreme eolian stresses, for either admixture or surface layers, would be a river or crushed gravel containing particles ranging in size from 0 08 to 0 37 inches in diameter

The general backfill layer will function as a water storage layer to promote vegetative growth Local soils (e g , sandy loams) will be used as the layer material This layer will be only lightly compacted to allow for adequate root penetration The thickness of this layer will be dependent upon the root depth of the selected vegetation species and the anticipated required water storage depths The type of soil specified will be dependent upon the thickness of the layer and the amount of water storage that is desired

The sand and gravel layers will act as filter media to prevent the overlying soils from migrating into the biotic barrier The filtration is required to maintain pore space within the biotic barrier to sustain the design capillary break function Compaction of these layers will be required to fill voids, decrease shifting, and provide a stable base for overlying layers The thickness of the filter layers will be based on sound engineering judgment

The multilayered barrier concept with a capillary break is based on a principle of soil physics called "the outflow law" which says that water will not move from the fine-soil layer down into the coarse-rock layer (capillary break) until the soil at the layer interface is virtually saturated (Phillips et al, 1985) This theory is based on the following

- optimum combination of topsoil depth and texture to retain precipitation near the surface,
- regular depletion of the water in this reservoir by evaporation and transpiration so that the soil at the layer interface remains unsaturated, and
- prevention of soil from sifting into underlying rock interstices

The angular riprap layer is composed of high quartzite-granite material This material is locally available and is more durable than the basalt materials specified in the Hanford Site

design The riprap layer provides a biotic barrier to prevent burrowing animals from entering the contaminated media and opening a direct channel for precipitation to reach the waste zone The layer will also restrict deep-rooted plants from extending to deeper zones by providing a capillary break The EPA Technical Guidance Document entitled "Final Covers on Hazardous Waste Landfills and Surface Impoundments" (1989b) reports that research results indicate that 6 inches of gravel over 30 inches of riprap may be effective in stopping deep-rooted plants This capillary break concept has been researched for several years for the final engineered cover design at the Hanford Site (Wing, 1993) Results of the tests have indicated that the capillary break has functioned as designed Slight compaction of this layer may be required to fill voids, decrease shifting, and provide a stable base for overlying layers

In two of the lysimeter tests performed at the Hanford site to research the permeability of the capillary break, enough water was added to force water to break through the capillary barrier (Petersen et al, 1993) As expected, it was determined that water does not pass through the capillary barrier in the liquid phase until the soil approaches saturation and pore pressure becomes positive Once breached, the capillary barriers in the lysimeters drained only slowly until they reached a stable water content almost twice as high as that normally held by the soil against gravity

The lower sand layer beneath the riprap will promote lateral drainage of water that infiltrates through the upper layers of the cover This layer will also act as a cushion to prevent the angular riprap from damaging the asphalt layers below According to the EPA Technical Guidance Document entitled, "Final Covers on Hazardous Waste Landfills and Surface Impoundments" (1989b), drainage layers should be greater than or equal to 12 inches Slight compaction of this layer will be required to fill voids, decrease shifting, and provide a stable base for overlying layers

A liquid applied asphalt membrane layer will act as a low permeability zone to mitigate the infiltration of any liquid that migrates through the upper layers Rubberized asphalt exhibits dramatic elastic properties that allow the material to stretch up to 13 times its original length without rupturing or exhibiting significant plastic deformation The plastic properties of rubberized asphalt provides a self-healing ability to repair punctures of the low-permeability layer Having been used since the dawn of civilization, asphalt is one of the oldest human-used engineering materials (Asphalt Institute, 1989) In 2600 B C the Egyptians used asphalt as a waterproofing material and as early as 3000 B C , asphalt was used as a water stop between the brick walls of water reservoirs It was used by early humans as a paving material, wood preservative, sealant, adhesive, and mortar Many artifacts dated 4,900 to 5,500 years old have been recovered in the Middle East in good condition, attesting to the long-term stability of asphalt under anaerobic conditions (Freeman, 1989b) Asphalt surface deposits containing skeletons of prehistoric animals are currently intact at the La Brea Tar Pit outside of Los Angeles, California (Asphalt Institute, 1989) These sources have revealed that asphalt is a natural material with long-term durability

The asphalt concrete layer will work in conjunction with the asphalt membrane layer to minimize infiltration Ultraviolet light and frost are known to decrease the integrity of asphalt concrete However, this layer will be shielded from ultraviolet light by the cover materials above, and it will be placed below the frost depth of 36 inches

Asphalt materials have been tested by Pacific Northwest Laboratory (PNL) as a cover system at a uranium mill tailings site in Grand Junction, Colorado Results of these tests have indicated that asphalt has an extremely low permeability to both radon and water and penetration by plants and animals (Freeman, 1989b)

The Hanford research team organized lysimeter tests to measure the efficiency of asphalt materials (Freeman, 1989b) In fiscal year 1989, these studies indicated that the asphalt barriers did not leak during the first 12 months of lysimeter monitoring Hanford research has revealed hydraulic conductivities of 3×10^{-7} centimeters per second (cm/s) for asphalt concrete mixtures of 20 to 22 wt % and 24 wt % asphalt content, respectively However, the Hanford research team has determined that the asphalt layers can achieve a hydraulic conductivity of $1\ 0 \times 10^{-11}$ cm/s The thickness of the asphalt layer is based upon the results of the research performed at the DOE's Hanford Site

A study performed by Heritage Research Group (HRG), Indianapolis, Indiana, used toxicity characteristic leaching procedure (TCLP) leachate to test fresh hot-mix asphalt (HMA) for the presence of the 40 EPA contaminants and the high-molecular weight polynuclear aromatic hydrocarbons (PAH's) routinely tested for by the EPA The HRG tested a mixture of AC-20 asphalt cement/slag, stone and sand that met Indiana DOT specifications for asphalt surface mixtures Of the 40 contaminants identified by the EPA as hazardous, chromium was the only element that had a level above detectable limits, measured at 0 1 ppm Since asphalt typically does not contain chromium, this small level was thought to be coming from the slag aggregate, which is a byproduct of the steel making process The only PAH detected was naphthalene, which was measured at 0 25 ppb Naphthalene is the most volatile PAH, and is not carcinogenic like some of the other PAH's No other PAHs were found to be present The results of this study indicate that the use of asphaltic materials will not provide an additional source of potential contaminants to the closure system (Audibert)

The gravel base layer will act as a structured base to increase the stability of the overlying asphalt layers Compaction of the gravel base will decrease voids, decrease shifting, and provide a stable base for the overlying layers

Compacted contaminated media backfill will include crushed liners from all SEPs, OU4 sludge, pondcrete and the materials excavated from the hillside north of the SEPs to the intersection of the piezometric surface with the topographic surface north of the perimeter security fence (buffer zone), existing soils under SEPs 207-A, 207-B, 207-C, and IHSS 176 down to the mean seasonal high ground water elevation Compaction is critical for the backfill material to provide stability and to reduce settlement

A gravel layer will be placed beneath the consolidated materials to provide the subsurface drainage layer This layer will provide adequate drainage of ground water away from the consolidated materials if the ground water elevation rises above the historical high elevation A sand and sand/gravel layer will be installed above the gravel drain to prevent the consolidated contaminated materials from migrating into the subsurface drainage layer causing a reduction in its efficiency due to plugging Sand/gravel and Sand layers will be placed beneath the gravel drain These bottom layers will act as a filter so that any solids carried by the rising ground water will not be deposited in the subsurface drainage layer and cause a reduction in its efficiency due to plugging

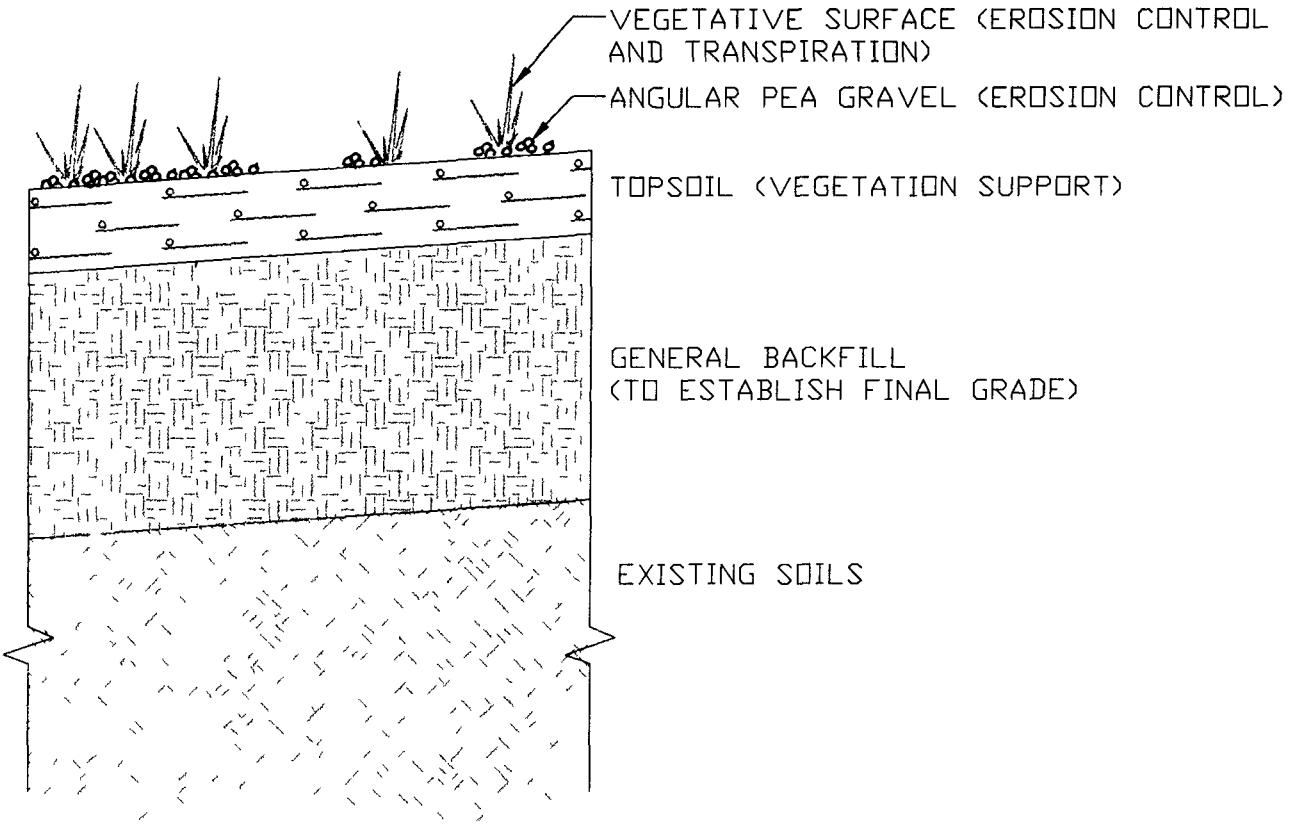
Reclaimed Areas

The reclaimed areas will have several natural layers placed in the excavated areas to form a consistent slope The excavated areas include SEP 207-C (Zone A), the hillside north of the SEPs to the downhill intersection of the piezometric surface with the topographic surface (Zone B), and the area north of the perimeter security fence (buffer zone) (Zone C) The reclaimed areas will reduce human and animal contact and provide consistent drainage pathways to minimize damage from erosion The layers will be constructed of several materials, each with its own function General backfill, topsoil, pea gravel and vegetation are included in the reclamation cover design All of the materials used in the reclamation cover design can be obtained locally outside the boundaries of the RFETS and are consistent with the materials used for the final engineered cover Contaminated materials from the reclaimed areas will have been removed and consolidated beneath the final engineered cover After excavation of the contaminated media and the use of imported clean backfill material in these areas, they will be considered protective of human health and the environment Figure IV 3-10 and Drawing 51045-123 illustrate the cross-section of the proposed reclamation cover

The surface layer will be composed of pea gravel and topsoil This layer will control erosion and support vegetation To encourage root growth, this layer will not be compacted The general backfill beneath the surface layer will have a thickness necessary to establish the appropriate grade The general backfill layer will store water for vegetative growth The soils will be composed of imported clean backfill

IV.3.1.3 Engineered Cover Performance Modeling

The primary purpose of a final engineered cover is to minimize infiltration of precipitation and to limit percolation of water through the contaminated soils and liner materials In determining the most effective final engineered cover design, calculation of the amount of infiltration percolating through the final engineered cover system is necessary to select the most viable cover components Infiltration is also important in predicting the potential for contaminant leaching and migration through the underlying vadose zone soils The Hydrologic Evaluation of Landfill Performance (HELP), computer model Version 2 05, was used to estimate the amount of infiltration and percolation through the final engineered cover design The HELP model was developed by the U S Army Corps of Engineers Waterways Experiment Station for



NOTE:

THE DEPTH OF THE GENERAL BACKFILL WILL VARY WITH RESPECT TO THE DEPTH OF THE EXCAVATION AND DESIRED FINAL GRADE

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GOLDEN, COLORADO

Figure IV 3-10

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Backfill Cover

the EPA It was developed to facilitate rapid and economical estimations of the water movement through and out of landfills. HELP was chosen because of its widespread acceptance in the engineering community

The HELP model prediction of the infiltration rate was used to evaluate the effectiveness of the final engineered cover design and in providing input for the VLEACH Model to predict the potential for contaminants to leach from the underlying vadose zone soils (Section 10 4) The HELP model will also be used throughout the detailed design process to optimize the final engineered cover design

HELP is a quasi-two-dimensional computer code that models landfill performance with respect to the hydrologic cycle. Figure IV 3-11 presents a conceptual model of the hydrologic input and output data The model accepts climatologic data, soil characteristics, and design data, and utilizes a solution technique that accounts for the daily effects of surface storage, runoff, infiltration, percolation, evaporation and transpiration, soil moisture storage, and lateral drainage HELP has the ability to model landfill systems including various combinations of vegetation, cover soils, waste cells, special drainage layers and relatively impermeable barrier soils, as well as synthetic membrane covers and liners (Schroeder et al , 1988) HELP does not account for capillary flow in the variably saturated cover components and as a consequence provides a conservative estimate of percolation through the final engineered cover (Nichols, 1991)

The proposed final engineered cover design which is shown in Figure IV 3-9 was modelled with HELP This final engineered cover design was modelled using five different scenarios

- normal climatological and vegetation data,
- normal precipitation with no vegetation,
- projected 100 year storm event with normal temperature and normal vegetation data, and
- projected future climate changes with a,

  - 15% increase in precipitation,
  - 200% increase in precipitation, and
  - 300% increase in precipitation

Normal climatological and vegetation data were modeled to establish a baseline for comparison There is a possibility that fire, drought, or disease could destroy the vegetated cover layer Therefore, the model was run without vegetation to determine the affect that vegetation had on cover performance The model was also run with parameters to reflect projected climate changes such as an increase in precipitation and temperature

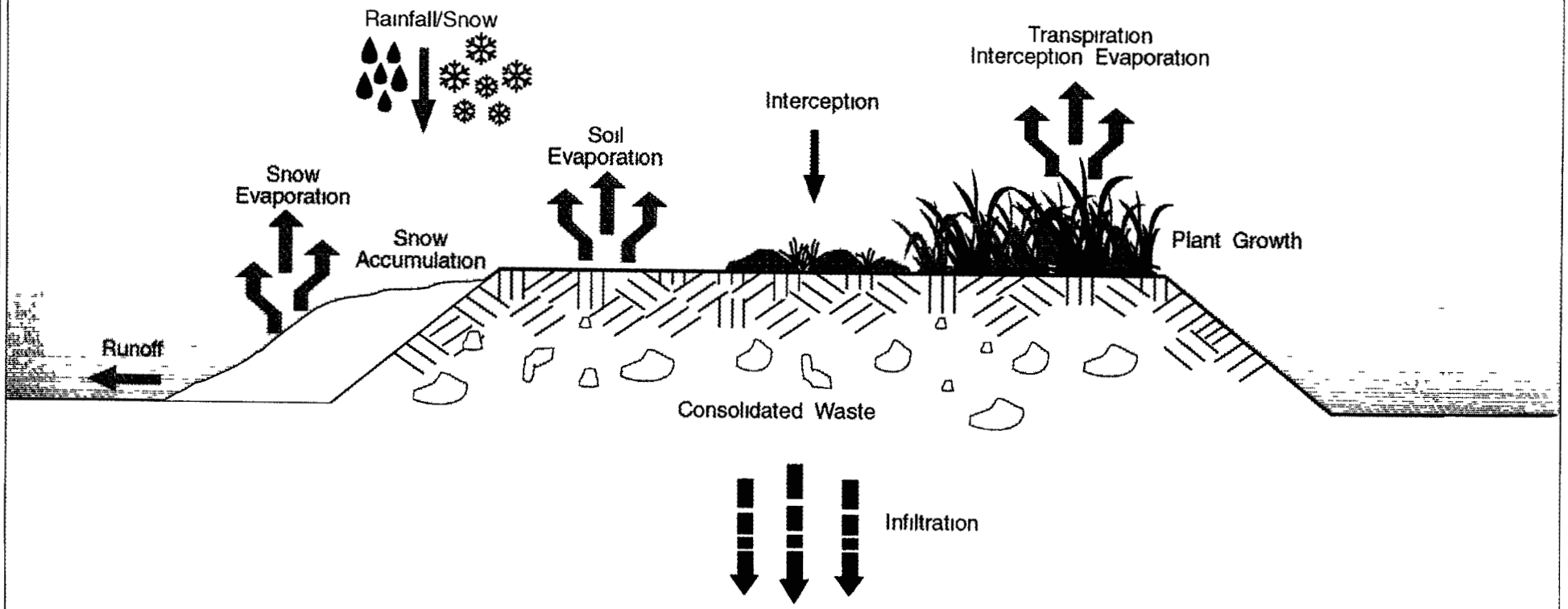

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Figure IV 3-11

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Simulation Processes in the HELP Model

DE30722b IM/IRA EA

IV.3.1.3.1 Soil Input

Soil Input Options

HELP allows the user to enter soil characteristics to each layer by either the default option or the manual option Table IV 3-3 shows the characteristics for the 18 default soil types and the soil texture classification assigned using the United Soil Classification System (USCS) available in HELP

Under the default option, the user selects soil textures for each layer HELP calculates the initial soil water content for each layer and the Soil Conservation Service (SCS) runoff curve number for the top layer The manual input option allows the user to enter values for porosity, wilting point, field capacity, initial soil water content, and saturated hydraulic conductivity These properties are defined below

Porosity - the volumetric soil water content at saturation

Field Capacity - the soil water content after a prolonged period of gravity drainage (also typically defined at moisture content of 1/3 bar)

Wilting Point - the lowest soil water content that can be achieved by plant transpiration (also typically defined at moisture content of 1/15 bar)

Saturated Hydraulic Conductivity - the rate at which water drains vertically through a saturated soil with no pressure gradient

Soil Water Content - the ratio of the volume of water in soil to the total soil volume (also known as the volumetric moisture content)

SCS Runoff-Curve Number - the concept of runoff-curve numbers was developed by the SCS to allow estimation of the relative amount of surface water runoff that would result from a rainfall event Runoff curve numbers are a function of soil permeability, the antecedent moisture condition, rate of precipitation (intensity of rainfall) and the amount of rainfall intercepted by vegetation or structures (ASI, 1991) Runoff curve numbers can theoretically range from zero (an infinite retention and infiltration capacity) to 100 percent (no retention and infiltration capacity) Typical values range from 40 or 50 percent for well-drained soils, and up to 98 percent for developed areas (pavement etc) (ASI, 1991) Curve numbers have been developed for each soil type for various land characteristics and land-use designations at RFETS by ASI (1991)

TABLE IV.3-3
HELP DEFAULT SOIL CHARACTERISTICS

Soil Texture Class		Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)
HELP	USCS				
1	GS	0 417	0 045	0 018	1 0E-02
2	SW	0 437	0 062	0 024	5 8E-03
3	SM	0 457	0 083	0.033	3.1E-03
4	SM	0 437	0 105	0 047	1 7E-03
5	SM	0 457	0 131	0 058	1 0E-02
6	SM	0 453	0 190	0 085	7 2E-04
7	SM	0 473	0 222	0 104	5 2E-04
8	ML	0 463	0 232	0 116	3 7E-04
9	ML	0 501	0 284	0 135	1 9E-04
10	SC	0 398	0 244	0.136	1 2E-04
11	CL	0 464	0 310	0 187	6 4E-05
12	CL	0 471	0 342	0 210	4 2E-05
13	CH	0 430	0 321	0 221	3 3E-05
14	CH	0 479	0 371	0 251	2 5E-05
15	CH	0 475	0 378	0 265	1 7E-05
16	Barrier Soil	0 430	0 366	0 280	1 0E-07
17	Barrier Soil	0 400	0 356	0 290	1 0E-08
18	Municipal Waste	0 520	0 294	0 140	2 0E-04
19	User-defined soil characteristics				
20	User-defined soil characteristics				

Site Specific Soil Characteristics

The input soil data for the specific layers of the final engineered covers are summarized below in the following paragraphs and in Table IV 3-4

Under the soil characteristics option within the HELP model, the user is able to enter soil moisture parameters (described above) that more accurately characterize site-specific soils or construction layers (manual option) than the HELP default soil types Ideally, these parameters are measured within a laboratory setting or in the field Without these parameters being analytically measured, an estimate can be obtained from a particle size distribution of the soil along with an estimate of the porosity or dry bulk density SoilProp computer model version 2 1 was used to estimate the wilting point, field capacity, and the saturated hydraulic conductivity Using the particle size distribution and porosity, SoilProp calculates a soil moisture curve that is described by both Van Genuchten and Brooks-Corey equations The parameters that describe the equations can be related to field capacity and wilting point pressure head by assuming the generally accepted industry standards of 1/3 and 15 bars respectively Due to numerical variances in the form of the equation representation of the moisture curve, slight discrepancies in the curve shape occur at low matric potential Additionally, within the HELP model there are limitations on the minimum value (0 02 vol/vol) that is acceptable for wilting point and field capacity, and a maximum value (103 34 cm) that is acceptable for the air-entry value (bubbling point) These limitations had only minor impact upon the predicted values of SoilProp for the biotic layers

For the final engineered cover, there are a total of eleven layers between the surface and the contaminated media The lower most layer, a gravel base course, serves as a structural support layer for the asphalt concrete above This layer is designed to be a structural support material, and therefore, was not considered in the analysis This layer was assumed to be combined with the contaminated media during construction of the final engineered cover Other layers have also been combined because their soil moisture characteristic parameters are similar or because of HELP limitations The function of each layer of the final engineered cover is described in Section IV 3 1 2 The model-specific layers are also described below Characteristic parameters are in units of vol/vol, if not reported

Angular Pea Gravel

It is assumed that this 6 inch layer will be composed of imported crushed geological materials Within the design life of the cover, it is assumed that this layer will eventually be absorbed into the topsoil and general backfill layers below, but to be conservatively treated as a separate layer The estimated parameters were obtained from HELP default values, Freeze and Cherry (1979), and EPA (1988) The soil parameters used in HELP for the porosity was 0 417, field capacity was 0 0454, the wilting point was 0 02, the hydraulic conductivity was 0 1 cm/sec, and the initial soil moisture content was 0 0454 This layer will not be compacted

TABLE IV.3-4
INPUT VALUES FOR SOIL AND BARRIER CHARACTERISTICS

Layer	Thickness (inches)	Layer Type	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conduct (cm/sec)
Gravel[(1),(2)]	6	Vertical	0 4170	0 0454	0 0200	1×10^{-1}
Topsoil/Gravel Admix/Backfill	48	Vertical	0 3400	0 1591	0 1260	0 037
Sand Filter #1	12	Lateral	0 3600	0 0358	0 0210	3 009
Gravel Filter #2	12	Lateral	0 4300	0 0261	0 0200	9 757
Upper Biotic Break	12	Lateral	0 4300	0 0217	0 0200	9 930
Lower Biotic Break	18	Lateral	0 4300	0 0217	0 0200	9 930
Sand Cushion	12	Lateral	0 3600	0 0355	0 0210	2 917
Asphalt Membrane[(1) (3)]	0 25	Barrier	0 0263	0 0250	0 0200	1×10^{-9}

(1) Soil and barrier data from HELP default soil data.
(2) Hydraulic Conductivity of sand and gravel taken from Freeze and Cherry (1979) and EPA (1988)
(3) Hydraulic Conductivity for barriers estimated from information from the Asphalt Institute (1976) and Freeman and Gee (1989a and 1989b)

Top Soil/Gravel Admix/Backfill

It is assumed that this 48 inch top soil/gravel admix and general backfill layer will be composed of materials from a local source and that the properties of the topsoil and the general backfill are consistent Soil properties were estimated from the SoilProp Computer code The soil parameters used in HELP for the porosity was 0 3400, field capacity was 0 1591, the wilting point was 0 1260, the hydraulic conductivity was 0 037 cm/sec, and the initial soil moisture content was 0 20 This layer will not be compacted

Sand Filter #1

It is assumed that this 12-inch layer will be composed of imported geological materials Within the design life of the final engineered cover, it is assumed that this layer will not be absorbed into the topsoil, general backfill, or filter #2 below The particle size distribution estimate was obtained from construction specification requirements for the final engineered cover The soil parameters used in HELP for the porosity was 0 36, field capacity was 0 03578, the wilting point was 0 021, the hydraulic conductivity was 3 01 cm/sec, and the initial soil moisture content was 0 15 This layer will not be compacted

Sand/Gravel Filter #2

It is assumed that this 12-inch layer will be composed of imported geological materials Within the design life of the cover it is assumed that this layer will not be absorbed into filter #1 or the biotic layers The particle size distribution estimate was obtained from construction specification requirements for the final engineered cover The soil parameters used in HELP for the porosity was 0 43, field capacity was 0 02608, the wilting point was 0 0200, the hydraulic conductivity was 9 7569 cm/sec, and the initial soil moisture content was 0 10 This layer will not be compacted

Upper and Lower Biotic Break

It is assumed that these 30-inch combined biotic layers will be composed of imported crushed geological materials The moisture properties of the upper and the lower biotic break are assumed to be nearly the same Within the design life of the cover it is assumed that this layer will not be absorbed into the filter #2 or the sand cushion layers The particle size distribution estimate was obtained from construction specification requirements for the final engineered cover The soil parameters used in HELP for the porosity was 0 43, field capacity was 0 0217, the wilting point was 0 02, the hydraulic conductivity was 9 93 cm/sec, and the initial soil moisture content was 0 01 This layer will not be compacted

Sand Cushion

It is assumed that this 12-inch sand cushion layer will be composed of imported geological materials Within the design life of the cover it is assumed that this layer will not be absorbed into the biotic layers The particle size distribution estimate was obtained from construction specification requirements for the final engineered cover The soil parameters used in HELP for the porosity was 0 36, field capacity was 0 0355, the wilting point was 0 021, the hydraulic conductivity was 2 917 cm/sec, and the initial soil moisture content was 0 05 This layer will not be compacted

Asphalt Barrier

The asphalt barrier is comprised of two layers including the rubberized asphalt membrane layer which overlays an asphalt concrete layer The HELP model does not have the ability to model a barrier layer directly below another barrier layer Therefore, the amount of infiltration was evaluated directly below the rubberized asphalt membrane layer

Research performed at Hanford indicated a saturated hydraulic conductivity of 6×10^{-11} cm/s for liquid asphalt (Freeman and Gee, 1989a) As a conservative measure and for constructability, a saturated hydraulic conductivity of 1×10^{-9} cm/s was used in the model Porosity was calculated based on void ratio information available from the Asphalt Institute Wilting point and field capacity were estimated based on the value for porosity

Initial Soil Water Content

HELP was initially run for a minimum of 20 years to establish an equilibrium for the initial soil water content Subsequent HELP simulations were run using these initial soil moisture content values

SCS Runoff-curve Number

The HELP model was set to calculate the SCS runoff-curve number A value of 63 11 was calculated by HELP

IV.3.1.3.2 Cover Design Input Data

An illustration of the layout and area of the proposed OU4 final engineered covers is shown in Figure IV 1-1 Input parameters for the final engineered cover, surface area, slope, and lateral drainage distance are shown below

Engineered cover surface area = 499,452 ft^2

Side Slope = 5 1

Maximum lateral drainage distance along slope (feet) = 700 ft

IV.3.1.3.3 Climate-Related Input Parameters

Climate data used as input into HELP are divided into two categories,

- normal conditions, and
- predicted climate change conditions

The differences are discussed below Default climatologic data is available for Denver, Colorado, however, where possible, site-specific data for Rocky Flats were used

Climatic change may occur as a result of emissions from human activities in the past century and may also result from natural activities such as volcanism Potential emissions released by these processes may increase the atmospheric concentrations of "greenhouse" gases carbon dioxide, methane, chlorofluorocarbons, and nitrous oxide (IPCC, 1992) Due to the increase in "greenhouse" gases some researchers predict an increase in average atmospheric temperature, precipitation and cloud cover (IPCC, 1990 and IPCC, 1992) Changes in these parameters will impact the local climatic conditions potentially resulting in increased precipitation, increased temperature, decreased evaporation and transpiration, and increased infiltration Cloud cover absorbs and reflects solar radiation, thus reducing the amount of solar radiation received at the earth's surface As a consequence, the evaporative demand at the surface would be reduced (Waugh, 1989)

Temperature

Temperature data from the Rocky Flat's Plant Site Environmental Report for 1992 (EG&G, 1992) was used as temperature input for normal climate conditions and are shown in Table IV 3-5 As previously mentioned, temperatures may increase during a potential climatic change due to an increase in "greenhouse" gasses Several models predict an increase in average annual temperature in North America by 3 6-7 2°F (2-4°C) during the winter months and 3 6-5 4°F (2-3°C) during the summer months by the year 2030 (IPCC, 1990 and 1992) There is much uncertainty to predicting climate changes beyond 100 years so it was assumed that the temperature will increase and reach an equilibrium by the year 2030 To simulate temperature changes for the HELP model, normal mean monthly RFETS temperatures were adjusted by adding 5 4°F to the months October through March and adding 4 5°F to the months April through September The numbers were based on a mean increase in temperature for the models described above The adjusted normal mean monthly temperatures at RFETS (°F) are shown in Table IV 3-5

TABLE IV.3-5
MONTHLY TEMPERATURES AT ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE (°F)*

	Normal (Mean) Monthly Temperatures	Adjusted Normal (Mean) Monthly Temperatures
January	31 0	36 4
February	33 0	38 4
March	37 0	42 4
April	45 5	50 0
May	55 5	60 0
June	64 5	69 0
July	71 5	76 0
August	70 5	75 0
September	61 5	66 0
October	52 5	57 9
November	40 0	45 4
December	33 5	38 9

* Data taken from EG&G (1992)

Precipitation Input

Three options are available to generate climatologic data a default precipitation option, a manual precipitation option, and a synthetic precipitation option For the purpose of this performance assessment the synthetic precipitation option was used with precipitation data for RFETS

Under the synthetic precipitation option the user has the option of entering normal mean monthly precipitation values to adjust for specific locations The first column in Table IV 3-6 shows the normal (mean) monthly precipitation values for RFETS The second column shows the average, monthly precipitation values used as input for the HELP model to adjust the data for Rocky Flats The third column shows the average, monthly, precipitation values generated by HELP By entering the user-defined precipitation values, HELP can generate precipitation values that replicate the averages for RFETS precipitation

Precipitation may increase during potential climatic change Several models predict an increase in average annual precipitation by as much as 15% in the Northern Hemisphere by the year 2030 (IPCC, 1990 and 1992) Because of the uncertainty with predicting climate changes beyond 100 years, the precipitation will be increased by 15, 200, and 300 percent to compare the cover performance under extreme conditions if the precipitation continues to increase

Thirty years of site-specific RFETS precipitation data were used to statistically predict a total annual precipitation amount for a 100-year storm event Existing monthly precipitation averages were used to calculate monthly averages to simulate a 100-year storm event modeling scenario

Growing Season

RFETS is located at an elevation of approximately 6000 feet above mean sea level The average growing season in this area is 126 to 142 days feet (SCS, 1980) The growing season used for this model was assumed to be 135 days and is shown below in the Julian Date model input format Although the length of the growing season will probably increase during climatic changes, no estimates of the changes are available so 135 days was used for the climatic change scenario

Start of growing season (Julian Date)	=	139
End of growing season (Julian Date)	=	274

TABLE IV.3-6
PRECIPITATION DATA

	Normal (Mean) Monthly Precipitation at RFETS (inches)*	Average Monthly Precipitation Input into HELP Model (inches)	Average Monthly Precipitation Input into HELP 100 Year Storm (inches)	Average (20 year) Monthly Precipitation Output of HELP Model (inches)
January	0 46	0 51	0 88	0 46
February	0 48	0 53	0 91	0 48
March	1 22	1 26	2 16	1 22
April	1 73	2 40	4 12	1 73
May	2 74	3 18	5 46	2 75
June	1 85	1 55	2 66	1 85
July	1 49	1 38	2 37	1 49
August	1 52	1 67	2 86	1 52
September	1 49	1 50	2 57	1 49
October	0 92	1 08	1 85	0 92
November	0 79	0 62	1 06	0 79
December	0 64	0 64	1 10	0 64
Total Annual Precipitation	15 33	16 32	28	15.34

* Data taken from EG&G (1992)

Evapotranspiration Input

Evapotranspiration is a significant factor in determining infiltration through the final engineered cover HELP models evapotranspiration as three components evaporation of water from the surface, from the soil, and transpiration from the plants HELP overestimates the amount of evapotranspiration in arid and semi-arid environments To counter overestimation of evapotranspiration, conservative values were used for the parameters that affect evapotranspiration the most in the HELP model evaporative zone depth and maximum leaf area index (vegetative cover) These will be discussed in detail below

Evaporative Zone Depth

Evaporative zone depth is the maximum depth from which water may be removed by evapotranspiration Where vegetation is present the evaporative depth should at least equal the expected average depth of root penetration The actual evaporative zone depth is slightly greater than this due to capillary action (Schroeder, 1988) An increase in evaporative zone depth produces an increase in evapotranspiration and generally a decrease in lateral drainage and percolation (EPA, 1991) Loamy or clayey soils in the Rocky Flats area with slopes less than 3 1, have an effective root depth of up to 60 inches (SCS, 1980) The main plant species on these soils consist of tall-prairie grasses western wheatgrass, blue gramma, green needlegrass, and little bluestem (SCS, 1993) HELP designates a value of 28 inches and 14 inches as a typical root depth value for a fair stand of grass and no vegetation, respectively, in Denver, Colorado For the purpose of this evaluation a conservative evaporative zone depth value of 18 and 14 inches was used to simulate poor vegetation and no vegetation, respectively

Evapotranspiration would likely decrease under the projected climate changes due to a decrease in solar radiation from increased cloud cover To simulate this effect the evaporative zone depth was decreased to a value of 12 inches

Maximum Leaf Area Index

Maximum leaf area index is the dimensionless ratio of the leaf area of actively transpiring vegetation to the nominal surface area of the land on which the vegetation is growing Typical values used in the HELP model (Schroeder et al, 1988) are

0 0 for bare grass,
1 0 for poor grass,
2 0 for fair grass,
3 3 for good grass, and
5 0 for excellent grass

As the leaf area index increases, the amount of evapotranspiration increases Given the precipitation values and the length of the growing season, the maximum leaf area index for

Denver, Colorado is 2 5, without irrigation A value of 1 0 was used as the maximum leaf area index for the poor grass scenario A value of 0 0 was used for no vegetation These are conservative estimates considering the maximum leaf area index value for Denver is about 2 5

A wetter climate would likely increase the abundance and diversity of plants capable of growing in the RFETS area Under the increased precipitation conditions a maximum leaf area index of 2 5 was selected This value is equivalent to the estimated leaf area index for Denver under present-day climatic conditions and therefore is conservative for simulating potential climatic change

Latitude

The latitude used for solar radiation data generation for normal conditions is 39 77° North, the latitude of Denver, Colorado There is not data available to support changing the latitude to reflect climate changes A sensitivity analysis was performed to measure the effects of latitude on the performance of the cover The results show that latitude had an insignificant effect on percolation through the cover For this reason the latitude used in the climate change simulation will remain the same as that used for normal conditions

A summary of the climate input parameters used in HELP are shown in Table IV 3-7

TABLE IV.3-7
SUMMARY OF CLIMATE INPUT PARAMETERS

Input Parameter	Normal Conditions			Climate Change Conditions
	Vegetation	No Vegetation	100-Year Storm	
Evaporative Zone Depth	18 inches	14 inches	18 inches	12 inches
Maximum Leaf Area Index	1 0	0 0	1 0	2 5

IV.3.1.3.4 Results of the HELP Model

The HELP model results are shown in Table IV 3-8 These results show that inclusion of the capillary break, drainage layer, and asphalt barrier in the final engineered cover significantly limits the amount of percolation through the final engineered cover Even for a 100-year storm event or when the precipitation is increased by 15, 200, and 300 percent under the possible climate change scenarios, the asphalt barrier minimizes the amount of percolation through the final engineered cover

TABLE IV.3-8
HELP MODEL RESULTS[1/]

	Percolation through 1000-year cover (with asphalt layer) (inches/year) and (ft^3/year)
Normal Conditions	0 0068 283
No Vegetation/ Normal Precipitation	0 0071 296
100 Year Storm Event/Normal Temperature and Normal Vegetation	0 0071 296
Climate Changes/ 15% Increase in Precipitation	0 0071 296
Climate Changes/ 200% Increase in Precipitation	0 0072 300
Climate Changes/ 300% Increase in Precipitation	0 0075 312

Note Volumetric infiltration rate (ft^3/yr) is dependent on the engineered cover area

1/ Percolation values were taken from the Average Annual Totals Section in the HELP model output

In general, modeling normal conditions of vegetation will decrease the amount of surface runoff and increase the amount of evapotranspiration, but tends to have little effect on the overall water balance (EPA, 1991) The results of the model runs support this finding The results indicate that vegetation does not appear to significantly affect percolation As mentioned earlier, HELP does not account for capillary flow The results of the "no vegetation" scenario may in fact be different and show that vegetation plays a more important role in reducing the amount of percolation if HELP accounted for this type of flow

The results of the HELP model indicate that the final engineered cover design will significantly reduce the amount of infiltration that percolates through the final engineered cover Under all scenarios, percolation through the final engineered cover is reduced to below 0 1 inches/year Leaching estimates show that an infiltration rate of $1x10^{-7}$ cm/s is sufficient to protect ground water The modeling results predict that the proposed final engineered cover will be effective at minimizing the amount of precipitation that infiltrates into the consolidated contaminated materials These results were used in the VLEACH model (Section 10 4) to assess whether the expected quantity of infiltration will result in a quality of leachate that will be protective of human health and the environment

IV.3.1.4 Waste Handling and Placement

Contaminated materials will be consolidated beneath the final engineered cover above the subsurface drain The different consolidated materials will consist of

- Soils,
- Liners,
- Processed sludge,
- Processed pondcrete, and
- Debris which can not be decontaminated

The consolidation of these various contaminated materials will be engineered to resist differential settlement and compaction, and to enhance the stability characteristics of the consolidated materials Soils from SEP 207-A and the 207-B series SEPs, crushed liners, processed sludge, and processed pondcrete will be blended together to form a homogeneous consolidated material that will be dispositioned upon the subsurface drainage layer The mixture will consist predominantly of soil such that compaction requirements can be achieved A homogenous mixture that is equally compacted will provide a stable base for the construction of the overlying final engineered cover and reduce the potential for differential settlement Strict construction procedures will be specified for the blending, disposition, and quality control of these contaminated materials Soils from SEP 207-C will be excavated, dispositioned above the mixed consolidated materials, and compacted These soils will be dispositioned separately from the blended materials because the mixing operation will occur in SEP 207-C prior to its excavation A trench will be excavated within the dispositioned and compacted SEP 207-C soils for the disposition of the debris that can not be decontaminated The trench will be filled with grout so that the void spaces caused by the size reduced debris are plugged The grouting will

minimize differential settlement Finally, the surface soils from areas adjacent to the SEPs will be excavated and dispositioned above the SEP 207-C soils in a thin layer These soils are dispositioned in a thin layer at the top since this soil will have a high organic content which may degrade and cause settlement Settlement of a thin layer will not impact the stability of the final engineered cover Additional details concerning the construction of the consolidated contaminated materials is presented in Section IV 6 5

IV.3.1.5 Design of the Subsurface Drainage Layer

As presented in Part III, Appendix D, the thickness of the vadose zone beneath the SEPs ranges from 0-20 feet with respect to the mean seasonal high ground water elevation The ground water elevation fluctuates seasonally Appendix III D provides modeling results indicating that if the ground water elevation were to rise in the future to saturate soils above the mean seasonal high ground water elevation, then contaminants could leach from the soils resulting in concentrations that would not be protective of ground water quality as calculated for an onsite resident at the IHSS boundary (toe of the final engineered cover) In order to mitigate the potential for ground water contamination that could result from a possible rise in the ground water elevation, DOE will excavate the contaminated soils, install a subsurface drainage layer, and consolidate the excavated soils with the liners, processed sludge and pondcrete, and debris beneath the final engineered cover and above the subsurface drainage layer

DOE estimated the conceivable distance that the ground water elevation could rise in order to determine the water removal efficiency of the subsurface drainage layer The maximum anticipated rise in ground water is 2 2 feet (Appendix III D) This value is used as the design basis for the subsurface drainage layer

Design Details of the Subsurface Drainage Layer

The subsurface drain is included within the final engineered cover design as a mitigative contamination control measure in the event that the ground water elevation rises above the mean seasonal high ground water elevation A subsurface drain system was selected as the preferred technology because it will operate passively if the mean seasonal high ground water elevation is exceeded A low permeability liner system was considered, but was not selected because it would require a leachate collection/detection system This would violate the regulatory requirements for a closure system that could function passively for a 1,000-year period Appendix III E presents a comparison between a subsurface drainage system and vertically installed hydraulic barriers (slurry cutoff walls), and justifies the selection of the subsurface drainage system

The base of the subsurface drain will be placed at the elevation of the mean of the seasonal high ground water elevation (Drawing No 51045-122) This system will remain dry throughout most of the year The drainage system will function only when the ground water elevation rises above the mean seasonal high ground water elevation Therefore, during some years it will function during the wet season, and other years it may not be required to function

It is anticipated that the system will only flow for a few weeks during years when the ground water elevation rises to a level greater than the mean seasonal high ground water elevation

The conceptual design of the subsurface drain layer consists of a uniform, 2 5-foot thick gravel layer with bottom elevations corresponding to the mean seasonal high ground water elevation The potential 2 2-foot rise in ground water will be contained within the gravel layer, which will drain to the ITS system through a system of subsurface gravel trenches Appendix III E presents information on the hydraulic effectiveness of this system Additionally, filter layers will be incorporated above and below the gravel layer to prevent clogging and migration of fine soil particles into the drainage gravel Filter fabrics will be installed above and below the gravel layer to ensure separation of materials during construction

IV.3.2 Building 788 and Ancillary Equipment and Debris

Building 788 is located within the boundaries of OU4 and must be dismantled prior to or along with implementation of the OU4 IM/IRA Building 788 (including ancillary equipment) is identified in the RCRA Part A application as Unit 21 and has been used subsequent to operation as a warehouse Building 788 operations were part of the "pondcrete" process which involved waste stabilization of a mixture of sludge removed from the RFETS SEPs and cement used for solidification RCRA Unit 48, located within Building 788, is identified as the pondcrete solidification process, and was used to treat waste containing both radiological and hazardous waste constituents (mixed waste) via solidification

Building 788 (including Units 21 and 48), although subject to the OU4 IM/IRA implementation activities, must be closed and managed according to the RCRA closure requirements The closure activities will comply with the requirements of the Colorado Hazardous Waste Act (CHWA) and RCRA, as well as the closure requirements for the SEPs as identified in the ARAR/TBC Compliance Demonstration Table (Table IV 11-1) As specified in 6 CCR 1007-3, 265 114, all contaminated equipment, structures, and soils must be properly disposed or decontaminated unless specified in 6CCR 1007-3, 265 197 Closure will be in accordance with regulations and standards for interim status units promulgated under applicable sections of 6 CCR 1007-3, 265, Subparts I and J, respectively Post closure provisions and requirements will not be imposed because the units are not being closed as a hazardous waste landfill

Any identified hazardous wastes and constituents will be removed from the areas in which Units 21 and 48 are located Remediation waste, including hazardous waste debris, will be managed in accordance with applicable RCRA requirements as stipulated in the Waste Management Plan (Section IV 4) It is proposed that remediation waste, both solid and hazardous waste, that cannot be effectively decontaminated from the closure of these units be consolidated within the OU4 CAMU

Contaminated debris and waste material (remediation waste) will be generated during the removal of Building 788 and the ancillary equipment (sludge processing and storage units,

RCRA Units 48 and 21, respectively) as part of the remediation of OU4 The contaminated debris/waste material that cannot be effectively decontaminated will be consolidated beneath the final engineered cover within the OU4 CAMU Reusable equipment is not considered waste and will therefore be segregated from the waste streams

IV.3.2.1 Building 964 and Ancillary Equipment and Debris

Building 964 is located within IHSS 176 (Operable Unit 10), and must be dismantled prior to or along with the implementation of the OU4 IM/IRA Building 964, located inside the protected area (PA) and east of SEP 207-B Center, consists of a wood frame structure covered with galvanized steel siding and a rolled asphalt roof The facility is identified in the RCRA Part A application as RCRA Unit 24 Building 964 originally served as a tool shed for the maintenance contractor In the mid 1980s, Building 964 was modified for use as a RCRA permitted unit for long term storage of low-level mixed waste Building 964 contains 2091 drums of low-level mixed waste and 17 cargo containers that currently store low-level mixed waste The drums and cargo containers will be removed from Building 964 for storage at an approved hazardous waste storage facility prior to the IM/IRA construction

Building 964, although subject to the OU4 IM/IRA implementation activities, must be closed and managed according to the RCRA closure requirements The closure activities will comply with the requirements of the Colorado Hazardous Waste Act (CHWA) and RCRA, and closure requirements for the SEPs as identified in the ARAR/TBC Compliance demonstration table (Table IV 11-1) As specified in 6CCR 1007-3, 264 114, all contaminated equipment, structures, and soils must be properly disposed of or decontaminated unless specified in the 6 CCR 1007-3, 265 197 (Closure and post-closure care) Closure will be in accordance with the regulations and standards for permitted facilities promulgated under 6 CCR 1007-3, 264, Subpart G Post Closure provisions and regulations will not be imposed because the units are not being closed as a hazardous waste landfill

Based on previously conducted radiological screening, Building 964 is assumed clean from a radiological perspective and does not have a history of contamination concerns Any identified hazardous wastes or constituents will be removed Remediation waste, including any identified hazardous waste debris, will be managed in accordance with applicable RCRA requirements as stipulated in the Waste Management Plan (Section IV 4) It is proposed that remediation waste from the closure of Building 964 (both solid and hazardous waste) that cannot be effectively decontaminated will be consolidated within the OU4 CAMU

Contaminated debris, rubble, and waste material may be generated during the removal of Building 964 as part of the remediation of OU4 Any contaminated debris/waste material that cannot be decontaminated for free-release, will be consolidated beneath the final engineered cover within the OU4 CAMU [Hence, building materials such as scrap metal, etc , which is not considered waste, will therefore be segregated from the waste streams for recycle or reuse]

IV.3.2.2 RCRA Units 21 and 48 Closure Sequence

The following discussion presents the engineering approach for closure of RCRA Units 21 and 48 The scope of the demolition is limited to the demolition and disposition of equipment and structures comprising RCRA Units 21 (Building 788) and 48 (pondcrete Solidification Process) It is anticipated that the closure, demolition, and disposition of the components will use commonly practiced engineering and dismantling techniques that will not pose unusual technical difficulties All equipment and structures will be demolished, staged, and dispositioned per Section IV 4 (Waste Management) All remaining concrete pads and soils will be addressed as described in Section IV 6 5 The closure sequence presented in this section is a preliminary planning sequence, subject to adjustment based on several factors such as available resources, technical feasibility, regulatory considerations, required control measures, and coordination with activities planned for OU4 remediation

Prior to any demolition efforts, all equipment and structures will be inspected to verify that all residual sediments, sludges, or free liquids have been removed In the event residuals are discovered, they will be removed, packaged, and shipped to a treatment, storage, and disposal facility (TSDF) Rain water collected in the clarifier, that meets the waste acceptance criteria, will be removed and transferred to an onsite wastewater treatment facility A sampling and analysis effort in conjunction with a regulated reuse and treatment evaluation will be conducted to strengthen segregation procedures that will be implemented during demolition and removal activities To determine which materials are recoverable, recyclable, or nonrecoverable, evaluation factors will be used which include (but are not limited to) economic considerations, available decontamination and/or treatment process options, volumes of secondary materials generated, and availability of disposition options Waste minimization considerations will be factored into the demolition sequencing evaluations It is assumed that interim staging areas within the area of the SEPs will be needed for debris segregation

Debris that is generated during the implementation of the removal activities will be managed in a manner consistent with the applicable requirements presented in the Waste Management Plan Section IV 4 The segregation strategy is to minimize or eliminate cross-contamination between debris during storage, and to manage the debris in a manner which facilitates its final disposition First-level segregation will require sorting based on waste type or form (i e , radiological waste, hazardous waste, mixed waste) Second-level segregation within the first-level categories may be required based on media type (e g , equipment, etc) with respect to potential future treatment and/or disposition options for that media

All equipment from RCRA Units 21 and 48 will be removed and staged within IHSS 101 (SEP 207-C is preferred) for the evaluation and implementation of waste management requirements, including size reduction Size reduction will involve dismantling to the extent practicable and cutting After size reduction, these materials will be further staged in SEP 207-C and await treatment and/or disposition beneath the final engineered cover Size reduction activities for contaminated materials will be conducted in Permacon® structures equipped with

portable high-efficiency particulate air (HEPA) filters to minimize the potential of releases to the environment

Throughout the closure activities, control measures will be in place to minimize the potential spread of contamination, protect the workers, the public, and the environment, and minimize airborne radiological and nonradiological contamination These measures will be implemented in the form of both engineered and administrative controls Typical engineered controls include physical barriers, containments, wetting agents, fixatives, filtration equipment, and sealants In addition to the engineering controls, administrative controls will also be implemented, including (but not limited to) controlling work area access/egress, establishing radiological control zones, monitoring personnel within and prior to exit of work zones, and monitoring the success of the engineered controls

Upon verification that all of the equipment is visually free of sediments, sludges, and liquids, the removal/demolition of RCRA Units 21 and 48 will be conducted sequentially by zone as shown on Drawing 51045-432 In addition, both before and after all materials and equipment have been radiologically surveyed, appropriate controls shall be used to prevent the spread of contamination Zone 1 includes equipment associated with RCRA Unit 48 situated on the northwest side of Building 788 This equipment includes a Morgan Mustang-Pumper, which is enclosed in an engineered building which will also be dismantled The cement mixer, cement storage silo, and propane storage tanks are likely to be removed prior to the initiation of RCRA closure activities Zone 2 includes a cement silo and its ancillary equipment located south of Building 788 (Section IV 6 5) Zone 3 contains the clarifier, its associated ancillary equipment, and the pugmill mixer Dismantled equipment from Zone 3 will be handled by the methods described previously

The completion of activities for Zones 1 and 2 will provide better access to SEP 207-C when transporting Zone 3 equipment to SEP 207-C for size reduction Additionally, removal of all major equipment and structures around Building 788 will increase the efficiency of the excavation and hauling activities involving SEP 207-C Prior to initiating the SEP 207-C soils excavation, demolition materials from Zones 1 through 3 will require relocation Certain materials will require unique handling and packaging prior to transport to the interim staging area(s) Loose materials will be controlled during transport to reduce the potential for contaminant release and migration Material/waste generated during the interim remedial action will be managed in accordance with the waste management criteria established in Section IV 4

Zone 4 includes Building 788 and support utilities Decommissioning of Building 788 will be performed in a systematic and controlled manner to enable these materials to be strategically situated under the final engineered cover for efficient and effective construction of the final engineered cover Non-destructive demolition techniques shall be employed to the extent practicable This involves effectively disassembling the building in a similar manner as it was erected All building materials will be segregated by shape (i e , flatwork and bulk)

IV.3.2.3 Building 964 Closure Sequence

The following discussion presents the approach for decommissioning of Building 964 The scope of the demolition is limited to demolishing Building 964 down to the concrete floor slab to allow for the IM/IRA Phase I closure of the SEPs The scope includes disposition of the debris, and waste materials in the OU4 CAMU or at the RFETS solid waste landfill It is anticipated that the closure, demolition, and disposition of the components will use commonly practiced engineering and dismantling techniques that will not pose unusual technical difficulties Building 964 will be demolished, staged, and dispositioned per Section IV 4 (Waste Management) The remaining concrete pad and associated soils will be addressed as described in Section IV 6 5 The closure sequence presented in this section is a preliminary planning sequence, subject to adjustment based on several factors such as available resources, technical feasibility, regulatory considerations, required control measures, and coordination with activities planned for OU4 remediation

Prior to demolition efforts, all waste storage drums, cargo containers, wood pallets, and miscellaneous items will be removed from the facility and monitored and cleared by RFETS Radiological Engineering before removal from the protected area All debris and waste materials generated during building removal will be sorted as follows

- Free release Items determined by radiological engineering to be free of contamination shall be recycled or disposed in the RFETS landfill

- Decontamination to Free release Items contaminated which can be decontaminated and then recycled or disposed in the RFETS landfill

- Contaminated Items determined by radiological engineering to be contaminated shall be sorted, stacked and stored for later incorporation under the OU4 CAMU

Additionally, to determine which materials are reusable, recyclable, or nonrecoverable, evaluation factors will be used which include (but are not limited to) economic considerations, available decontamination and/or treatment process options, volumes of secondary materials generated, ALARA (building materials generated from the demolition, and availability of disposition options Waste management considerations are factored into the demolition sequencing evaluations The debris and waste materials generated by the demolition may be staged in temporary laydown and sorting areas until ultimate disposition locations can be determined Contaminated materials will be staged within the CAMU Uncontaminated materials may be staged outside the CAMU

Debris that is generated during the implementation of the removal activities will be managed in a manner consistent with the applicable requirements presented in the Waste Management Plan Section IV 4 The segregation strategy is to minimize or eliminate cross-contamination between debris during storage (if required), and to manage the debris in a manner which facilitates its final disposition First-level segregation will require sorting based on waste

type and form (i e , radiological waste, hazardous waste, mixed waste) Second-level segregation within the first-level categories may be required based on media type (e g , equipment, etc) with respect to potential future treatment and/or disposition options for that media Building materials may be segregated by shape (i e , flatwork and bulk)

All debris and waste materials from Building 964 will be removed and staged for the evaluation and implementation of the waste management requirements, including size reduction Size reduction will involve dismantling to the extent practicable and cutting as required Following size reduction, these materials may be further staged in their temporary laydown areas and await treatment and/or final disposition determination Size reduction activities for contaminated materials (where contaminant release is a concern) will be conducted in Permacon® structures equipped with portable high-efficiency particulate air (HEPA) filters to minimize the potential of releases to the environment

Throughout the closure activities, control measures will be in place to minimize the potential spread of contamination, protect workers, the public, and the environment, and minimize airborne radiological and non-radiological contamination These measures will be implemented in the form of both engineered and administrative controls Typical engineered controls include physical barriers, containments and wetting agents, fixatives, filtration equipment, and sealants In addition to the engineered controls, administrative controls will also be implemented, including (but not limited to) controlling work area access/egress, establishing radiological control zones, monitoring personnel within and prior to exit of work zones, and monitoring the success of the engineered controls

During and following the interim remedial activities, certain debris and waste materials that is generated will require unique handling and packaging prior to their transport to the temporary laydown and staging area(s) Loose materials will be controlled during transport to reduce the potential for contaminant release and migration Debris and waste materials generated during the interim remedial action will be managed in accordance with the waste management criteria established in Section IV 4 The demolition activities will be performed in a systematic and controlled manner to enable the debris, rubble, and waste materials designated for disposal under the OU4 CAMU to be strategically situated under the final engineered cover for efficient and effective construction of the final engineered cover Non-destructive demolition techniques shall be employed to the extent practicable This involves effectively disassembling the building in a similar manner as it was erected

IV.3.2.4 Certification of Closure

As required by 6 CCR 1007-3, 265 115 (Certification of Closure), "within 60 days of completion of closure of each hazardous surface impoundment, waste pile, land treatment, and landfill unit, and within 60 days of the completion of final closure, the owner or operator must submit to the [CDPHE] by registered mail, a certification that the hazardous waste management unit or facility, as applicable, has been closed in accordance with the specifications in the approved closure plan The certification must be signed by the owner or operator and by an

independent registered professional engineer Documentation supporting the independent registered professional engineer's certification must be furnished to the [CDPHE] upon request until he releases the owner or operator from the financial assurance requirements for closure under 6 CCR 1007-3, 266 14 (Financial assurance for closure and or post-closure) "

The definition for "final closure", presented in 6 CCR 1007-3, 260 10, means the closure of all hazardous waste management units at the facility are in accordance with all applicable closure requirements so that hazardous waste management activities under Parts 264 and 265 of these regulations are no longer conducted at the facility unless subject to the provisions in Section 262 34 Since Units 21, 48, and 24 are not being closed as land disposal units, closure certification for these units is not required until all RCRA units at the RFETS are closed Due to the number of RCRA units at RFETS and the time period over which closure activities will be conducted, it was decided that a preliminary Certificate of Closure will be issued for Units 21, 48, and 24 following their closure as part of the OU4 IM/IRA A final Certificate of Closure will then be issued following the closure of the other hazardous waste management units at the RFETS which will include Units 21, 48, and 24 and all the other RCRA units undergoing closure The preliminary closure certification will be signed by the owner's representative, the operator's representative and an independent registered professional engineer

A certification statement will be provided to document that closure is completed in accordance with the provisions of the approved OU4 IM/IRA As back-up information to the certification statement, closure activities will be observed by the independent engineer and will be documented in a closure report The closure report will consist of the following

- Field logs describing major closure activities,
- Photographs,
- Waste analysis and characterization data, if required [NOTE Waste generated during remedial activities will be characterized and evaluated to determine hazardous waste streams pursuant to 6 CCR 1007-3, 261, and 262 11,
- Any agency correspondence describing closure agreements, and
- Other pertinent information which will provide a historical record for the closure activities including (but not limited to) records/documentation maintained for waste generation, classification, minimization, segregation, treatment, packaging, storage and manifesting for offsite transport to verify proper management and final disposition of the waste and equipment in compliance with the approved IM/IRA DD

The closure criteria and activities for waste management must be implemented to verify that closure is completed according to applicable requirements When closure is complete and certified, the units will be removed from the Part A Permit application Also, in accordance with 6 CCR 1007-3, 264 552, as part of the post-closure requirements, a notification to the

property deed will be provided to notify any potential purchaser of the property that the land has been used to manage hazardous waste

IV.3.3 Utilities Dispositioning

There are numerous utility lines throughout the OU4 area Some of the utilities will need to remain in service after closure of the SEPs If these utilities will be impacted by the SEP closure/remediation, they will be relocated Utilities that will be impacted by the final engineered cover that can be removed from service will be removed or closed in place Figure IV 3-12 provides a flow diagram that will be used to assess the removal or rerouting of all the utilities in the vicinity of the OU4 SEPs Drawing 51045-430 identifies and locates the utilities in the vicinity of the SEPs The following sections address how the utilities will be removed, rerouted, or closed in place

IV.3.3.1 Utilities Requiring Removal or Rerouting

There are several utilities that will remain in operation after closure of the OU4 SEPs Domestic cold water, raw water, storm drains, and telephone and electrical power will remain in service in and around the OU4 area, and will require relocation The following steps will be required to accomplish removal and rerouting

- Excavation of the buried utilities from the connection to the plantwide system to the farthest service point will be required Health and safety personnel will be present during excavation to provide both radiological health and safety evaluations All excavated materials will be laid in piles parallel to the excavation trench Excavation procedures will be specified in the project-specific health and safety plan

- Backfill materials from the existing trench will be removed along with the other excavated materials for consolidation under the final engineered cover

- If COC concentrations in the excavated material (i e , outside the final engineered cover) are above the PRGs, then excavation will continue until the soil concentrations are less than the vadose zone PRGs Contaminated soils will be contained and removed from the excavation area and dispositioned as contaminated media for consolidation beneath the final engineered cover

- Removal of each utility from the excavated area will require that appropriate methods be used for the specific conditions The type of material will dictate which dismantling method(s) are used Removal of existing utilities that require relocation would accomplish the following

  - No residual contaminants,
  - Require no provisions in cover design, and
  - Provide complete clean-site remediation of utilities materials

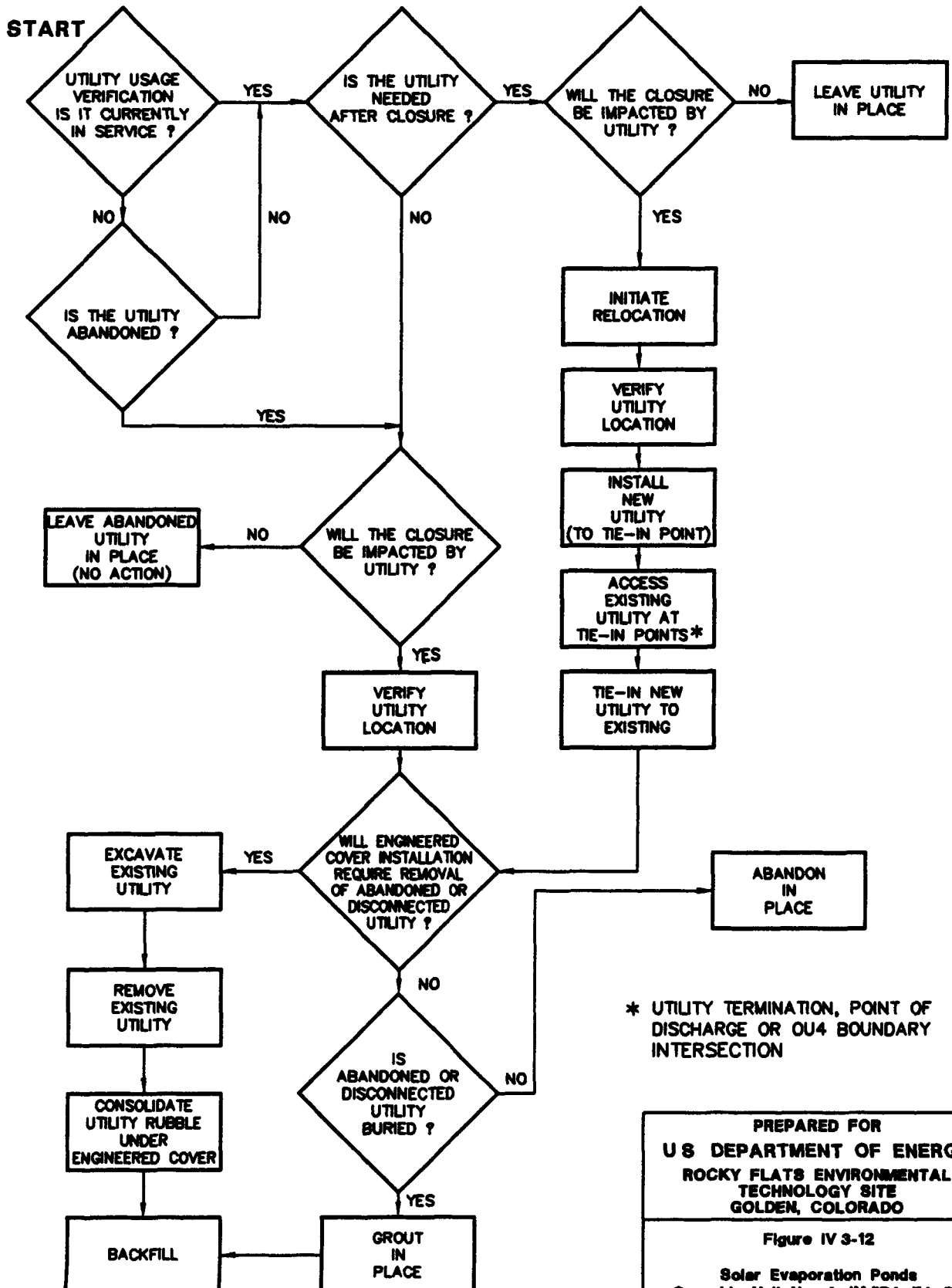


Figure IV 3-12

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Utilities Removal Logic Diagram

The following is a list of the construction material of the specific utilities and the appropriate dismantling procedure for each

Cement Asbestos Pipe

Cement asbestos pipe (CAP) is best removed in sections by dismantling at the bell and spigot joints Where this type of dismantling is not practical, wet-saw cutting would be the best approach Saw-cutting CAP will require that asbestos abatement procedures be used to contain the airborne materials resulting from removal of the CAP from the trench Workers will also have to follow the appropriate health and safety procedures for asbestos abatement

Vitrified Clay Pipe

As with CAP, vitrified clay pipe (VCP) is best removed in complete sections by dismantling at the bell and spigot joints However, in some cases, this may prove impractical One example would be if the excavated VCP is damaged In this case, the pieces will be removed Large pieces can be broken into manageable sizes for containerization or transport The weight of VCP may require that rigging and overhead machinery be used to remove the pipe from the trenches

Cast Iron, Steel, and Stainless Steel Piping

Cast iron (CI), steel (STL), and stainless steel (SS) piping could be dismantled by sawing or mechanical cutting Where access is available, pipe cutters can be used on pipe up to 4 inches in diameter (nominal) Those pipes that do not permit ample access for a pipe cutter or have diameters greater than 4 inches will require saw-cutting The cutting area will be lined with plastic sheeting to collect the metal fines and prevent any mixing with the surrounding excavated materials

Polyvinyl Chloride Pipe

Polyvinyl chloride (PVC) pipe will be saw-cut into manageable lengths as required The sawing can be accomplished in the excavations as the piping is exposed Plastic sheeting will be placed in the excavation to contain the saw cuttings

Corrugated Metal Pipe

Corrugated metal pipe (CMP) will be removed by means of saw-cutting However, care will be taken to determine the presence of sediments in the bottom of the CMP An inspection hole will be cut in the top prior to the complete cutting of each section A health and safety survey of any sedimentary materials will be made prior to exposure of those materials when the pipe is opened Since dismantling at the original joints of the CMP could be difficult, the

sections will be cut to manageable lengths for handling and containerization A tarpaulin will be placed in the excavation to contain saw cuttings

IV.3.3.2 Utilities Suitable for Closure In-Place

In-place closure will leave the piping in the OU4 area intact The only isolation technique available would be permanent closure of existing valves that feed the pipe lines below the cover Existing valves will be permanently disabled by removing the handles and welding the shafts in the closed position Access to these valves may also be eliminated by filling the open valve box with grout The final engineered cover may then be installed above the grouted valve box or disabled valves and piping

Capping the piping at the OU4 boundaries would effectively isolate all of the piping within the OU4 boundary from the rest of the RFETS operations Each pipe closed in-place would be excavated at the OU4 boundary and the point of termination in the OU4 area The exposed pipe will be cut and a section removed to allow for installation of a permanent pipe cap The pipe caps will be made of the same material as the pipe being capped All pipe caps will be permanently installed for each piping material type as follows

- STL and SS - Butt-welded or socket-welded pipe cap fittings,
- CI - Material-transition to PVC and install a solvent-glued and back-welded PVC pipe cap or a fabricated flat-end plate welded in place,
- PVC - Solvent-glued and back-welded pipe cap,
- VCP - Bell and spigot - VCP fitting with end plugs installed and grouted in place or transition to PVC with a solvent-glued and back-welded pipe cap, and
- CMP - Fabricated end-plate welded in place or transition to fiberglass and installation of fiberglass reinforced plastic (FRP) end cap with catalyzed resin and woven fiberglass wrapping

Grouting the piping at the OU4 boundaries and the points of termination is an alternative method to capping An inert nonshrinking Portland cement-based grout would be used Each end of the pipe section to be grouted would be excavated and exposed A standpipe would be installed at each end for filling The grout could then be pumped into the pipe from one of the exposed ends until flow was seen rising in the opposite standpipe Grout spill control/containment should be provided for grout that may have contacted hazardous materials in the piping The standpipes would then be cut to below grade and the excavations at both ends filled with grout to encapsulate the standpipes and provide a barrier at each end of the pipe Drawing 51045-431 provides a detail for the grouting design Grouting underground utilities is desirable because it would

- Completely isolate the utility and backfilled trenches,
- Provide long-term structural integrity without appreciable degradation, and
- Prevent any future exposure or tampering

IV.3.4 Power Modification Request and Power Usage Survey

A power modification request (PMR) will be required to identify both the electrical services which will be disconnected and no longer needed and those services requiring relocation for continued service or new service requirements associated with the closure/remedy Prior to processing the PMR, a power usage survey will be conducted This survey will be performed as a component of the utility location verification work plan discussed in Section IV 6 2 The PMR will include provisions for electrical requirements associated with post-closure monitoring systems Part V presents the conceptual design for the post-closure monitoring system

IV.3.5 Sludge Processing

A design is currently underway to process sludges from the OU4 SEPs and the 788 clarifier The sludges have been removed from the SEPs and the clarifier and are being stored on an interim basis in 66 tanks on the 750 pad Each of the interim storage tanks has a nominal 10,000-gallon capacity There are approximately 660,000 gallons of sludge in the interim storage tanks Some commingling of sludge has occurred in the storage tanks during the transfer operations form the SEPs The objective is to remove the SEP sludges from the interim storage tanks and process these wastes to satisfy the Waste Acceptance Criteria (WAC) as presented in IV 2 3 for placement beneath the final engineered cover The sludges will be removed from the tanks, processed with a cementicious mixture to absorb free moisture, immobilize contaminants and destroy pathogens and gas-producing micro-organisms It is assumed that sand will be added as the bulking agent The processed sludge may be mixed with OU4 soils to produce a particulate waste form

The processed sludge will be staged in closed containers on the Pad 750 while tests are conducted to confirm compliance with the WAC Upon satisfying the WAC, the processed sludge will be transported to the OU4 SEPs on an as-needed basis for consolidation beneath the final engineered cover

The sludge from SEPs 207-A and the 207-B Series SEPs consists of settled solids in a liquid phase The settled solids occupy approximately 90 percent of the tank volume Free water was decanted off of the settled sludges in the tanks to reduce the volume in storage The settled sludges are expected to contain approximately 16 percent solids and have a high viscosity The free liquid phase contains some dissolved salts

The sludge from SEP 207-C has unique characteristics due to the nature and source of the original wastes deposited for evaporation in SEP 207-C The liquid phase of the sludge is a saturated or near-saturated brine, with sodium and potassium the predominant cations and nitrate, chloride, and sulfate the predominant anions Significant concentrations of heavy metals

are present The brine layer was stratified in SEP 207-C, with lower Total Dissolved Solids (TDS) and specific gravity values near the pond surface, and higher TDS and specific gravity values at depth The salinity of the brine layer was a function of precipitation, evaporation, and temperature The TDS of the brine layer ranged from 5 8 to 42 9 percent by weight based on the data collected from the waste characterization study, the treatability study, and a sampling effort to characterize stratification of the brine The specific gravity of the sludge ranged from 1 042 to 1 378 The stabilization treatability study showed that the samples of SEP 207-C brine were saturated at approximately 35-40% TDS at room temperature. Beneath the brine layer was a precipitated/crystallized salt layer Brine salt concentration and temperature influenced the thickness of this layer in SEP 207-C sludge Beneath the salt layer is a solids layer comprised of fine-grained material with up to 15 percent biological organic content

The OU4 SEP sludge process shown on Figure IV 3-13 will consist of the following unit operations

- Transfer of the SEP sludges from the interim storage and sludge feed tanks to process equipment
- Storage and feeding of treatment additives
- Mixing/blending processing of SEP sludges with additives
- Processed sludge storage and testing
- Processed sludge transfer to OU4 closure area

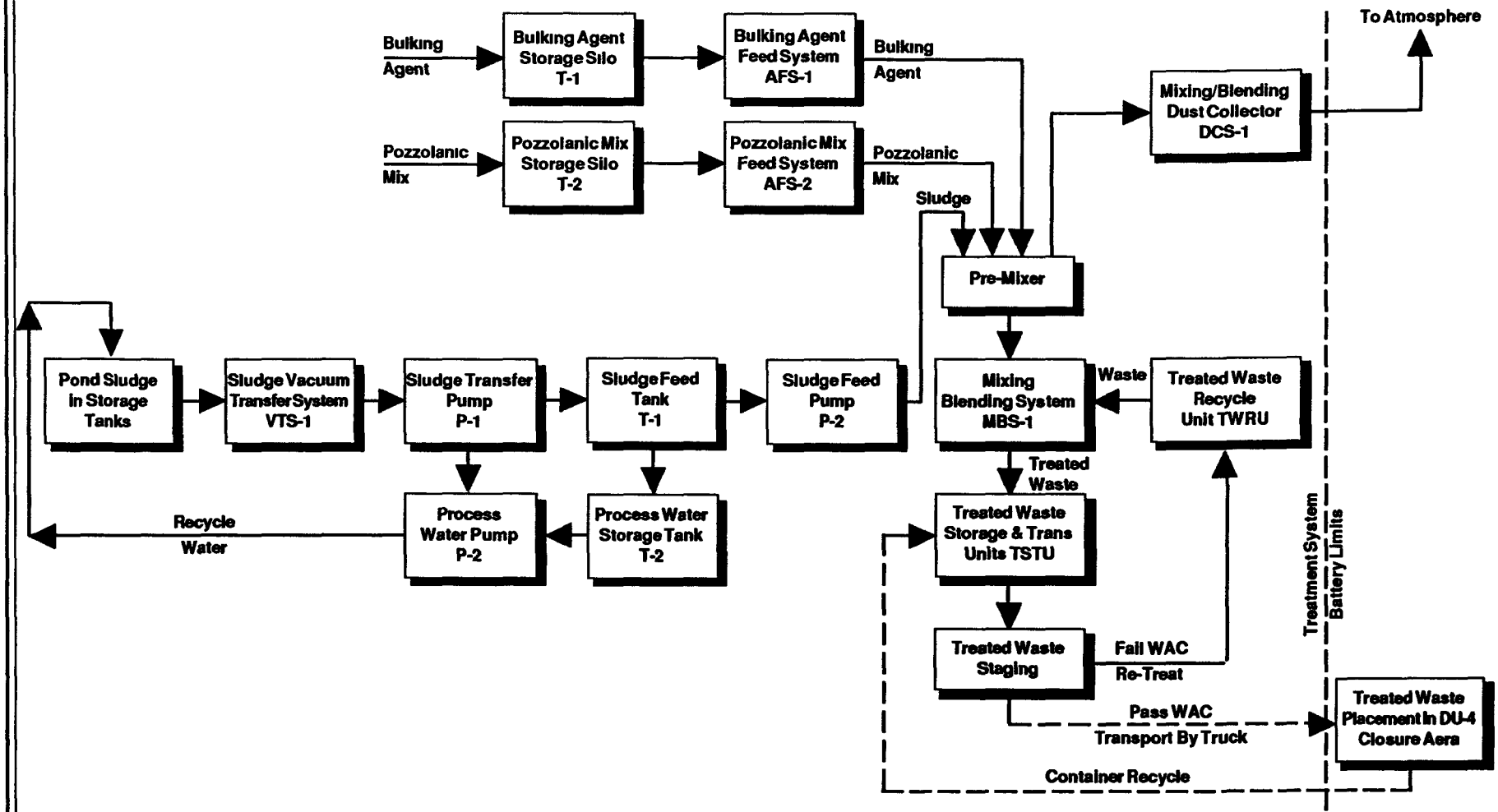
The above operations will be performed with self-contained, skid-mounted, pre-piped, and pre-wired packaged units Wherever possible, these units will be mobile and will utilize standard "off-the-shelf" equipment In addition, a number of the equipment modules (tanks, agitators, pumps, etc) constructed earlier for the SEPs 207-A, 207-B Series, and SEP 207-C cement stabilization systems will be used where applicable Standard processing equipment will be modified, as necessary, to conform to the applicable RFETS Health & Safety and Environmental Standards

Containers for the transport of the processed sludge will be covered to prevent air emissions and loss of material during their transfer to OU4 Once the containers have been emptied, they will be returned to their respective unit operations for reuse

IV.3.5.1 Sludge Transfer and Feed

The sludges from the five SEPs and Building 788 Clarifier will be removed from the interim storage tanks by one Sludge Transfer Unit (STU) and fed to the treatment process by one Sludge Feed Unit (SFU)

There are several methods available for removing the sludges from the storage tanks (e g , semi-portable vacuum system, vacuum truck, submersible slurry pumping, etc) The STU described below is based on a semi-portable vacuum system because it offers the following advantages



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GOLDEN, COLORADO

Figure IV.3-13

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Sludge Processing
Block Flow Diagram

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- It can be located closer to the storage tanks than a vacuum truck,
- It can be emptied and cleaned between batches more easily than a vacuum truck,
- It provides a greater suction head than a vacuum truck,
- It can remove the contents of the tanks more thoroughly than a submersible slurry pump

The STU consists of a sludge vacuum transfer system (VTS-1), a sludge transfer Pump (P-1) and a sludge transfer flow system (FS-1) The Sludge Vacuum Transfer System includes a vacuum pump and cone-bottom discharge hopper The vacuum pump will be used to transfer the pond sludges from the interim storage tanks into the discharge hopper The suction end of the vacuum hose will be introduced through the manways at the top of the tanks and extended into the sludge The position of the hose end will be carefully controlled manually to prevent aspiration of air into the suction system Any liquid which decants from the sludge will be collected and recycled, as necessary, to fluidize the sludge and to rinse the tanks The discharge hopper will be fully enclosed and will include a venting system equipped with a HEPA filter to treat the pressurized air discharge from the vacuum system

The sludge collected in the discharge hopper will be transferred to the SFU by a variable speed, positive displacement, progressive-cavity pump (P-1) and slurry transfer line The transfer line will consist of a high pressure rubber hose system with quick-disconnect fittings to facilitate installation and removal

The SFU consists of a sludge feed tank (T-1), a mixer (M-1), a process water storage tank (T-2), a sludge feed pump (P-2), a process water pump (P-3), and a sludge feed flow system (FS-2) The sludge feed tank is cone-bottomed and will be used to blend and decant the SEP sludge prior to treatment The sludge will be fed from the sludge feed tank to the treatment process by the variable-speed progressive-cavity, positive-displacement sludge feed pump Free water decanted in the Sludge Feed Tank and fresh make-up water, if required, will be stored in the process water storgage tank and returned to the STU by the centrifugal process water pump and flexible hoses for sludge dilution and/or tank rinsing

Removal of the SEP sludges from the interim storage tanks with the STU will be a manually-controlled operation at the STU control panel The volume of sludge removed will be measured by determining depth of liquid in the discharge hopper Transfer of the pond sludges from the discharge hopper to the SFU will also be a manually-controlled operation at the STU control panel The flow of pond sludges transferred to the SFU will be measured and indicated by the sludge transfer flow system and controlled by manually adjusting the variable speed drive of the sludge transfer pump

Feed of the SEP sludges to the treatment process by the SFU will be a manually-controlled operation at the SFU control panel The flow of sludges fed to the treatment process will be measured and indicated by the sludge feed flow system and controlled by manually adjusting the variable speed drive of the sludge feed pump

Grab samples of the removed sludge will be collected at the rate of two samples per interim storage tank These samples will be field-analyzed for percent moisture content Results of these field analyses will be used to adjust the feed rate of sludge, and/or the feed rates of additive(s), to the process system

Equipment required for sludge processing will be provided with secondary containment Secondary containment will not, however, be required for sludge additives or the resulting processed sludge Sludge feed tanks will be emptied prior to weekends, holidays or extended downtime

The sludge collected in the discharge hopper of the STU will be transferred to the sludge feed tank of the SFU by a progressive-cavity discharge pump and slurry transfer line, as described earlier

IV.3.5.2 Process Additives Storage and Feed

The process additives will be stored and fed by two additive storage and feed units (ASFUs) Each ASFU will consist of a storage silo (T-3 for bulking agent, T-4 for pozzolanic agent) and an additive feed system (ASF-1 for bulking agent, ASF-2 for pozzolanic agent) Additives will be used to blend with the SEP sludges and produce a friable mix Although treatability study testing will be required to confirm the nature and quantity of the additives to be used, it is likely that a dry bulking agent such as sand will be added as well as a mixture of Portland cement and lime A bulking agent will be added in sufficient quantity to impart a friable texture to the processed sludge It is assumed that sand will be added as the bulking agent in a sand-to-sludge ratio of 2 5 1 by volume This assumption will be finalized during the detailed title design process Lime will be added to the sludge to raise the pH to levels sufficient to kill pathogens and gas-producing microorganisms associated with the SEP sludges An added benefit of lime addition is the additional absorption of moisture The amount of lime required for both pathogen/micro-organism destruction and for moisture control will be determined during the treatability study Lime will be added to the sludge in quantities sufficient to achieve a pH of approximately 12 in the processed sludge, and control the moisture content of the waste It is assumed that Portland Type II cement and hydrated lime [$Ca(OH)_2$] will be used, at a rate of about 0 5 tons of cement/lime mix per wet ton of SEPs 207-A and 207-B sludge, and at the rate of about 260 pounds of cement/lime mix per dry ton of Pond 207-C sludge These assumptions will be validated during treatability studies that will be performed as a component of the detailed Title design process

Additives such as drying agents (e g , calcium chloride), silica gel, pozzolanic agents, (e g , fly ash), and/or bulking agents, (e g , bentonite), may be required, depending the on results of treatability testing The process additives will be delivered to the treatment site by bulk hopper truck and stored in the storage silos The transfer from the hopper truck to the storage silo will be performed by a standard commercial pneumatic transport and delivery system which is part of the bulk hopper truck unloading system The storage silos will be equipped

with a passive venting and dust collection system which will control any emissions during delivery or operations

The additives will be fed to the treatment process by the additive feed systems Each additive feed system will consist of a rotary valve feeder, a weigh-belt conveyor, and a screw conveyor The additive will be discharged onto the weigh-belt conveyor by the rotary valve feeder and the weigh-belt feeder will measure and control the delivery rate of the rotary valve feeder The controlled amount of additive will then be delivered to the feed point of the treatment process by the screw conveyor

Transfer of the treatment additives from the bulk delivery truck to the storage silo will be a manually-controlled operation The truck-mounted transfer air blower will be operated by the truck driver

The amount of additive in the storage silo will be measured and indicated by level-sensing devices High- and low-level conditions inside the storage silo will be alarmed

Operation of the additive feed systems will be a manually-initiated and semi-automatically-controlled operation The rotary valve feeder, weigh-belt conveyor, and screw conveyor will be manually controlled at the ASFUs control panels The additive feed rate will be automatically controlled to a manually-set rate by the weigh-belt conveyor which will regulate the operational speed of the rotary valve feeder and screw conveyor

IV.3.5.3 Mixing/Blending Process

The mixing/blending treatment of pond sludges with additives is performed in one Mixing Treatment Unit (MTU) The MTU consists of a mixing/blending system (MBS-1), a treated waste container jockey system (JS-1), and a mixing/blending dust collector system (DCS-1) The process consists of mixing/blending the pond sludges with the process additives (sand and cement/lime mix) as necessary to produce a processed sludge that satisfies the WAC

The mix/blending system includes a pre-mixer, a twin-shaft pug-mill, and a covered belt-type conveyor with shrouded discharge chute The SEP sludge is first blended in the pre-mixer with the pozzolanic agent mix to maximize cement and lime hydration The combined SEP sludge and pozzolanic agent mix is then blended with the bulking agent in the pub mill The processed sludge is transferred from the pug mill to a roll-off-type container by the belt conveyor and discharge chute

The bulking agent adsorbs a portion of the free moisture contained in the SEP sludge and increases its cohesiveness The cement/lime mixture binds the SEP sludge particles and absorbs any residual free moisture in addition to serving as a biocide The character of the processed sludge is presumed to be similar to a friable soil It will have no free liquid (estimated maximum moisture content of 20 percent by weight) and should be highly resistant to dust generation during handling (estimated minimum moisture content of 15 percent by weight)

The treated waste container jockey system slowly moves the treated waste container along a short length of track with a winch and pulley system to evenly distribute the processed sludge in the treated waste container

Dust generated by the operation of the mixing/blending system will be collected by the mixing/blending dust collector system This system consists of a baghouse-type dust collector, an exhaust blower, and an exhaust HEPA filter Dust emissions are transported through the baghouse-type collector by the exhaust blower The baghouse-type collector removes the majority of the dust contained in the exhaust airstream and any residual dust is removed from the discharge of the exhaust blower by the HEPA filter Excess dust accumulated in the baghouse collector is periodically removed for re-processing through the MTU

The treatment of the SEP sludges by mixing/blending with additives will be manually-controlled operation Operational control of the mixing/blending system equipment will be conducted manually at the MTU control panel The rate of production of processed sludge will be controlled by the operational speeds of the pug mill and belt conveyor, and by the feed rates of the sludges and treatment additives These processing rates will be based on the free water content of the sludge and on the treatment parameters developed from the treatability test results The operational speeds of the pug-mill and belt conveyor will be manually adjusted by the variable-speed control located on the MTU control panel

IV.3.5.4 Processed Sludge Storage and Testing

The processed sludge will be stored and tested in eight treated waste storage and transport units (TSTUs) The processed sludge will be discharged from the mixing/blending system belt conveyor directly into one of the TSTUs Each TSTU consists of a roll-off-type container equipped with a removable top cover, an end-dump gate, and bottom wheels for movement on the tracks of the MTU's treated waste container jockey system When filled, the top cover is placed on the TSTU and it is moved away from the loading point to permit introduction of an empty TSTU The full TSTUs will be moved to an area of the Pad 750, or other suitable location, to be staged/stored for curing purposes Staging of processed sludge will also provide a surge or buffer capacity between the operating requirements and schedule of the process system and those of SEP closure contractor It is anticipated that eight TSTUs of processed sludge will be constantly staged representing about two days production from the MTU

Routine testing of the staged processed sludge will be performed as previously discussed In the unlikely event that the contents of a TSTU does not satisfy the WAC, re-treatment will be required Non-attainment of the WAC may result from physical/chemical changes in the SEP sludges

In the event that the contents of a TSTU fails to meet the WAC, the off-specification treated waste will be removed from the TSTU and returned to the MTU's mixing/blending system by a treated waste recycle unit (TWRU) featuring a portable vacuum system similar to that used as part of the STU for removal of the SEP sludges from the interim storage tank In

the MTU's mixing/blending system, the off-specification treated waste will be mixed with extra bulking agent and/or pozzolanic agent mix to meet the WAC

The transfer, storage, and testing of treated waste in the TSTUs will be a manually-controlled operation Operational control of the processed sludge transfer and storage will be performed by regulating the traffic of TSTU tractor trucks between the MTU, the processed sludge staging/storage area, and the SEP closure area

Samples of the processed sludge will be collected from the TSTUs at the staging/storage area after completion of the curing period The processed sludge samples will be field-tested for compliance with the WAC In particular, these field tests will verify that the treated waste samples pass the Paint Filter Liquids Test (SW 9095) and that the pH of the processed sludge is at least equal to the value determined from the treatability study as necessary for the destruction of pathogens and gas-producing microorganisms

IV.3.5.5 Processed Sludge Transfer to OU4

The processed sludge will be transferred to the OU4 closure area in the same TSTUs as used for staging and storage Once the processed sludge has been removed from the TSTUs at the SEP closure area, the empty TSTUs will be returned to the MTU to receive additional processed sludge

Transportation of the processed sludge to the OU4 SEP closure area will be controlled by regulating the traffic of TSTU tractor trucks between the processed sludge staging/storage area and the SEP closure area

IV.3.6 Pondcrete Processing

A design is also underway to develop a process to treat pondcrete from the OU4 SEPs The pondcrete is being stored in approximately 8,200 triwall containers and in 20 to 30 half-crates and drums Each triwall has a nominal volume and weight of about 14 cubic feet and 1,300 pounds, respectively Approximately 2,600 of the triwalls have been overpacked in metal containers at two or three triwalls per container The pondcrete is currently in interim storage in Tents 8 through 11, located on Pad 904 The objective of the current initiative is to remove the pondcrete from Pad 904 and process these wastes to satisfy the WAC as presented in IV 2 3 for placement beneath the final engineered cover

This pondcrete will be removed from storage, size-reduced to 0 5-inch or smaller, treated with a mixture of lime and cement to adsorb any free moisture and destroy any pathogens or gas-producing micro-organisms, and mixed with a bulking agent such as sand or other additive to produce a friable treated waste The pondcrete size reduction and treatment system will shown on Figure IV 3-14 consist of the following unit operations

- Transfer of the pondcrete from interim storage to size reduction and processing

- Storage and feeding of process additives
- pondcrete size reduction and mixing/blending with treatment additives
- Processed pondcrete storage and testing
- Processed pondcrete transfer to OU4
- Equipment decontamination and decommissioning

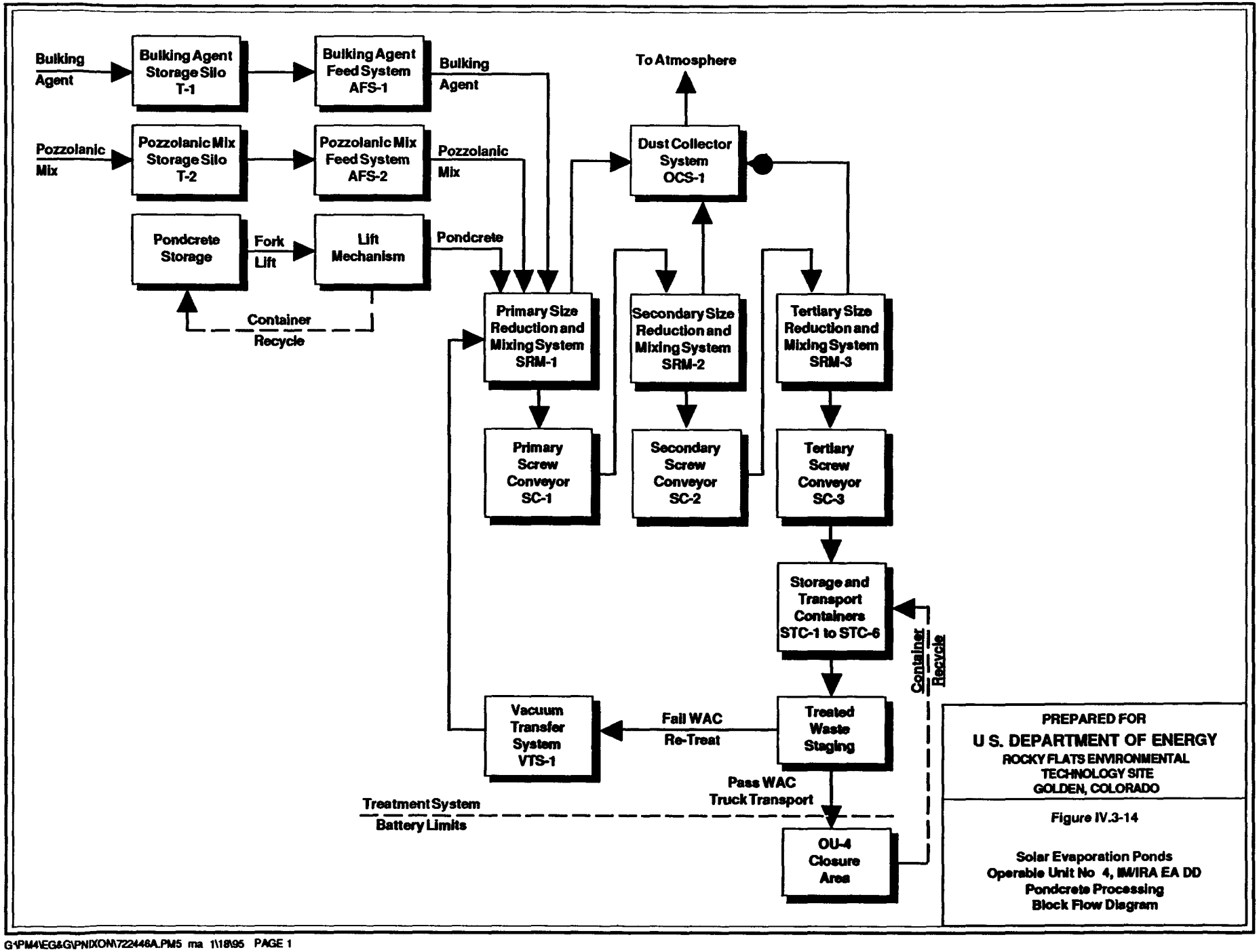
IV.3.6.1 Transfer of pondcrete

The pondcrete triwalls not already in metal containers will be placed into new re-usable metal containers As required, a drying agent will also be added in each metal container to adsorb any free liquid which may be released from the triwalls As a part of this operation, storage of the existing and new pondcrete metal containers and pondcrete half-crates will be consolidated inside Tents 8, 9 and 10

The new and existing pondcrete metal containers and pondcrete half-crates will be transferred by fork-lift trucks from temporary storage in Tents 8, 9, or 10 to the size reduction and treatment unit located in Tent 11 It is expected that approximately three metal containers per hour will be transferred to the pondcrete size reduction and treatment system At the size reduction and treatment unit, the metal containers or half-crates will be deposited onto a lifting mechanism (LM-1) located at the foot of the primary size reduction and mixing unit This mechanism will lift the metal container or half-crate and unload either the container's contents or the entire half-crate into the feed hopper of the primary size reduction and mixing unit (SRM-1) The empty metal container will then be returned to the temporary storage area (Tents 8, 9 and 10) Grab samples of the pondcrete waste will be collected periodically and visually evaluated for cohesiveness and field-analyzed for percent moisture content

IV.3.6.2 Storage and Feeding of Treatment Additives

The treatment additives will be stored and fed by two additive storage and feed units (ASFUs) Each ASFU will consist of a storage silo (T-1 for bulking agent, T-2 for pozzolanic agent) and an additive feed unit (ASF-1 for bulking agent, ASF-2 for pozzolanic agent) Additives will be blended with the pondcrete as part of the size-reduction process to produce a friable mix Although treatability study testing will be required to confirm the nature and quantity of the additives to be used, it is likely that a dry bulking agent such as sand will be added as well as a mixture of Portland cement and lime Bulking agent will be added in sufficient quantity to adsorb free moisture and impart a friable texture to the treated waste It is assumed that sand will be added at the rate of about 0 74 tons of sand per wet ton of pondcrete The cement and lime mixture will be added in quantities sufficient to complete the adsorption of free moisture and achieve a pH of approximately 12 in the treated waste to destroy any pathogens and gas-producing micro-organisms that may be present It is assumed that a mixture of Portland Types I and II cement and hydrated lime [$Ca(OH)_2$] will be added at the rate of about 0 6 tons of cement/lime mixture per wet ton of pondcrete



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Other additives such as drying agents (e g , calcium chloride), silica gel pozzolanic agents, (e g , fly ash), and/or bulking agents, (e g , bentonite), may also be required, based on results of treatability testing The treatment additives will be delivered to the treatment site by bulk hopper truck and stored in the storage silos The transfer from the hopper truck to the storage silo will be performed by a standard commercial pneumatic transport and delivery system which is part of the bulk hopper truck unloading system The storage silos will be equipped with a passive venting and dust collection system to control any emissions during delivery or operations

The additives will be fed to the size reduction and treatment process by the additive feed systems Each additive feed system will consist of a rotary valve feeder, a weigh-belt conveyor, and a screw conveyor The additive will be discharged onto the weigh-belt conveyor by the rotary valve feeder and the weigh-belt feeder will measure and control the delivery rate of the rotary valve feeder A controlled amount of additive will then be delivered to the primary size reduction and mixing system by the screw conveyor

The amount of additive in a storage silo will be measured and indicated by level-sensing devices High and low-level conditions inside the storage silo will be alarmed

The additive storage and feed systems will be a manually-initiated and semi-automatically-controlled operation The rotary valve feeder, weigh-belt conveyor, and screw conveyor will be manually controlled at the system's control panel The additive feed rate will be automatically controlled to a manually-set rate by the weigh-belt conveyor which will regulate the operational speed of the rotary valve feeder and screw conveyor The quantity of treatment additive delivered to the primary size reduction and mixing system will be controlled by adjusting the operating time of each additive feed system

IV.3.6.3 Pondcrete Size Reduction and Treatment

The size reduction of the pondcrete and the treatment of the size-reduced waste by mixing with additives will be performed in three stages by a size reduction and treatment unit (SRTU) The SRTU will consist of one primary size reduction and mixing system (SRM-1), one secondary size reduction and mixing system (SRM-2), one tertiary size reduction and mixing system (SRM-3), three (primary, secondary, tertiary) screw conveyors (SC-1 through SC-3), one treated waste container jockey system (JS-1), and one dust collector system (DCS-1)

The treatment process will consist of progressively reducing the particle size of the pondcrete and trash (plastic wrap and pallets), first to minus 6-inch, then minus 1-inch, and finally to minus 0 5-inch, and of mixing the size-reduced pondcrete and trash with the treatment additives (sand and cement/lime mix) It is assumed that all of the treatment additives will be fed into the primary size reduction and mixing process to insure optimum blending of the waste with the additives and to take maximum advantage of the drying characteristics of these additives Provision will be made in the design of the system to allow multiple additive feed points at the secondary and tertiary size reduction and mixing stages

The primary size reduction and mixing unit will be a screw-auger type shredder equipped with a hydraulically-operated bottom trap-door to retain the materials being shredded and blended within range of the screw-augers and insure optimal size reduction and blending Size reduction is achieved primarily by the "scissoring" cutting action of the helixes of the screw-augers bearing against each other The screw-augers also crush the material between them and against rigid baffles located on the wall of the feed hopper The action of the rotating screw-augers also provides for mixing of the size-reduced pondcrete with the treatment additives In the primary size reduction and mixing system the contents of one pondcrete metal container, including plastic wrapping and wooden pallets, or of one pondcrete half-crate, will be reduced in size to 6-inch or less and blended with a measured amount of treatment additives as determined from treatability testing and adjusted in response to field observations

Once the primary size reduction and mixing operation is complete, as verified by visual observation, the bottom trap-door of the primary size reduction and mixing system will be opened and the shredded and the size-reduced and blended materials will be released into the primary screw conveyor which will transfer it to the secondary size reduction and mixing system

The secondary size reduction and mixing system will be a ring-and-pick type shredder with counter-rotating shafts Size reduction will be achieved by the picks of one shaft grabbing the material to be shredded and shearing it against the rings of the adjacent shaft or stationary plates mounted on the side of the shredder The counter-rotating action of the shredding shafts also achieves a reasonable degree of blending In the secondary size reduction and mixing system the size of pondcrete discharged from the primary size reduction and mixing system will be reduced to 1-inch or less and the waste will be blended with the process additives The discharge of the secondary size reduction and mixing system will be collected into the secondary screw conveyor which will transfer it to the tertiary size reduction and mixing system

The tertiary size reduction and mixing system will also be a ring-and-pick type shredder It will be identical to the secondary size reduction and mixing system, except that it will be designed to reduce the size of the pondcrete waste to 0 5-inch or less

Throughout the three stages of the SRTU, the process of mixing the pondcrete with the treatment additives will be one of homogenization and blending, as opposed to high-intensity mixing The bulking agent will adsorb free moisture and impart friability to the treated waste The pozzolanic agent mix will bind the pondcrete particles and absorb residual free moisture in addition to serving as a biocide The character of the treated waste is presumed to be similar to a friable soil It will have no free moisture (estimated maximum moisture content of 20 percent by weight) and should be dust free (estimated minimum moisture content of 10 percent by weight)

The discharge of the tertiary size reduction and mixing system will be collected into the tertiary screw conveyor which will transfer it to the treated waste container jockey system The treated waste container jockey system will slowly move the treated waste transport container

along a short length of tracks with a winch and pulley system to evenly distribute the treated pondcrete inside the container

Each size reduction and mixing system will be enclosed and vented to a dust collector system This system will consist of a baghouse-type collector, an exhaust blower, and an exhaust HEPA filter Dust emissions will be aspirated from the size reduction and mixing systems and forced through the baghouse collector by the exhaust blower The baghouse collector will remove the majority of the dust and any residual dust will be removed from the discharge of the exhaust blower by the HEPA filter Excess dust accumulated in the baghouse collector will be periodically removed for re-processing through the size reduction and treatment process

The effectiveness of the pondcrete waste size-reduction and treatment process will be visually checked at all three stages In particular, frequent observations will be made of the contents of the primary size reduction and mixing system to determine when proper size reduction and mixing has been achieved so that a batch may be released for processing through the secondary and tertiary size reduction and mixing stages

IV.3.6.4. Processed Waste Storage and Testing

The processed pondcrete will be stored, tested, and, if necessary, recycled in a treated waste staging and testing unit (TSTU) The TSTU will consist of six storage and transport containers (STC-1 through 6) and one vacuum transfer system (VTS-1)

The processed pondcrete will be discharged from the tertiary screw conveyor directly into one of the storage and transport containers Each container will be the roll-off type equipped with a removable top cover, an end-dump gate, and bottom wheels for movement on the tracks of the treated waste container jockey system When filled, the top cover will be placed on the storage and transport container and it will be moved away from the loading point to permit introduction of an empty container The full storage and transport container will be moved to an area of the Pad 904 to be staged/stored for curing purposes The staging of processed pondcrete will also provide a surge or buffer capacity between the operating requirements and schedule of the treatment system and those of the closure area contractor Typically, six storage and transport containers will be staged representing about two days production of processed pondcrete

The testing of processed pondcrete will be performed by collecting grab samples from the storage and transport containers after completion of the curing period The processed pondcrete samples will be field-tested for compliance with the WAC In particular, these field tests will verify that the processed pondcrete samples pass the paint filter liquid test (SW 9095) and that the pH of the processed pondcrete is at least equal to the value determined from the treatability study as necessary for the destruction of pathogens and gas-producing micro-organisms

In the event that the contents of a storage and transport container fails to meet the WAC, the off-specification processed pondcrete will be aspirated from the container and returned to the primary size reduction and mixing system by the portable vacuum transfer system This system will feature a vacuum pump, a cone-bottom discharge hopper equipped with a variable-speed rotary valve feeder, and a variable-speed screw conveyor The discharge hopper will be fully enclosed and will include a venting system equipped with a HEPA filter to remove dust from the pressurized air discharge of the vacuum transfer system In the primary size reduction and mixing system, the off-specification processed pondcrete will be blended with extra bulking agent and/or pozzolanic agent mix to produce a processed pondcrete that meets the WAC

IV.3.6.5 Processed Pondcrete Transfer to OU4

The processed pondcrete will be transferred to the OU4 area in the same storage and transport containers used for staging and storage Once the processed pondcrete has been removed from the storage and transport containers at the OU4 area, the empty containers will be returned to the SRTU

IV.4 WASTE MANAGEMENT

The implementation of the OU4 IM/IRA will follow the DOE mandate to minimize the generation of new wastes Waste generation will be minimized by the consolidation of soil and debris beneath the final engineered cover The CAMU concept provided in 6 CCR 1007-3 264 552 and 264 553, provides the regulatory framework by which waste generation will be minimized Figure IV 4-1 presents a waste management flow diagram that specifies the wastes that will be generated and those wastes that will not be consolidated beneath the final engineered cover The primary wastes that will require additional handling or treatment for disposal include

- Cement asbestos pipe,
- Removed utility electrical equipment and wire,
- Personal protective equipment,
- Building 788 material and ancillary equipment,
- Vegetation (potential), and
- Decontamination wastes

Vegetation may require offsite disposal if it would significantly degrade the performance of the final engineered cover Figure IV 4-1 also identifies potential methods for managing the generated wastes Offsite disposal will be minimized The following subsections describe how each waste stream will be dispositioned

IV.4.1 Excavated Soil

Soil will be generated from the areas within OU4 that are being remediated as part of the OU4 IM/IRA and from the removal/relocation of buried utilities Section IV 3 1 presents the plan for the disposition of soils that are being remediated Soils will be dispositioned based on the location of the excavation and the type and level of contamination The volume of soils generated will depend on the determined PRGs, which can potentially be modified prior to implementation of the IM/IRA, and the actual results of post-excavation sampling

Soils excavated from within the area of the final engineered cover will be consolidated beneath the final engineered cover Contaminated soils excavated in OU4 and IHSS 176 will be consolidated beneath the final engineered cover and clean soil will be used as backfill within the excavation Soils excavated in OU4 that do not require remediation, based on the OU4 RFI/RI results, will be returned to the excavation as backfill Uncontaminated excess soil that cannot be used as backfill in the utility excavation will be used as backfill to create the reclaimed areas surrounding the SEPs

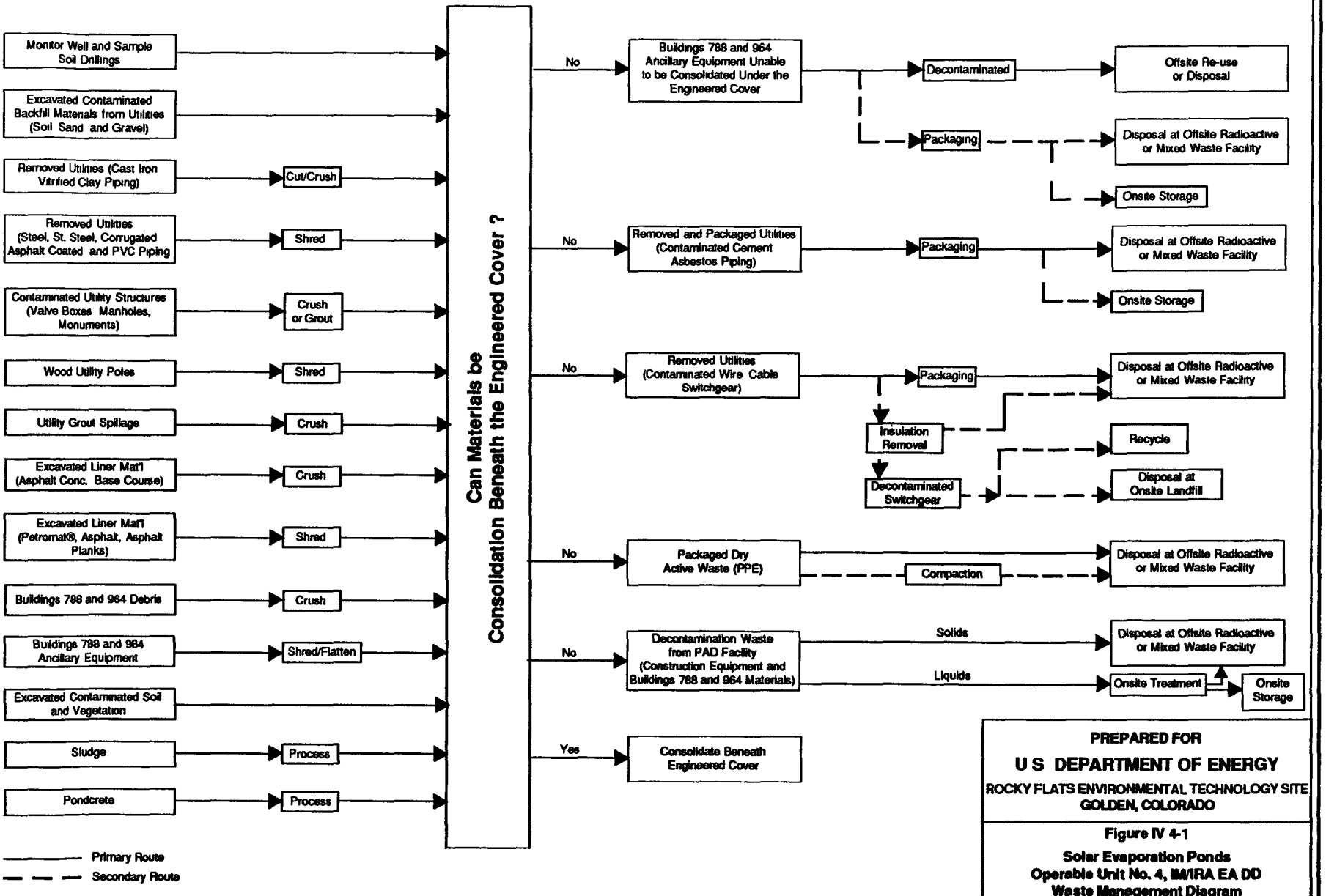

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Figure IV 4-1

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Waste Management Diagram

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Contaminated soils generated during potential utilities removal (OU9 OPWLs adjacent to OU4) will be consolidated under the OU4 final engineered cover, if possible, or returned to the original excavation site Returning excavated soil to its source location will reduce the amount of clean backfill that is brought onsite and mixed with potentially contaminated soils that may require future remediation Excess soils may remain that cannot be returned to the source excavation Disposition of these excess soils beneath the OU4 final engineered cover would depend on historical process knowledge indicating that the contaminants are the same as those in OU4, or waste characterization results indicating that the contaminants within the excess soil are at concentrations that would be protective of human health and the environment if they were consolidated beneath the final engineered cover Section IV 10 4 provides a methodology for making the determination that contaminated soils consolidated beneath the final engineered cover will be protective of human health and the environment

Investigation-derived material (IDM) from the OU4 Phase I and Phase II RFI/RI programs will be consolidated beneath the final engineered cover The empty 30-gallon drums will be returned to the waste management program for potential re-use

IV.4.2 Debris

Debris will be generated during implementation of the OU4 IM/IRA The debris materials will include

- Utilities piping,
- Electrical cable/switchgear,
- Grout spillage,
- Concrete foundations/footings, and
- Equipment associated with RCRA Units 21, 48, and 24

Figure IV 4-2 presents a detailed flow diagram for the disposition of the various types of materials that were used for utilities piping It should be noted that the wooden utility poles will be chipped and disposed of in a thin layer within the consolidated materials

Cement-asbestos material was used at the RFETS for piping wastewater This material will not be consolidated beneath the final engineered cover Excavated cement-asbestos pipe will be packaged and disposed of in accordance with asbestos disposal regulations

Electrical cable and switchgear will be packaged in standard waste crates for onsite storage, recycling, or disposal If this material is contaminated, then it may require disposal at an offsite low-level radioactive or mixed-waste disposal facility

Concrete debris from the vicinity of the SEPs will be crushed and consolidated beneath the final engineered cover Any grout spilled during utility abandonment will also be crushed and consolidated beneath the final engineered cover

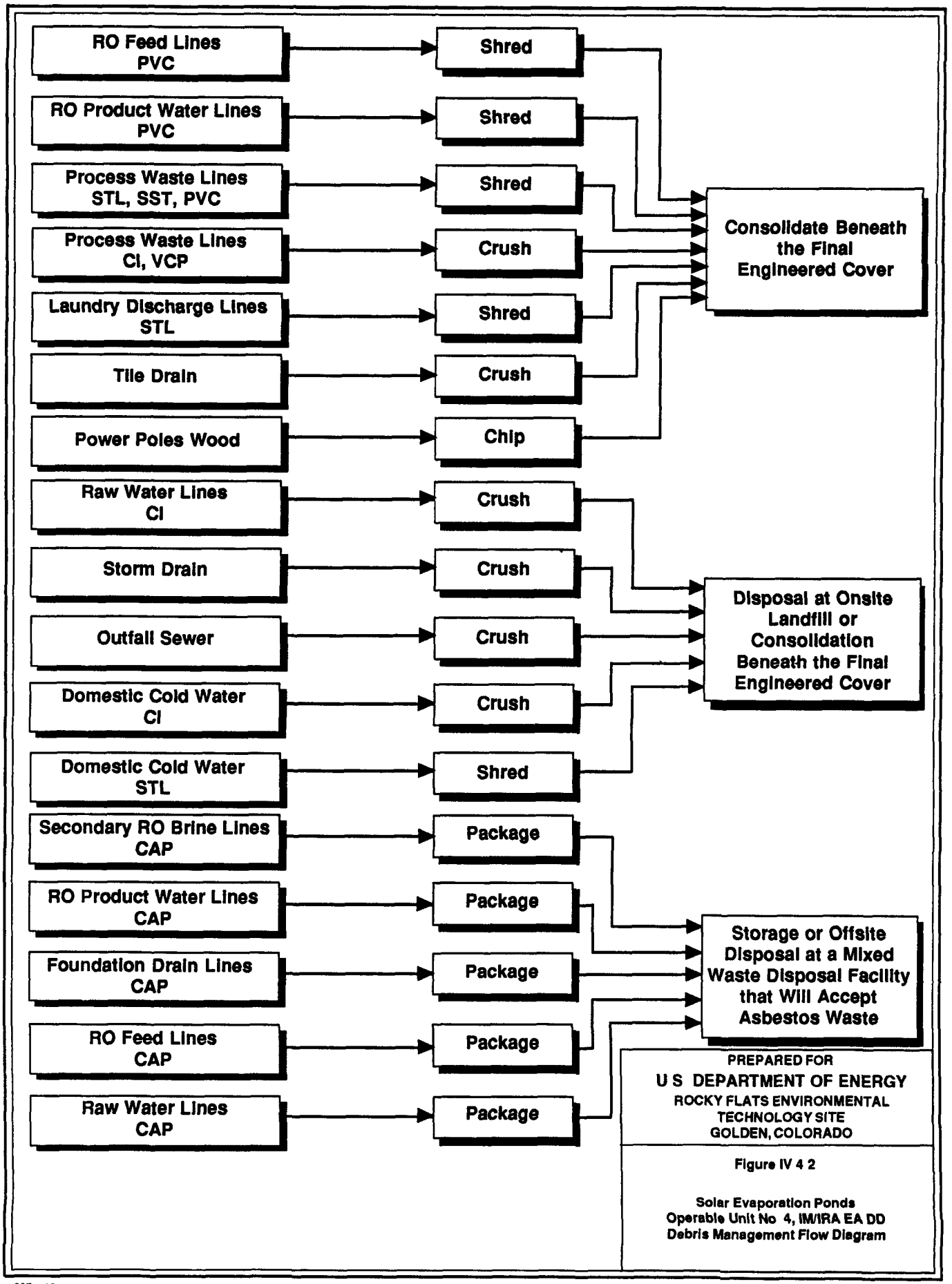
RO Feed Lines PVC
RO Product Water Lines PVC
Process Waste Lines STL, SST, PVC
Process Waste Lines CI, VCP
Laundry Discharge Lines STL
Tile Drain
Power Poles Wood
Raw Water Lines CI
Storm Drain
Outfall Sewer
Domestic Cold Water CI
Domestic Cold Water STL
Secondary RO Brine Lines CAP
RO Product Water Lines CAP
Foundation Drain Lines CAP
RO Feed Lines CAP
Raw Water Lines CAP
Shred
Shred
Shred
Crush
Shred
Crush
Chip
Crush
Crush
Crush
Crush
Shred
Package
Package
Package
Package
Package
Consolidate Beneath the Final Engineered Cover
Disposal at Onsite Landfill or Consolidation Beneath the Final Engineered Cover
Storage or Offsite Disposal at a Mixed Waste Disposal Facility that Will Accept Asbestos Waste
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Figure IV 4 2
Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Debris Management Flow Diagram

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Equipment associated with Building 788 that cannot be decontaminated may be crushed, flattened, or shredded and spread in a thin layer above the consolidated liners, provided that the material will not cause differential settlement of the final engineered cover

Based on previously conducted radiological surveys, Building 964 is assumed to be clean Therefore, no air quality modeling was developed for Building 964 and no impact to air quality from the demolition of Building 964 is expected

All items either removed from Building 964 or rubble from the demolition of the building will be monitored prior to the removal of the material from the protected area The appropriate surveys and release approvals will be obtained as described in the RFETS Radiological Control procedures and the RFETS Transportation Manual

IV.4.3 Building and Ancillary Equipment Debris

The following paragraphs address the closure of Buildings 788 and 964

IV.4.3.1 Building 788 Debris and Waste Material

The following discussion describes the strategy by which materials generated during the demolition of Building 788, (RCRA Units 21 and 48) will be segregated and dispositioned A contamination assessment will be performed to determine if the debris/waste material from the removal/closure of Building 788 contains hazardous constituents pursuant to 40 CFR 262 11 Subpart C and to determine whether radiological contamination exists A project specific Sampling and Analysis Plan (SAP) will be developed and samples of the debris/waste material contamination will be obtained, if necessary, to confirm the appropriate waste management methodology

The debris/waste material from Building 788 is assumed to be contaminated with similar constituents found in OU4 (i e , contaminated from the same sources), therefore, the placement of the debris in the CAMU (if decontamination is not practicable) should not contribute to a significant increase in the risk associated with the overall closure of OU4 Results from the sample and analyses implementation will be used to confirm this assumption All residual sludges/process waste will be removed, to the extent practicable, prior to dispositioning the debris beneath the final engineered cover in the OU4 CAMU If necessary, debris will be size reduced to optimize compaction, and integrity of the final engineered cover

IV.4.3.2 Building 964 Debris and Waste Material

The following discussion describes the strategy by which materials generated during the demolition of Building 964 (RCRA Unit 24) will be segregated and dispositioned A contamination assessment will be performed to determine if the debris, rubble and waste material from the demolition of Building 964 contains hazardous constituents pursuant to 40 CFR 262 11,

Subpart C and to determine whether radiological contamination exists A project specific Sampling and Analysis Plan (SAP) will be developed Chemical and radiological samples and surveys of the debris/waste material contamination will be obtained to confirm the appropriate waste management methodology

Based on a previously conducted screening, Building 964 is assumed clean from a radiological perspective and does not have a history of contamination concerns resulting from hazardous waste spills Building 964 is a permitted RCRA facility and does not qualify for interim status

The debris and waste material that will be generated from the removal of Building 964 is assumed (as a result of previous contamination surveys) to be free of contaminants and will most likely be disposed in the RFETS landfill All items either removed from Building 964 or rubble from the demolition of the building will be monitored prior to the removal of the material from the protected area The appropriate surveys and release approvals will be obtained as described in the RFETS Radiological Control procedures and the RFETS Transportation Manual Any contaminated will materials will be dispositioned beneath the final engineered cover (if decontamination is not practicable) The disposition of the debris and waste material beneath the final engineered cover in the OU4 CAMU should not contribute to a significant increase in the risk associated with the overall closure of OU4 The results from the Sample and Analyses Plan will be used to confirm this assumption All residual sludges/process waste will be removed, to the extent practicable, prior to dispositioning the debris beneath the final engineered cover If necessary, debris will be size reduced to optimize compaction, and the integrity of the final engineered cover

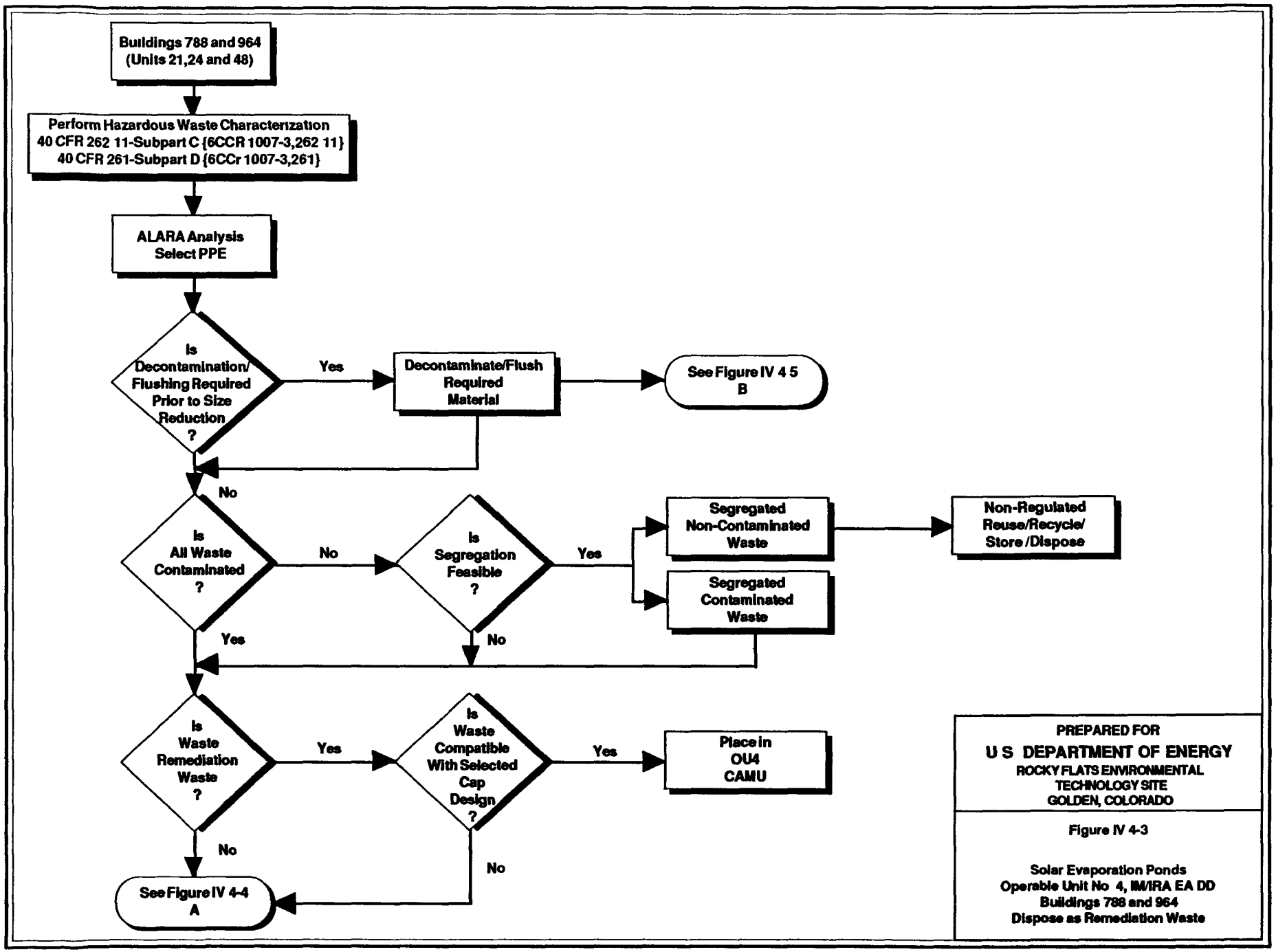
IV.4.3.3 Waste to be Generated

Waste generated during the removal/closure of Buildings 788 and 964 and their ancillaries is identified as process and debris/waste material Waste that could be generated must be properly characterized and segregated into like categories for efficiency of handling and ease of tracking A waste tracking system be developed so that the waste can be tracked for logistical and regulatory compliance purposes These remediation wastes are presented in the Waste Management Flow Diagrams (Figures IV 4-3, IV 4-4, and IV 4-5) The Demolition Waste Segregation Decision Flowcharts (Figures IV 4-6 and IV 4-7), will ensure appropriate waste segregation and cost effective sampling and analysis for waste disposition determination

IV.4.3.3.1 Management of Process Wastes

The identified process wastes from RCRA Unit 48 include

- Sediments and sludges from process equipment,
- Personal protective equipment (PPE),
- Decontamination fluids and other liquids, and
- Miscellaneous waste streams



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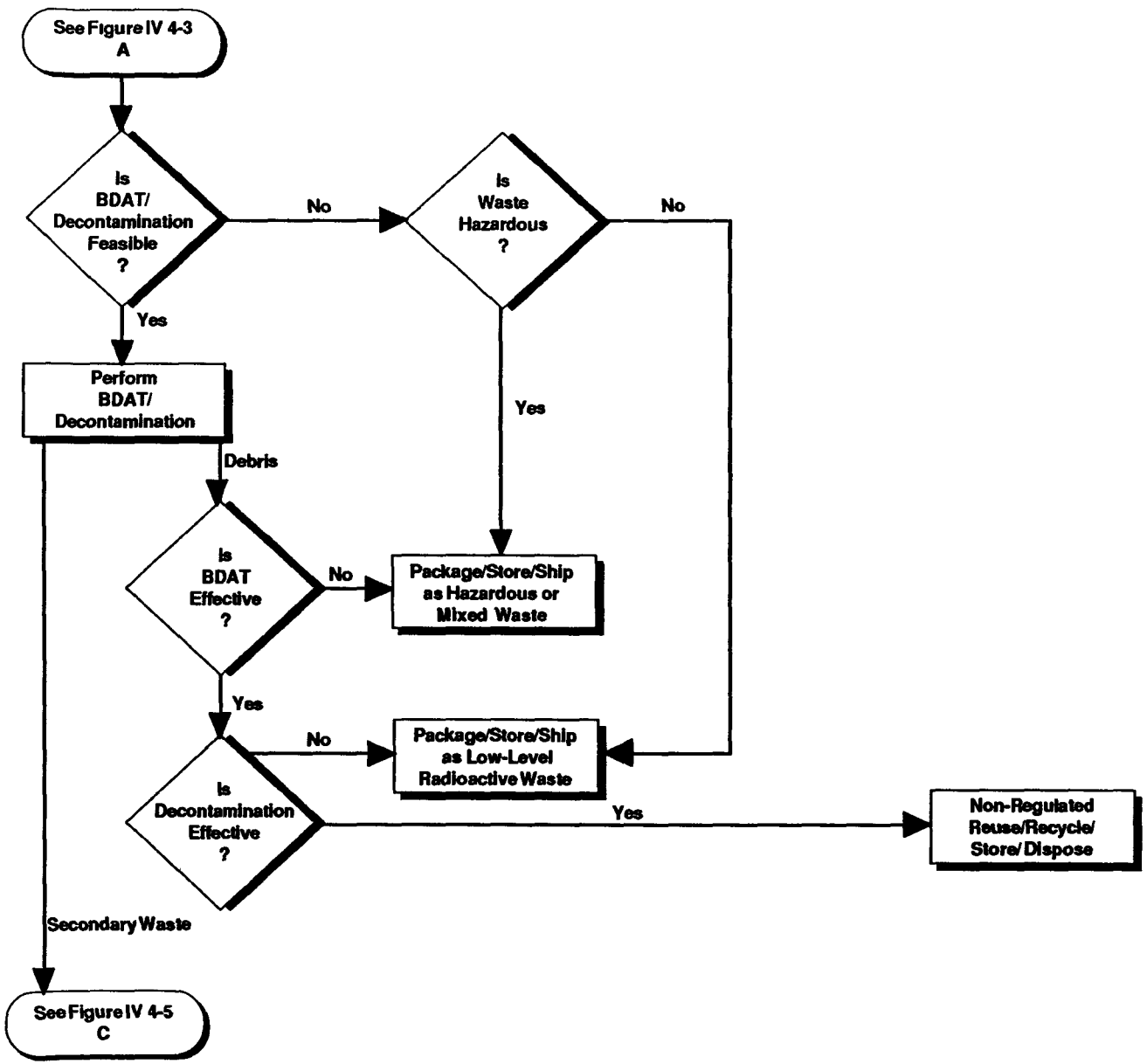

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Figure IV 4-4

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Buildings 788 and 964
Dispose as Nonremediation Waste

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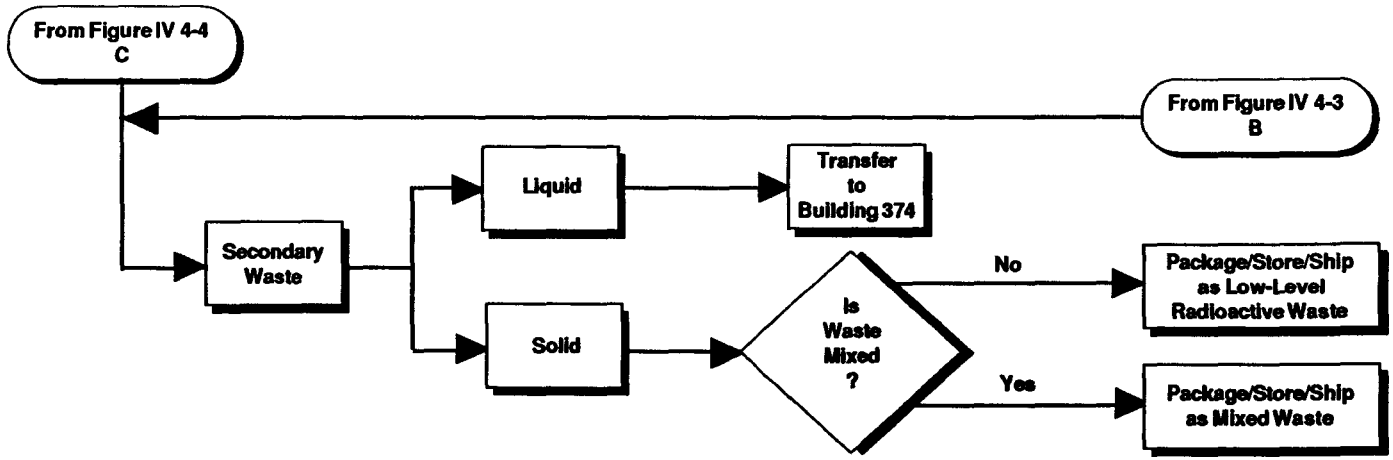

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Figure IV 4-5

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Buildings 788 and 964
Secondary Waste Disposal

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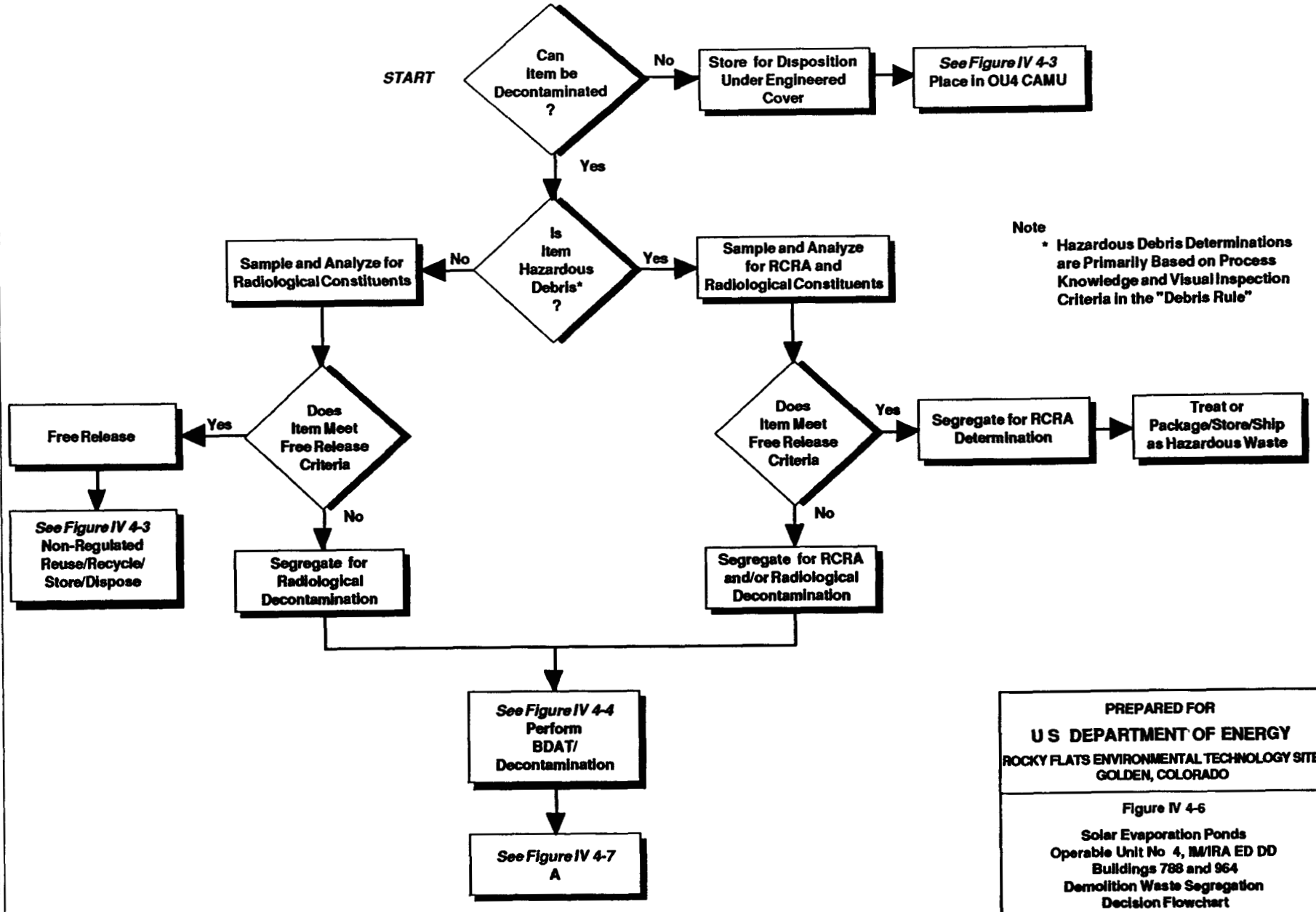

Note
* Hazardous Debris Determinations are Primarily Based on Process Knowledge and Visual Inspection Criteria in the "Debris Rule"

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Figure IV 4-6

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA ED DD
Buildings 788 and 964
Demolition Waste Segregation
Decision Flowchart

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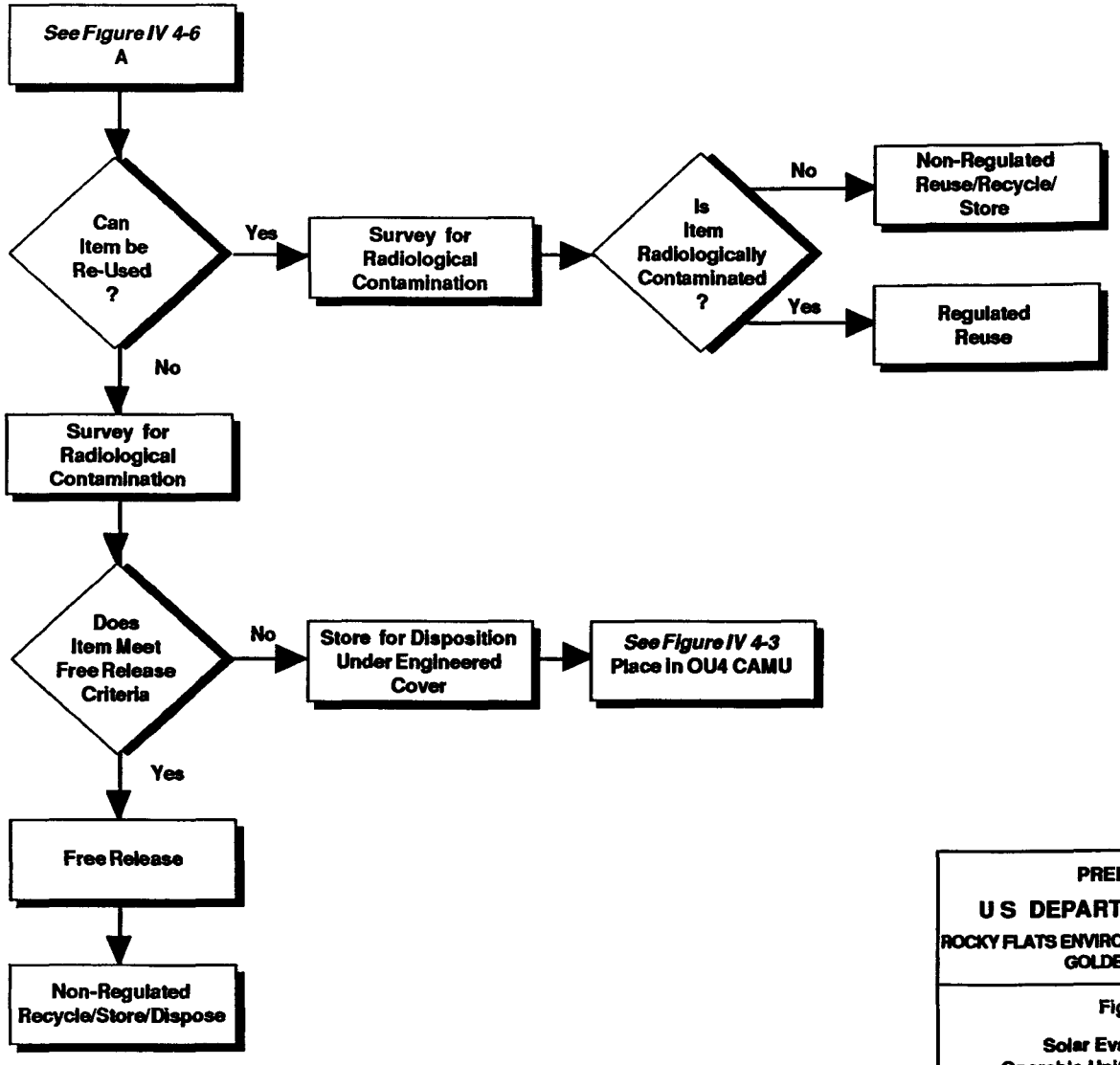

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Figure IV 4-7

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Buildings 788 and 964
Demolition Waste Segregation
Decision Flowchart (continued)

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All sampling and analysis will be performed prior to and during demolition Appendix IV D provides a sampling and analysis strategy for the material that will be removed Upon receiving the analytical results, items will be marked or tagged such that the demolition sub-contractor knows how to segregate the demolition materials The management description for each process waste stream is presented below

Sediments, Liquids, and Sludges From Process Equipment

The residues removed from the process equipment are expected to be in either pumpable or non-pumpable forms Pumpable sediments and sludges will be mechanically transferred to liquid-tight containers for transport to the temporary sludge storage tanks for subsequent processing with the pond sludges If adequate capacity in the tanks is not available, the liquid-tight containers will be temporarily stored until capacity becomes available

Non-pumpable sediments and sludges will be manually transferred to drums Absorbent materials will be added to the drums to minimize any free liquids The drums will be transferred to Pad 750 for storage If adequate storage capacity is not available, the drums will be stored temporarily within the OU4 CAMU on the Building 788 foundation pad or on a temporary pad in SEP 207-C (if necessary)

Personal Protective Equipment

Waste consisting of contaminated PPE is expected to be generated as a result of the closure/remediation activities All PPE will be handled in accordance with the RFETS Standard Operating Procedure (SOP) FO 06, "Handling of Personal Protective Equipment " Launderable PPE may be washed onsite and, if necessary, drummed as low-level radioactive waste or low-level mixed waste, along with the disposable PPE, however, if the PPE is contaminated with a hazardous waste, then the PPE will be drummed and placed in onsite RCRA storage awaiting development of treatment technologies or storage capacity

Miscellaneous Waste Streams

Currently undefined waste streams may be encountered during demolition All debris/waste materials will be properly designated and packaged prior to their exit from the working or controlled area

IV.4.3.3.2 Debris/Waste Material Management

The identified debris/waste material includes structural steel and siding (Building 788), process equipment from RCRA Unit 48, ancillary piping from the building and RCRA Unit 48, non-ferrous debris and other debris and waste material from Building 964 The waste will be managed as feasible to segregate the non-contaminated from the contaminated materials The non-contaminated waste will be packaged for re-use, onsite/offsite recycle, or disposal at a sanitary landfill The contaminated waste will be segregated to separate the flat metallic material

(siding and structural steel) from the remaining bulk material that will require further size reduction and/or flattening This material will be evaluated for potential free release and/or reuse following decontamination After appropriate segregation, any remaining flat material that cannot be decontaminated will be consolidated with the other contaminated materials under the final engineered cover, and above the drainage layer Any remaining bulk material that cannot be decontaminated will be placed into a trench excavated within the consolidated contaminated soils and grouted to minimize void space and to provide subgrade stability for the final engineered cover

Immediate candidates for disposition under the final engineered cover are the size-reduced pug mill, Morgan pumper, and clarifier Hazardous waste contamination on these pieces of equipment is due primarily to hardened/solidified sludge which is not readily removed

Any storage shelves in Building 788 will be considered for re-use Radiological surveys will be required to determine whether the re-use is appropriate in regulated versus non-regulated areas of the RFETS

Disposition of the remaining materials is subject to the results of initial sampling and analysis and visual inspection Pursuant to the Debris Rule (40 CFR 268 45 - Treatment Standards for Hazardous Debris), a "clean debris surface" means the surface, when viewed without magnification, shall be free of all visible contaminated soil and hazardous waste except that residual staining from soil and waste consisting of light shadows, slight streaks, or minor discolorations, and soil and waste in cracks, crevices, and pits may be present provided that such staining and waste and soils in cracks, crevices, and pits shall be limited to no more than 5% of each square inch of surface area Radiological surveys will also be required to determine the appropriate disposition of the materials

If the physical configuration of the material involves a large number of "surface irregularities", the question of effectiveness is raised Since it is difficult to reach and screen the "irregularities", decontamination may not verifiable for free release In certain cases (i e , air compressors, pipes) decontamination may satisfy the RCRA requirements but not the free release requirements

IV.4.4 Vegetation

Vegetation growing within the project areas consists primarily of grasses and weeds There are no trees or shrubs in these areas The vegetation will be mixed with the excavated soils and dispositioned with the soil materials The excavation of these areas will be performed in the winter when the vegetation is dormant so that the organic material volume will be minimized

IV.4.5 Decontamination Wastes

Decontamination wastewaters generated during the decontamination activities that are compatible with RFETS waste treatment facilities will be treated onsite Compatible waste currently includes high and low pH solutions, radioactive solutions, and inorganic contaminated solutions Decontamination wastewater are expected to contain only trace amounts of organics and will be treated by the Building 374 wastewater treatment system Solid decontamination wastes will be drummed and compacted for offsite radioactive or mixed waste disposal, or stored onsite in a RCRA storage area if mixed waste disposal is not yet available

IV.5 REQUIRED SPECIFICATIONS

This section identifies the construction specifications that will be prepared during the title design phase of the project A construction specification will be prepared for each of the applicable major section numbers from the Construction Specification Institute's (CSI) specification program The Division 1 specification provides the general project requirements, and Divisions 2-16 specifications present detailed project requirements per specific applicable discipline Typical outlines for Division 1 and Divisions 2 through 16 specifications are as follows

DIVISION 1
GENERAL REQUIREMENTS

PART 1 GENERAL

1 1 Scope of Work

1 1 1 Work Included
1 1 2 Related Work Specified Elsewhere
1 1 3 Work to be Performed by Others

1 2 Reference Documents

1 3 Submittals

1 3 1 Procedures
1 3 2 Certifications
1 3 3 Records

1 4 Quality Assurance

PART 2 PRODUCTS

2 1 Equipment and Material Requirements

2 2 Product Delivery, Storage, and Handling

PART 3 EXECUTION

3 1 Performance Requirements

3 2 Inspection Requirements

3 3 Testing Requirements

3 4 Acceptance

TYPICAL DIVISIONS 2 THROUGH 16

PART 1 GENERAL

1 1 Scope of Work

1 1 1 Work Included
1 1 2 Related Work Specified Elsewhere
1 1 3 Work to be Performed by Others

1 2 Reference Documents

1 3 Submittals

1 3 1 Procedures
1 3 2 Certifications
1 3 3 Records

1 4 Quality Assurance

PART 2 PRODUCTS

2 1 Equipment and Material Requirements

2 2 Product Delivery, Storage, and Handling

PART 3 EXECUTION

3 1 Performance Requirements

3 2 Inspection Requirements

3 3 Testing Requirements

3 4 Acceptance

IV.5.1 Engineered Cover Specifications

The construction specifications associated with the final engineered cover will address each layer of the final engineered cover system as well as the general site improvements At a minimum, the following specifications have been identified for the construction activities It should be noted that several of the layers of the final engineered cover will be addressed under Specification Section 02200 entitled "Earthwork " Additional specifications may be required as further definition of the design is obtained

CSI Section No.	Title Division 1 - General Requirements
01100	Special Subcontract Requirements
01300	Submittals
01500	Temporary Facilities, Controls, and Special Project Requirements
01610	Material Handling and Waste Disposal
01700	Subcontractor Safety and Health Requirements

CSI Section No.	Title Division 2 - Civil
02005	Analytical Testing Laboratory
02010	Sampling and Analysis
02015	Land Use and Subsurface Conditions
02050	Demolition
02110	Clearing, Grubbing, Regrading
02140	Temporary Diversion and Control of Water During Construction
02150	Temporary Erosion and Sediment Control
02200	Earthwork
02205	Stockpiling of Material/Waste Handling
02210	Grades, Lines and Levels
02222	Excavating, Trenching and Backfilling
02215	Geotextile Fabric
02225	Asphalt Concrete
02235	Asphalt Membrane
02240	Soil Testing Laboratory
02650	Bituminous Pavement
02700	Pipe Culverts
02830	Administrative Control Fences and Gates
02930	Reclamation Seeding, Mulching and Fertilizing

IV.5.2 Utilities Specifications

Construction drawings will be provided for the grouting and abandonment of the piping systems formerly used for transferring aqueous solutions between the SEPs and Building 910 Also included with these types of piping systems are those which were used to transfer SEP water between the ponds to allow for routine maintenance of the SEPs

Specifications will also be provided for the installation and/or the rerouting of required electrical services At a minimum, the following specifications have been identified for these construction activities Additional specifications may be required as further definition for the design is obtained

CSI Section No.	Title
	Division 6 - Electrical
16010	Electrical Systems
16050	Basic Electrical Materials and Methods
16401	Overhead Electrical Systems
16402	Underground Electrical Systems
16450	Grounding
16460	Transformers
16520	Lighting
16740	Telephone System Site Preparation
16770	Life Safety Disaster Warning Systems

CSI Section No.	Title
	Division 3 - Concrete
03300	Cast-in-Place Concrete
03600	Grout

IV.6 IMPLEMENTATION PLAN AND PROPOSED SCHEDULE

This section provides a description of the engineering implementation studies that have been performed during the title design phase of the project The results of these studies will be used to finalize the design This section also provides a preliminary construction schedule

Several failure scenarios have been evaluated or are planned to be evaluated during the detailed design of the final engineered cover These scenarios have been performed to study the potential for cover failure and the causes of such a failure The following failure scenarious have been evaluated and are presented in more detail throughout this document

- Slope, stability and settlement analysis,
- Creep analysis,
- Erosion, including soil loss, sheet flow, rut and gully, and wind analysis,
- Seismic evaluation,
- Surface water runoff,
- Root penetration,
- Burrowing animals,
- Air emissions during construction,
- 200 and 300 percent increase in monthly precipitation,
- 100-year storm event, and
- Catastrophic rise in ground water elevation

IV.6.1 Geotechnical Investigation

The stability of the hillside north of the proposed location of the final engineered cover was investigated due to recent field observations and results of previous studies (Woodward-Clyde, 1970, CTL/Thompson, 1979) Results of the field investigations show the presence of ground water seepage, surface soil sloughing, and potential bedrock slump blocks in the north hillside Because of the critical nature of the subgrade stability with respect to the stability of the final engineered cover, a geotechnical investigation was required to collect data on slope stability and settlement Previous investigations have collected analytical and physical data on the soils and bedrock in the area of the SEPs, but data specific to slope stability and settlement analyses were lacking from the Phase I RFI/RI program

The stability analysis required determination of shear strength and density characteristics of the soil and bedrock and also required information regarding locations of fracture zones, slickensides, and other potential failure surfaces Other information (e g , ground water elevations) needed for the analysis was available from previous studies Sample collection and geotechnical testing provided soil engineering parameters required for analysis of the hillside stability and for evaluation of potential stabilization remedies

The settlement analysis required determination of consolidation characteristics of the soil and fill below the proposed cover Physical properties of the materials such as moisture content,

density, and specific gravity was also needed The results of the analysis are provided in Appendix IV H

IV.6.2 Utilities Verification Plan

A utilities verification plan will be implemented to obtain accurate information regarding the identification, service, origin, location, and status of the utilities in the vicinity of the OU4 SEPs which might be affected by the closure/remediation activities Drawing 51045-440 provides a table from which initial physical information may be obtained This information was obtained from RFETS Utility Drawings and includes the location, size, service, and material of construction for the piping, and electrical and telephone services in the 207-SEPs area and adjacent areas that may be disturbed during OU4 SEPs closure Due to the uncertainty of the accuracy of the utilities drawings, a utilities survey will be performed This survey is intended to accurately complete and verify the physical information presented on Drawings 50145-440 and 51045-441 This survey will enable the selected construction contractor to accurately locate the utilities during closure/remediation

IV.6.3 Project Schedule

Figure IV 6-1 provides a summary-level conceptual project construction schedule Construction activities are planned to start in October 1996 The construction should be completed in Octoboer 1999 It is important to note that this schedule reflects durations for the implementation of the conceptual design The regulatory construction milestones will be dependent upon the schedule submitted with the final design package It is also important to note that the milestones are contingent upon the receipt of regulatory approval to implement the IM/IRA The following are project milestone activities and estimated dates (month and year) for their occurrence The estimated project milestones are based upon receipt of CDPHE/EPA approval by January 1996

Project Milestones

Milestone Activity	Estimated Date
Complete Title Design	Nov 95
Project Approval	Jan 96
Removal of Building 788	Aug 96
Removal of Building 964	Aug 96
Award Contract	Aug 96
Mobilize Construction	Oct 96
Utilities Completion	Jul 97
Final Engineered Cover Completion	Aug 99
Demobilization	Oct 99
Post Closure System Start-up	Dec 99

The schedule is based on the following assumptions

- Materials will be delivered 6 days per week over a 12-hour working day
- The construction contractor will work five 10-hour days because extended work hours over a long period of time has proven to be too inefficient and unsafe
- Materials will be brought in as needed for specific layers of the final engineered cover because there is limited laydown area available for early material stockpiling
- Buildings 788 and 964 and ancillary equipment will be removed prior to the start of construction
- The start of construction date is based on the DOE IAG milestone schedule

IV.6.4 Implementation of Site Preparation Activities

DOE will commence construction of site preparation activities prior to formal approval of the IM/IRA in an effort to expedite the construction schedule These activities will not be components of the OU4 closure/remediation, however, completion of certain activities will be required prior to the start of the closure/remediation activities The activities for early construction include

- Upgrading the site security system so construction equipment can access the Protected Area (PA) efficiently,
- Relocation of utility lines that will be impacted by construction and are required for ongoing RFETS activities,
- Removal of excess utilities and equipment located aboveground,
- General site improvements such as pulling electrical power and a sewer line to the locations where construction and laboratory trailers will be located Site lighting will also be installed for security purposes as well as performing construction activities at night,
- Equipment outside and within Building 788 and 964 that is not specifically a component of RCRA Units 21, 48, and 24 may be removed from the building prior to the commencement of the RCRA closure activities Much of this equipment will not be considered waste and will be removed from the building for re-use Examples of potentially reusable equipment are the cement silos, air compressors, battery rechargers, propane storage tanks, unit heaters, and electrical lighting, and

- The DOE will remove the shell of Building 964 prior to implementing the IM/IRA The removal will be conducted according to the approved closure plan that currently exists in the RFETS RCRA Part B permit The closure certification will be submitted upon completion of the IM/IRA when the building foundation and any contaminated soils have been removed and dispostioned beneath the final engineered cover

It is important that the vegetated areas requiring remediation be excavated during the winter months when plants are essentially dormant and have died back This will reduce the volume of plant material consolidated beneath the final engineered cover DOE may have to excavate these areas early in order to perform the work during the appropriate season In the event of early excavation, DOE will move the excavated materials into piles located within the excavation zone The piles will be covered with tarpaulins for future disposition when remediated activities formally commence The excavated areas will be tested for verification that all the contamination was removed, and backfilled upon the completion of dispositioning the contaminated piles

IV.6.5 IM/IRA Construction Implementation Sequence

Construction of the final engineered cover will include several well-planned phases of work A stringent Quality Assurance/Quality Control (QA/QC) program will be followed throughout all construction activities A more detailed description of this QA/QC plan is presented in Section IV 8 The tasks that must be completed prior to the construction of the final engineered cover include installation of a security fence and accessways, rerouting of utilities, location of the construction trailer park, installation of utilities for construction trailers, and construction of a roadway

Initially, the site must be prepared for construction activities To accommodate the configuration of the final engineered cover, the rubbish and intermodal containers currently located adjacent to the eastern side of SEP 207-B North, must be relocated outside the newly installed construction security fence This will make accessible for Construction, all available real estate between the construction security fence and the eastern boundary of the final engineered cover and SEP 207-C as is practical to be utilized for stockpiling of construction materials and soils mixing operations This stockpile and laydown area must be cleared and graded to achieve a consistent slope If required, this area will also be covered with gravel to establish a clean zone The trailer area, as shown on Drawing 51045-110, must also be cleared and graded to a consistent slope The removal of Buildings 788 and 964 (RCRA Units 21, 48, and 24) will be completed prior to construction of the final engineered cover In addition, some monitoring wells on the SEP berms will have to be removed and relocated and/or abandoned

All construction materials required for reclamation activities and final engineered cover construction will arrive on the site and may be stockpiled east of the final engineered cover boundary in the designated stockpile area These materials will be delivered to the site throughout the project to keep ahead of construction needs

There may be existing excavations on the area north of the perimeter fence (Zone C) and on the hillside north of the SEPs (Zone B) due to tasks completed prior to the commencement of final engineered cover construction activities as discussed in Section IV 6 4 Approximately 5,400 cubic yards of topsoil and 1,800 cubic yards of pea gravel will be placed in the area north of the perimeter security fence (buffer zone) Approximately 3,200 cubic yards of topsoil and 1,100 cubic yards of pea gravel will be placed on the hillside north of the SEPs These reclamation final engineered covers are described as Alternative 1 in Section III 3 2 1

The liners in SEPs 207-A, 207-C, and the B-series SEP liners, totaling approximately 11,800 cubic yards, will be crushed, excavated, and stockpiled in the SEP 207-C as appropriate

Berms and soils from SEPs 207-A and the B-Series SEPs will be excavated to the mean seasonal high ground water elevation Upon completion, the first layer of subsurface drain material (fine sand) will be used to level the excavated surface to establish a minimum of one percent slope for the subsurface drain This will initiate the construction of the subsurface drain

The subsurface drain involves five layers of material These layers are presented from the lowest layer to the highest layer The first and second six-inch layers of sand and sandy gravel, respectively, with an approximate volume of 7,400 cubic yards each, filter suspended solids generated as ground water as it flows from low to high porosity zones The third layer is the primary drainage layer which involves twelve inches of washed gravel consisting of approximately 14,800 cubic yards The fourth and fifth layers of gravely sand and fine sand, with an approximate volume of 7,400 cubic yards each, precludes the settling of contaminated soils within the voids of the drainage layer Approximately 232,000 square yards of geotextile filter fabrics will be used during construction between the sandy materials and the washed gravel to maintain segregation of the various materials during construction

The installation of the vadose zone monitoring equipment will begin upon completion of the upper sand layer of the subsurface drain Initially, two feet of excavated soils will be placed on the completed subsurface drain Horizontal channels will then be excavated to a depth of approximately 2 feet and the neutron probe access tubes (NPATs) will be laid into the cuts Imported sand will be used to backfill around the NPATs Instrumentation and conduits will be laid at this time to connect the frequency domain capacitance (FDCs) and the suction lysimeters The instruments themselves will be placed aboveground on vertical posts The electrical conduits and instruments will be protected during construction by temporary solid metal pipe Once the backfilling of waste material reaches the level of the top of casing, the casing will be pulled out of the ground and backfilling and compaction of the instrumentation hole will be completed manually The instrumentation holes will be backfilled and compacted incrementally as the thickness of the waste zone or final engineered cover increases during construction

Once the subsurface drain is complete, excavated contaminated soils from SEPs 207-A and the B-series SEPs will be proportionally blended with the crushed liners, processed pondcrete and sludge, and will be placed on the completed subsurface drain This material to

be backfilled will consist of a homogeneous mixture of the following approximate volumes and proportions

Description	Volume	%
SEP A & B Soils	92,200 CY	77 5%
Processed Pondcrete	10,000 CY	8 4%
Processed Sludge	5,000 CY	4 2%
Crushed Liners	11,800 CY	9.9%
TOTAL	119,000 CY	100%

The volume of concrete building foundations is approximately 300 cubic yards and is negligible Based on the currently scheduled production rate of 1,000 cubic yards of contaminated materials placed per day, the following volumes are required on a daily basis to prevent schedule impacts

SEP A & B Soils	775 CY
Proceesed Pondcrete	84 CY
Processed Sludge	42 CY
Crushed Liners	99 CY
TOTAL	1000 CY

To prevent having extended periods of open excavation and to minimize the effects of anticipated rain events, the above described order of operations (excavation, drain placement, soil/waste mixing, and backfill) will be accomplished in a grid pattern Several smaller areas will undergo the various stages of completion simultaneously

This also allows the contractor to plan his work on a daily basis based on several factors including, weather, equipment availability, and degrees of difficulty of various portions of the work It also provides the contractor with the ability to develop "work around" scenarios to minimize schedule impacts

Following the replacement of soil from SEPs 207-A and the B series SEPs, and wastes, SEP-207C will be excavated to the mean seasonal high ground water elevation These soils will be distributed and compacted on top of the homogenous mixed soils and consolidated hazardous wastes

Upon completion of the SEP 207-C soils consolidation, the size reduced debris from Buildings 788 and 964 will be entombed This will require an excavation of approximately 400 cubic yards into the compacted SEP 207-C soils Size reduced debris will be placed in the excavation and covered with a minimum 6-inches of grout All void spaces in and around the debris will be completely filled with grout

Upon completion of the above activities, contaminated surficial soil from Zones B and C (Figure IV 3 1), will be excavated and distributed over the soils excavated from the SEPs

Transfer of staged soils should proceed from north to south while placement in the newly prepared area continues until the elevations of compacted soils in the two areas are equal The remaining staged soils will then be distributed, from north to south over both areas, and compacted

Backfilling activities associated with SEP 207-C and Zones B and C may take place at any time after completing excavation of contaminated soil With respect to SEP 207-C, excavation will be deemed complete upon reaching the mean seasonal high ground water elevation or until all the soils at concentrations exceeding the PRGs are removed Surface soils will be excavated from Zone B There are two vadose zone hotspots where Radium-226 concentrations exceed PRGs These vadose zone hotspots will be excavated during the removal of the contaminated surface soils from Zone B Only surface soil will be excavated from Zone C

During construction of the engineered cover, ground water monitoring wells outside the toe of the final engineered cover will be installed as a component of the post-closure monitoring system Wastes generated from the installation of these wells can be stockpiled for future placement above the subsurface drains for inclusion beneath the final engineered cover The top of the monitoring wells will be placed at least 6 inches below the surface Protective casings will be installed to minimize the potential for damage to the wells as a result of ongoing construction activities

The excavation in SEP 207-C will be backfilled with excess clean soils excavated from the north berm areas of the SEPs lcoated north of the vadose soil excavation (to establish final grade) or with clean imported soil Excavation activities associated with this area have been discussed in Section IV 6 4 General backfill, topsoil and pea gravel described as Alternative 1 in Section III 3 2 1 will be placed in SEP 207-C and graded to achieve the appropriate slope

After compaction of all the consolidated materials, the OU4 SEPs will be ready to receive the clean imported components of the final engineered cover The components include (from the lowest layer to the highest layer) the gravel base course, asphalt concrete, asphalt membrane, lower sand layer, angular riprap, gravel filter, sand filter, general backfill, topsoil/gravel admix, pea gravel, and vegetation Post-closure instrumentation for monitoring moisture in the final engineered cover will be installed concurrently with the construction of the final engineered cover to avoid drilling through the layers of the engineered cover In each case, the final engineered cover materials will be placed and compacted and trenches for the equipment will be excavated into the compacted layer to maintain consistency of compaction around the equipment Sensors will be located at four locations in the cover These depths are at the bottom of the sand (drainage/cushion) layer Following placement and compaction of the layer, the areas around the monitoring devices will be manually backfilled and compacted

The first layer installed for the final engineered cover includes approximately 7,370 cubic yards of gravel base course This material will be transferred from the stockpile area east of

SEP 207-B North to SEP 207-A and the B-Series SEPs The gravel base course will be six inches thick and will be graded and compacted to the appropriate slope

The volume of asphalt concrete and the asphalt membrane layer total approximately 7,480 cubic yards (combined) The asphalt concrete and asphalt membrane will arrive onsite at the time it is needed The asphalt concrete will be placed in two 3-inch thick lifts, graded, and compacted to achieve the appropriate grade The asphalt membrane layer will be applied as a liquid form to a total layer thickness of 200 mils over the asphalt concrete A geotextile fabric will be laid between the asphalt concrete and the asphalt membrane to aid QA of the placement process The layers will be allowed adequate time for curing prior to placement of the next layer The asphalt layers may be painted white as necessary to reduce surface temperatures and avoid problems associated with thermal expansion. Quality-control testing will be performed before and after the materials are placed in the final engineered cover

Approximately 15,200 cubic yards of sand will be placed above the asphalt layer This material will be transferred from the clean stockpile area east of SEP 207-B North to the final engineered cover location The drainage/cushion sand layer will be 12 inches thick and will be graded and compacted to the appropriate grade

Angular riprap will be placed above the lower sand layer totaling approximately 39,850 cubic yards The angular riprap will be transferred from the stockpile area to the final engineered cover location Grading and compaction will be required to complete the construction of the angular riprap layer The lower layer of angular riprap (6"-10" diameter material) will be 18 inches thick and the upper angular riprap layer (2"-4" diameter material) will be 12 inches thick

Approximately 16,850 cubic yards of gravel will be placed above the angular riprap layer This material will also be transferred from the stockpile area The gravel will require grading and compaction to achieve the appropriate slope The gravel filter layer will be 12 inches thick

The sand filter layer will total approximately 17,330 cubic yards of material which will be transferred from the stockpile area Grading and compaction will be required for this layer The sand filter layer will be 12 inches thick

Approximately 46,430 cubic yards of general backfill will be placed above the upper sand layer This material will be transferred from the stockpile area and graded to achieve the appropriate grade This layer will be only slightly compacted to allow for adequate root penetration for the support of vegetative growth The general backfill layer will be 30 inches thick

Approximately 29,000 cubic yards of topsoil/gravel admix will be transferred from the stockpile area for placement above the local soil backfill layer The topsoil will be graded to the appropriate grade The topsoil/gravel admix layer will be 18 inches thick and will not be

compacted to allow for adequate root penetration for the support of vegetative growth Angular pea gravel totaling approximately 9,680 cubic yards will be placed above the topsoil/gravel admix layer and graded to the appropriate grade An overall thickness of pea gravel will be six inches

A perimeter toe drain will be constructed to direct clean runoff away from the final engineered cover Approximately 770 cubic yards of sand will be required to install the perimeter toe drain The perimeter runoff swales will also be constructed to direct runoff away from the final engineered cover

The areas including the area north of the security fence (buffer zone), shown as Zone C in Figure IV 3-1, the hillside north of the SEPs, shown as Zone B in Figure IV 3-1, Zone A shown on Figure IV 3-1, SEP 207-C, perimeter runoff swales, and the final engineered cover will require 27 acres of seeding to produce the required stand of vegetative growth

During implementation of the preferred remedy, it is conceivable that soil may be spilled during normal excavation and onsite transportation operations Although minor spillage of soils is not considered to be an imminent threat to human health and the environment, standard operating procedures will be developed to minimize potential spills, and provisions (i e , spill removal, contaminant migration controls, and soil erosion controls) will be made to preclude spills The analytical results from the verification samples will be used to confirm that spilled soils above the PRGs have been properly removed

Since minor spills do not pose a threat to human health and the environment, implementation of the RFETS contingency plan, which is presented as Part VI of the RCRA Part B Permit Application, is not required The contingency plan would, however, be implemented if the emergency coordinator determines that the magnitude of the incident poses a significant threat to human health and the environment If the emergency coordinator determines that activation of the contingency is required, all related operations will cease until the incident is determined to be under control In addition to the contingency plan, the National Response Center will be notified if the quantity of soils spilled within any 24-hour period exceeds the specified Reportable Quantity (RQ) Based on the maximum RFI/RI contaminant concentration results, it is determined that a minimum of 2,400 kilograms of soil would need to be released in any 24-hour period before RQ notification is required Based on the average density of the excavated OU4 soils (104 3 lbs/ft^3), this quantity amounts to approximately 1 43 cubic meters (or approximately 1 87 cubic yards)

During construction, DOE will provide erosion control to prevent soil erosion from causing siltation of the ITS or surface water drainage channels Erosion control measures may consist of haybales and/or silt fences Also, stormwater will be monitored in accordance with the NPDES permit to ensure compliance with the NPDES permit

The final construction activities will include the installation of a fence surrounding the final engineered cover to prevent intruder access, finalizing construction of the ground water

monitoring wells that were protected during construction activities, and installation of remaining above-ground monitoring equipment and conduits Signs will be posted on the fence stating "Danger - Keep Out Corrective Action Management Unit" to prevent workers from entering the site

Dust Suppression

Dust will be generated during the SEP excavation and construction of the final engineered cover The DOE is most concerned with dust generated from the excavation and movement of the contaminated soils (due to radiological health concerns), but is also committed to minimize dust generated from routine construction activities that do not involve contaminated materials There are many ways that dust emissions are suppressed during construction/excavation activities Common dust suppression activities include

1) Require that work stops under excessive wind conditions,
2) Use of water sprays during construction to minimize dust production,
3) Use of fixative solutions on exposed surfaces to minimize dust production,
4) Use of tarpaulins to contain soils and isolate materials from the elements

A combination of these common practices will be used at OU4 to minimize the release of dust

Dust emissions can result from typical construction activities which includes the excavation of contaminated soils According to RFETS procedures, construction work will stop if the wind exceeds 35 miles per hour This will minimize dust dispersion from the physical act of excavation under inclement conditions The construction access roads will be asphalt paved as much as practicable, and will include main thoroughfares Paved roads will eliminate a source of dust caused by dirt roads that experience heavy traffic In addition, water sprays (or fixative solutions) will be applied as required to the unpaved roads or on paved roads if dust accumulating becomes a problem Contaminated soils from the OU4 buffer zone will be transported to the OU4 SEP area in tarpaulin covered dump trucks In addition, water or fixative solutions may be sprayed onto the contaminated soil during truck loading and dumping operations Tarpaulins may also be used to cover the truck cargo areas This will prevent contaminated soils from blowing out of the trucks The OU4 IM/IRA construction strategy includes trucks and equipment that will be dedicated to working in the contaminated zones and trucks and equipment that will be dedicated to the uncontaminated zones This will prevent contaminated soils on the trucks and equipment from being spread throughout the clean construction roads and areas

During the excavation period, piles of contaminated soils and materials will be sprayed with a water/fixative mixture Fixative solutions will be applied to piles that will remain idle for extensive periods (This may be the case for the liners which will be excavated or treated early, and stockpiled for future disposition) Tarpaulins could also be used to cover stockpiles Tarpaulins would be used if the other methods were not effective Tarpaulins are not preferred

because often they are not durable and are labor- and maintenance-intensive The crushing of liners and concrete debris will be conducted within enclosed equipment, or the entire crushing operation may be enclosed within a structure such as a permacon® or a tent Water sprays will also be used during the crushing operations to minimize the production of contaminated dust A spray bar will be used at the crusher and at the end of the conveyor prior to releasing the material to the stockpile Dust will be generated during the actual excavation activities by excavators and scrapers This dust source will be the most difficult to suppress Water sprays will be used during the excavation as necessary to reduce the dust emissions High Efficiency Particulate Air (HEPA) filtered enclosed cabs may be required for the construction equipment In any case, each operator will have a respirator in case the health and safety supervisor determines that the combination of weather conditions and radiological concentrations in the soils are high enough to merit respiratory protection The risk assessment modeling will be continued during the design development to ensure that construction workers and offsite residents will be protected from airborne contamination

The above mentioned practices will be used to greatly reduce dust emissions, but as with any large-scale outdoor construction activity, they will not be 100 percent effective The anticipated special conditions at the OU4 IM/IRA construction site warranted the high level of analysis and design measures As a result of these efforts, an air monitoring system will be installed to verify air quality and effectiveness of the dust suppression measures during construction This will ensure that the construction workers are adequately protected from contamination, and that there is no significant emission of contamination that could impact offsite residents The air monitoring system will allow early warning of excessive dust emissions and indicate if the construction activities should be placed on hold until the cause of the emissions is identified and rectified

Air Monitoring

The purpose of an air monitoring system is to ensure and verify that personnel are not exposed to airborne contamination which exceeds the regulatory limits Air monitoring will be performed in several locations during the construction/excavation activities in order to assess the quantities and types of dust emissions Real-time monitoring will be performed by health and safety specialists to ensure that the construction environment is suitable for worker safety Continuous air monitors (CAMs) will be used to assess the airborne contamination and radiation levels at the construction site If the airborne contamination and radiation levels exceed a specified set point established by health and safety specialists (based on site specific conditions), then an alarm will sound and work will stop until appropriate protective measures are taken Real-time carbon monoxide monitoring will be used in any enclosed areas to assure that vehicle exhaust does not exceed levels established by Occupational Safety and Health Administration (OSHA) standards

Conservative computer modeling results will be used to predict the worker exposure and to dictate the initial personal protective equipment requirements The CAP88-PC model and the Nearfield box model will be used to predict the radiological risks to the public and workers from

the construction operations Preliminary modeling results indicate that the radiological risk to offsite receptors is in the 1 0E-09 range and 1 0E-08 range for site construction workers This predicted risk is significantly lower than the EPA target risk level of 1 0E-06 The modeling results are based on EPA standard receptors, RFETS climatic/weather data, and a conservative assumption that all the excavated soil will have the 95 percent upper confidence interval contaminant concentrations The initial personal protective equipment requirements will likely be more conservative than what is necessary based on the computer modeling results and until actual data is collected that confirms the modeling results Breathing zone air (BZA) samplers will be worn by designated individuals to assess the amount of particulates inhaled by the construction workers These instruments may also be mounted on construction equipment such as vehicles and excavators A BZA provides an air sample that is practically identical to the air that the individual construction worker is actually breathing, not just of the surrounding area The results of the BZA samples will provide an accurate assessment of the exposure to the construction workers These results will be used to determine and verify the appropriate level of personal protective equipment for worker protection Area air samplers will be utilized in the vicinity of each of the different tasks that are being performed and will provide an indication of local area air emissions Area air samplers will also be located at the OU4 fenceline to monitor the hazards to RFETS employees that are working onsite, but not directly at the SEPs DOE Order 5480 11 requires that site worker exposures be maintained As-Low-As Reasonably Achievable (ALARA), with a limit of 5 rem for the annual dose equivalent from both internal and external sources All site workers are monitored throughout the year to assess individual exposures A worker who is approaching a 5 rem yearly dose will be re-assigned to other activities with a lower exposure potential

Air samples will be routinely taken at the RFETS boundary in order to assess impacts to the general public DOE Order 5400 5 establishes that exposures to members of the public to radioactive materials released to the atmosphere shall not cause members of the public to receive in a year an effective dose equivalent greater than 10 mrem Air modeling will be used to predict whether the contribution of radioactive particulates will cause the RFETS discharge to exceed the 10 mrem effective dose equivalent limit

IV.6.6 Certification of SEP Closure

As required by 6 CCR 1007-3, 265 115 (Certification of Closure), "within 60 days of completion of closure of each hazardous surface impoundment , and within 60 days of the completion of final closure, the owner or operator must submit to the [CDPHE] by registered mail, a certification that the hazardous waste management unit or facility, as applicable, has been closed in accordance with the specifications in the approved closure plan The certification must be signed by the owner or operator and by an independent registered professional engineer Documentation supporting the independent registered professional engineer's certification must be furnished to the [CDPHE] upon request until he releases the owner or operator from the financial assurance requirements for closure under 6 CCR 1007-3, 266 14 (Financial assurance for closure and or post-closure) "

The definition for "final closure" presented in 6 CCR 1007-3, 260 10, states that closure of all hazardous waste management units at the facility shall occur in accordance with all applicable closure requirements and that hazardous waste management activities under 6 CCR 1007-3, 264 and 265 are no longer conducted at the facility unless subjected to the provisions of 6 CCR 1007-3, 262 34 An independent professional engineer will be responsible for overseeing the closure activities to ensure that they comply with the CDPHE/EPA approved Decision Document A field log will be maintained to document the professional engineers observations The field observations will be supported with photographs, construction quality control results, and the verification sampling results This information will be included in the closure report The closure report will be certified by the professional engineer and submitted to CDPHE/EPA within 60 days after closure completion The closure criteria and activities for waste management must be implemented to verify that closure is completed according to the approved construction plans and appropriate requirements When closure is complete and certified, the unit will be removed from the Part A Permit application Also, in accordance with 6 CCR 1007-3, 264 552, notification to the property deed will be provided to notify any potential purchaser that the land has been used to manage hazardous waste

IV.7 COST ESTIMATE

This section presents the estimated costs for implementing the OU4 SEP IM/IRA This includes a summary estimate, a funding strategy, and a project contingency analysis The cost information used to prepare the estimate was obtained through Means Man-Hour Standards for Construction and interviews with local contractors/vendors

IV.7.1 Summary Estimate

Table IV 7-1 presents a summary of the capital cost estimate The detailed backup sheets are included as Appendix IV E The estimated cost of the project is approximately $107 8 million The estimate is based on 1994 dollars escalated at 9 7 percent of the construction costs to reflect 1998 dollars

IV.7.2 Funding Strategy

The OU4 SEP IM/IRA will be funded in fiscal year (FY) 95, 96, 97, 98, 99, and 2000 based on the conceptual schedule Table IV 7-2 presents an anticipated funding schedule per fiscal year

TABLE IV.7-2
FISCAL YEAR FUNDING STRATEGY
(IN THOUSANDS OF DOLLARS)

	Fiscal Year					
	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Estimated Funding ($)	**3.0**	**20.0**	**33.8**	**29.0**	**15.0**	**2.0**

IV.7.3 Contingency Analysis

The contingency analysis for the project is based on the specific level of confidence with respect to the major components of the closure/remediation The contingency considers the risk of the following

1) Variations and unknowns in scope definition,
2) Technical uncertainties (utility location uncertainty, and lack of detailed construction specifications),
3) Estimating methodologies used to develop the estimate and associated expenditures, and
4) Cost impacts from the technical complexity of the closure/remediation (primarily due to excavation and utilities removal)

TABLE IV 7-1
DOE ESTIMATED COST SUMMARY

A ENGINEERING, DESIGN AND INSPECTION	$2,500,000
B LAND AND LAND RIGHTS	
C CONSTRUCTION COSTS	$28,700,000
(1) IMPROVEMENTS TO LAND	
(2) BUILDINGS	
(A) NEW	
(B) MODIFICATIONS	
(3) OTHER STRUCTURES	
(4) SPECIAL FACILITIES (SLUDGES/PONDCRETE PROCESS)	$41,200,000
(A) EQUIPMENT	
(B) INSTALLATION	
(5) UTILITIES	
(6) PROJECT & CONSTRUCTION MGMT	$19,800,000
D STANDARD EQUIPMENT	
E REMOVAL COST LESS SALVAGE	$500,000
F CONTINGENCY	$15,100,000
G TOTAL ESTIMATED COST (ROUNDED TEC)	$107,800,000

The overall contingency for the project is estimated to be approximately 30 percent The total contingency cost is approximately $15 1 million The major factors contributing to the contingency are variations and uncertainty with respect to the project scope and technical uncertainties

IV.8 CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL PLAN

A construction QA/QC Plan will be prepared to describe the QA and QC procedures that will be followed during the construction of the final engineered cover at OU4 Its purpose will be to ensure, with a reasonable degree of certainty, that the completed final engineered cover meets or exceeds all of the requirements of the design criteria and the accepted final design

For clarification purposes, QC is defined as the activities performed by the third party construction contractors in monitoring the construction activities such that all constructed final engineered cover components comply with the construction drawings and specifications QA is defined as the activities performed by the construction oversight contractor for ensuring that the construction contractors have constructed the final engineered cover in accordance with the accepted construction drawings and specifications, and that the contractor(s) have adequately followed and are in compliance with the approved construction QC procedures Construction QC and QA plan outlines are presented in Appendix IV F

Appendix IV G provides a Sampling and Analysis Plan (SAP) that will be implemented to verify that all the contaminated soils have been excavated from areas undergoing remediation outside of the footprint of the final engineered cover

The QC requirements and forms applicable to each construction contractor will be included in the specifications for the general contractor and the electrical, piping, and drilling contractors These contractors are envisioned to be responsible for all construction activities on this project

The Project Quality Assurance Program Plan (PQAP) will establish the quality requirements for the work performed, and shall be in conformance with the requirements of DOE Order 5700 6C, Quality Assurance Quality assurance standards which meet the majority of the requirements of the order for the development and implementation of the quality assurance programs are EPA QMS 005 and ANSI/ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities

IV.9 HEALTH AND SAFETY CONSIDERATIONS

DOE Order 4700 1 requires that a comprehensive health and safety program be established and utilized for all projects to be conducted at DOE facilities The goals of this Environmental Safety and Health (ES&H) Program are to protect DOE employees, contractor employees, and the general public from hazards, to protect property from damage, and to prevent delay or interruptions that can be caused by accidents and fires in connection with the construction activities

A Project Health and Safety Plan was utilized for the RFI/RI sampling activities Prior to the start of the construction of the remedial alternative for the SEPs, a Health and Safety Plan specific to the construction activities will be provided to EG&G for review and approval It will provide specific information related to the Environmental Safety and Health Work Survey, safety and health hazard analysis, personnel training requirements, monitoring requirements, and medical surveillance information pertinent to the scope of work Activities that will be discussed in detail include construction safety, radiation, contamination, and the transportation (both onsite and offsite) of materials Construction of the remedial alternative will not begin until the project-specific Health and Safety Plan has been approved

IV.10 IM/IRA RISK ANALYSIS AND POTENTIAL IMPACT DETERMINATION

The following sections describe the expected impacts the proposed IM/IRA action would have on OU4 and the surrounding area compared to the impacts resulting from implementation of no action Issues addressed include human health and ecological risks, potential effects to air and water quality, impacts to natural resources, transportation, cultural/archeological resources, and other potential impacts Both the proposed IM/IRA alternative and the no action alternative were evaluated quantitatively and qualitatively through modeling and reasonable estimations based on available information It should be noted that the risk-based impacts focus primarily on human health because the OU4 site has been highly disturbed by RFETS industrial activities Therefore, the ecosystem surrounding the SEPs is not considered to support a normal association of vegetation and wildlife Quantitative estimates of potential ecological effects will be addressed in the baseline risk assessment that will be prepared at the conclusion of the Phase II RFI/RI additional hydrogeological studies It is important to note that the comparison of the proposed action to the no-action alternative is included to meet the requirements for an Environmental Assessment (EA) The no-action alternative cannot be selected as the OU4 IM/IRA due to the fact that this alternative failed the threshold comparison criteria (compliance with ARARs, and overall protection of human health and the environment) presented in Section III 5

IV.10.1 Human Health Risk

The proposed IM/IRA action should be protective of and result in no unacceptable risks to human health and the environment The proposed action would eliminate exposure to surface soil and airborne contaminants for the lifetime of the final engineered cover In addition, exposure to contaminants in surface water runoff would be eliminated for the lifetime of the final engineered cover While a potential for contaminants leaching into the ground water exists due to precipitation and infiltration with the proposed action, results of the VLEACH modeling (Section IV 10 4) demonstrate that this potential is negligible By controlling the contaminant leaching to the extent necessary to protect human health and the environment, the proposed IM/IRA complies with the closure performance standards specified in 6 CCR 1007-3, 265 111 and 265 228 Results of the atmospheric distribution calculations (Section IV 10 3) indicate there is negligible risk to the community outside of the Rocky Flats Plant boundary from the proposed action

The ability of the proposed IM/IRA to meet the ARARs and other regulatory requirements was also evaluated An ARAR evaluation of the five GRAs is included in Part III of this Decision Document Only action- and location-specific ARARs were considered in the IM/IRA evaluation No chemical-specific ARARs were identified for the media evaluated as part of the IM/IRA Because surface and subsurface soils are the only media that were considered during the IM/IRA, and because there are no promulgated, chemical-specific ARARs for soil, consideration of only action- and location-specific ARARs was considered sufficient Other regulatory requirements generally include DOE directives and executive orders The proposed action is, therefore, adequately protective of human health and the environment

A detailed ARAR/TBC evaluation is shown in Table III 5-2 This table lists all the proposed action- and location-specific ARARs and denotes which ones are applicable, relevant and appropriate, to be considered, and not ARARs for each of the five GRAs Because General Response Action II is the proposed IM/IRA, the column associated with General Response Action II lists the results of the ARAR evaluation for the proposed IM/IRA The requirements that do not apply include those for generating, storing, and transporting hazardous waste This table presents all the ARARs that the proposed IM/IRA (as well as the other four GRAs) must meet in order to be protective of human health and the environment

Table IV 11-1, Section IV 11 2 shows regulatory requirements and the implementation strategy for the proposed IM/IRA In this evaluation, the regulatory requirements are separated by category and an implementation strategy for each of the requirements is presented This table is designed to provide a listing of all the appropriate regulatory actions that must be completed to implement the proposed IM/IRA As described in the table, each of the requirements should be met using the proposed implementation strategy In this way, the proposed IM/IRA will be protective of human health and the environment by meeting all the pertaining regulatory requirements

IV.10.2 Ecological Risk

A detailed, quantitative environmental evaluation of the potential threats to the natural environment associated with contaminants or the proposed action under the IM/IRA program has not yet been conducted at the site OU4 has been characterized as a highly disturbed industrial area which can support only the most hardy species of plants and animals The natural environment at and adjacent to OU4 has been significantly altered by construction and operation of the SEPs and other industrial facilities (DOE, 1993a) A complete description of the environmental characteristics of OU4 is presented in Section I 4 of this document Vegetation within OU4 boundaries is attributed to previous reseeding programs at the site and natural colonization by some hardy plant species (DOE, 1993a) Wildlife species observed within the OU4 boundaries include small mammals such as deer mice, medium-sized mammals such as desert cottontails and feral cats, and possibly small birds of ground nesting species (DOE, 1992a)

The Preebles Meadow Jumping Mouse (Zapus hudsonius preblei) has been identified to inhabit the area along the banks of North Walnut Creek The OU4 buffer zone area may be used by this species for foraging The Preebles Meadow Jumping Mouse is currently under consideration by the U S Fish and Wildlife Service for listing under the Endangered Species Act as a federal endangered species The species is currently a State of Colorado "Species of Special Concern " The DOE will conduct a habitat study during the 1995 fiscal year to assess whether the remediation of the OU4 buffer zone will impact habitat used by this species The results of the study may have an impact on the remediation plans for any area determined to be habitat for this species Remediation plans could be terminated for these areas; however, the life cycle of the Preebles Meadow Jumping Mouse includes an approximate 6 month hibernation period

Remediation work could be scheduled during the lengthy period of hibernation so that the mouse would not be impacted

A quantitative and qualitative environmental evaluation is a large component of the baseline risk assessment that will be completed for OU4 as part of the additional hydrogeological investigation and focused risk assessment activities for the site Previous environmental sampling programs conducted at OU4 may not have addressed all potential ecological receptors and contaminant fate and transport mechanisms governing ecological exposure No attempt has yet been made to define ecological endpoints to be used to measure adverse effects or "risks" associated with OU4 contamination (e g , reduction in population size due to increased mortality or decreased births or increased emigration or decreased immigration, and changes in community structure due to direct or indirect contaminant influences)

Given the current environmental characteristics of OU4, the objectives of the OU4 IM/IRA program, and DOE's plans to qualitatively and quantitatively assess potential, remaining threats to ecological receptors at OU4 in forthcoming characterization efforts, EPA and CDPHE determined not to require quantitative characterization of the adverse environmental effects associated with contaminants in surficial and vadose zone soils In support of this approach, however, a potential list of contaminant concentration levels that may provide some level of protection for specific ecological receptors (i e , vegetation, rat, mouse, and rabbit) was developed from available guidance materials and technical literature Contaminant concentration levels presented on this preliminary list included concentration limits where no observed effect (NOEL) was measured, lowest observed effect (LOEL) was measured, chronic dose that was lethal to 50 percent of the target population (chronic LD_{50}), and the acute dose that was lethal to 50 percent of the target population (acute LD_{50}) This preliminary list is analogous to the risk-based human health PRGs discussed in Sections III 2 2 and IV 10 1 because specific ecological contaminant concentration "goals" were identified for a variety of measurable adverse assessment endpoints or "risks" to target ecological receptors Comparison of these potential ecological concentration limits to the risk-based human health PRGs developed under the OU4 IM/IRA program demonstrated that the risk-based human health PRGs for surficial soils and vadose zone soils were generally more conservative than the potential ecological concentration limits Quantitative estimates of potential effects due to exposure to remaining OU4 contamination will be addressed in the forthcoming baseline risk assessment once ecological receptors, potential exposure pathways, and target assessment endpoints have been defined

It is possible, however, to qualitatively assess potential physical changes to the OU4 environment as a result of implementing the proposed IM/IRA alternative Approximately 27 acres (1,176,120 ft square feet) within the boundaries of OU4 will be affected by construction of the final engineered cover Relocation of contaminated soils, placement of clean borrow soils, and construction of the final engineered cover will extensively alter the existing topography of the site Current conceptual engineering plans call for the excavation, relocation, and consolidation of 170,230 cubic yards (4 4 x 10^6 cubic feet) of contaminated soil material within the OU4 final engineered cover Interim storage of construction material and clean fill within OU4 will also be required during cover construction Sections of OU4 that potentially may be

used as material staging areas are included in the total affected acreage estimate It is highly probable that these construction activities will interfere with any existing vegetation and animal use of the OU4 site However, installation of the final engineered cover and revegetation of other affected areas within OU4 marks the end of disruptive industrial activity at the site Additionally, implementation of the proposed IM/IRA alternative will likely diminish the nature and extent of additional remediation activities required at the site by isolating potential sources of contamination, which will minimize potential receptor exposure and prevent further environmental migration

IV.10.3 Impact to Air Quality

During the excavation of the SEP liners, underlying soils, and adjacent soils, dust will be released into the air that has the potential to be inhaled by workers performing the excavation, on-site personnel, and the off-site public Additionally, Buildings 788, located between SEPs 207-A and 207-C, and 964, located east of the B-Series SEPs, will also be removed Building 788 and the equipment surrounding the building have been contaminated due to past operations conducted with various contaminants Building 788 is included in RCRA Unit 21, and the surrounding equipment is included in RCRA Unit 48 For the purposes of atmospheric dispersion, the building's fixed contamination does not pose a threat, but any removable contamination could potentially be released during removal operations Fixed contamination is any contamination that can not be readily removed from a surface and the subsequent hazard is from external radiation Removable contamination is that contamination that could be easily removed from a surface by means of air currents, wiping of the surface, or other such events Frequent radiological surveys have indicated that the building surfaces have a detectable amount of removable contamination This removable contamination has the potential to become airborne and be an inhalation hazard to the workers, on-site personnel, and possibly the off-site public To ensure that these receptors will suffer no ill effects as a result of the excavation, computerized air dispersion models were used to estimate worst-case quantities of chemical and radiological contaminants that the receptors might inhale These models will look at the possible health effects related only to the remediation of the SEPs Possible health effects would include any short term toxicological effects and long term increases in cancer risk Hypothetical adult receptors were evaluated for each scenario In additoion, a hypothetical child was included as an off-site receptor for each scenario Note that models such as the ones used to perform these estimates have been determined to be conservative as they are based on empirical data and must cover a wide range of situations The purpose of this conservative calculation was to produce an estimate of the intake (chemical and radiological) that receptors might receive if they are not using personal protective equipment and are exposed for the full duration of the excavation and building removal Also, since some of the chemicals and radionuclides are potential carcinogens, the increase to the receptors' overall cancer risk was determined Cancer risk refers to the chance that an individual will incur a latent cancer later in life due to a given exposure The 95% upper confidence level (UCL) concentrations were used as the source term for the emissions and it has been assumed that the soils are homogeneously contaminated (even though this realistically is not the case) Use of the 95%

UCLs adds conservatism to the final result as those concentrations will provide an upper bound for the wide range of actual soil concentrations Additionally, the 95% UCL concentrations are also being used to represent the contamination of the Building 788 surfaces The use of these reasonable maximum exposure calculations is consistent with the risk analysis presented in Part III 2 Therefore, these are scoping calculations, performed to determine if a less conservative evaluation needs to be done

For the SEPs, the estimation of the receptor subchronic intake involved several steps The chemicals and radionuclides that were evaluated were taken from the list of PCOCs designated in Part III Then various assumptions about the contaminated area and the receptors were defined (breathing rates, body weights, etc) The models that were used for the estimation of the emission rates were chosen from those available in the Air/Superfund National Technical Guidance Series (NTGS) Vol 3 *Estimation of Air Emissions from Clean-up Activities at Superfund Sites* (EPA, 1989a) The model equations for the SEP soil removal are presented in Section IV 10 3 1 After the emission rates had been determined, the removal times for the contaminated soils were defined so that the total emissions from the excavation could be calculated Applicable dispersion factors for the 100 m and 2000 m receptors were identified so the diffusion of the dust plume could be quantified The 100 m distance was chosen as the minimum distance that the dispersion model can accurately predict the dispersion and the 2000 m distance was chosen as it is the distance to the nearest fenceline A separate model was used to calculate the worker subchronic intakes Once the dispersion factors have been defined, the total subchronic intake of each receptor can be calculated This is done using an equation that combines all of the previously discussed information, the breathing rate of the receptor, the diffusion of the plume, the removal time, and the emission rate As stated earlier, the worker receptor uses a separate model called a Nearfield Box Model This model consists of two equations the first determines the contaminant concentration close to the equipment and the second provides the intake of the worker Once the intakes have been calculated, the hazard quotient and the overall cancer risk incurred from the intake were quantified The basic methodology of the Risk Assessment Guidance for Superfund (RAGS) Part A (EPA, 1989c) was used to find these quantities

The model that was developed for Building 788 was based on very conservative assumptions due to the lack of actual characterization data for either RCRA Unit 21 or 48 The surfaces of the building and the equipment are assumed to be covered with a contaminated dust layer 1/10th mm thick This quantity of dust is the source term for the model It has been assumed that both RCRA units have contamination levels characteristic of the soils underlying the SEPs The higher of the surficial or vadose zone numbers has been used for the calculation to yield a more conservative answer

The radiological impacts from the demolition of Building 788 were calculated using the CAP88-PC (EPA, 1992c) computer modeling package for all receptors except the worker The worker has been modeled using the same Nearfield Box Model as used in the SEPs estimates The RCRA contaminants were modeled using the methodology of RAGS Part A, with additional information incorporated from the work of Jofu Mishima in the *Defense Programs Safety Survey*

- *Airborne Release Fractions/Rates Respirable Fractions* (1993) The CAP88-PC model determines the incremental cancer risk (ICR) and the radiological dose equivalent from the inhalation of the dust releases From the RCRA contaminants, the RAGS methodology was followed to yield both the hazard index and the ICR for all the receptors except the worker The worker intake, calculated using the Nearfield Box Model, used the RAGS methodology for the calculation of the hazard index and the ICR was then applied

Also evaluated were the air emissions from the inclusion of the sludge and the pondcrete with the soils which are to be placed under the final engineered cover For this scenario, it was assumed that the crushing and mixing activities were to be carried out inside a tent-like structure (i e permacon) and then loaded into a dump truck which would then dump the mixture into the excavated SEPs for final disposition Since there are no models available that can adequately estimate the emissions from the crushing and mixing activities a tent structure equipped with a single stage HEPA filter was assumed The normal operations emissions and an accident condition emissions (loss of the structure containment) were evaluated The dumping aspect was modeled using an equation from the NTGS document (EPA 1989a) The source term for the mixture was compiled based on the 95%UCLs for the sludges, pondcrete, and soils Weight fractions were utilized to yield an overall mixture 95%UCL for each contaminant

Section IV 10 3 1 explains the modeling for the SEPs, Section IV 10 3 2 explains the modeling of the Building 788 dismantlement, and Section IV 10 3 3 looks at the incorporation of the pondcrete, sludge, and soil under the cap Note that any emissions from the placement of the utilities and debris under the final engineered cover will be inconsequential in comparison to the other dust emissions sources Summary of Receptor Exposure Factors are presented in Table IV 10-1 The final results of the air modeling for the SEP excavation, Building 788 D&D, and Crushing and Dumping are presented in Table IV 10-2 This table presents the cancer risk, radiation dose equivalent, and the hazard index for each receptor These values are the summation of Tables IV 10-3, IV 10-4, and IV 10-5, each of these tables is a summary of a specific piece that comprises the overall remediation activity The final results for the pondcrete/sludge/soil mixture are presented in Tables IV 10-5 and IV 10-6 Table IV 10-5 presents the normal operations phase which includes crushing, mixing, and dumping of the mixture constituents Table IV 10-6 presents the results from a hypothetical accident condition in the mixing and crushing operation Also within Appendix IV I are the individual contaminant outputs for each receptor and scenario

Based on previously conducted radiological surveys, Building 964 is assumed to be clean Therefore, no air quality modeling was developed for Building 964 and no impact to air quality from the demolition of Building 964 is expected

TABLE IV.10-1
SUMMARY OF RECEPTOR EXPOSURE FACTORS

Receptor	Breathing Rate (m^3/hr)	Body weight (kg)	Distance from source (m)	Exposure Frequency (hr/day)	Receptor Lifetime (yr)
Worker	1 2	70	In work zone	24	50
On-site Adult	1 2	70	100	24	50
Off-site Adult	1 2	70	2000	24	50
Off-site Child	0 83	19 7	2000	24	70

TABLE IV 10-2
SUMMARY TABLE OF RECEPTOR RESULTS
FINAL RESULTS OF AIR IMPACT MODELING

Receptor	Hazard Index	Incremental Cancer Risk	Dose Equivalent (mrem)
On-site Adult	1 1E-02	2 8E-06	3 4E+00
Off-site Adult	2 4E-04	3 9E-08	7 4E-02
Worker	4 5E-02	1 6E-06	5 7
Off-site Child	5 9E-4	6 4E-08	5 1E-02

Note Includes Normal Operations, Building 788 D&D, and SEP Excavation

TABLE IV 10-3
RECEPTOR RESULTS FOR SEPS

Receptor	Hazard Quotient	Incremental Cancer Risk	Dose Equivalent (mrem)
On-site Adult	1 1E-02	1 4E-06	3 2
Off-site Adult	2 4e-04	3 0e-08	7 2E-02
Worker	1 1e-02	1 4e-06	3 2
Off-site Child	5 9e-04	5 8e-08	5 0E-02

TABLE IV 10-4
RECEPTOR RESULTS FOR BUILDING 788

Receptor	Hazard Index	Incremental Cancer Risk	Dose Equivalent (mrem)
On-site Adult	2 6E-06	1 4E-06	1 4E-01
Off-site Adult	1 7E-08	9 0E-09	9 4E-04
Worker	3 4E-02	2 2E-07	2 5
Off-site Child	4 2E-08	6 2E-09	6 5E-04

TABLE IV 10-5
RECEPTOR RESULTS FOR PONDCRETE/SLUDGE/SOIL MIXTURE (NORMAL OPERATIONS)

Receptor	Hazard Quotient	Incremental Cancer Risk	Dose Equivalent (mrem)
On-site Adult	5 6E-05	4 0E-09	3 4E-02
Off-site Adult	1 2E-06	8 8E-11	7 5E-04
Worker	5 6E-05	4 0E-09	3 4E-03
Off-site Child	3 1E-06	9 0E-11	5 2E-04

Note Includes Crushing, Mixing, and Dumping of the Mixture

TABLE IV 10-6
RECEPTOR RESULTS FOR PONDCRETE/SLUDGE/SOIL MIXTURE (ACCIDENT CONDITION)

Receptor	Hazard Quotient	Incremental Cancer Risk	Dose Equivalent (mrem)
On-site Adult	2 7E-04	2 0E-08	1 7E-01
Off-site Adult	6 0E-06	4 4E-10	3 8E-03
Worker	2 7E-04	2 0E-08	1 7E-01
Off-site Child	1 5E-05	9 2E-10	2 6E-03

IV.10.3.1 SEP Air Dispersion Modeling

Various assumptions were utilized in the models including

1) Mass of a reference adult is 70 kilograms (kg) (Shleien, 1992),
2) Mass of a 6 year old child is 19 7 kg (EPA, 1990),
3) Downwind exposure height is 2 meters (m),
4) Width of the contaminated area is 3600 m,
5) Average breathing rates are 1 2 m^3/hour (light activity) for the adult (Shleien, 1992) and 0 83 m^3/hour for the child (EPA, 1990),
6) Respirable particles are less than 15 microns in diameter (EPA, 1989a),
7) Workday is 24 hours (three 8 hour shifts),
8) Receptors include a worker (among the excavation equipment), on-site personnel (worker) 100 m from the excavation, an off-site resident at the nearest fenceline (2000 m), and a child at the fenceline (2000 m),
9) Receptors remain in the plume 24 hours/day (maximum dose from the removal activities), and
10) A scraper weighs 30-50 tons and travels at speeds of 10-20 miles per hour and two scrapers are assumed to be used for the removal of other (soils on north hillside and around north road) soils and four backhoes are assumed to be used for the removal of pond soils
11) Adult lifetime of 50 years and a child lifetime of 70 years was assumed

These assumptions are, for the most part, conservative assumptions Some of the conservatisms are explained here The lifespan of a human being is typically 70-75 years, and therefore, the receptor lifetime for a child was assumed to be 70 years and for an adult (age 20-30 years), the receptor lifetime was assumed to be 50 years A 6 year old child was chosen because this was believed to be the youngest age of a child that may be near the site boundary with a parent to inhale any contaminants The breathing rate that is normally used by DOE (0 96 m^3/hr) for adult receptors is less than that being used here (see DOE Order 5400 5) By using the increased breathing rate, the receptors will receive a higher intake Item 7 adds conservatism as no worker will work for an entire 24-hour shift, even though it is possible for the off-site receptors to remain within 2,000 meters of the work being completed for the entire 24 hour/day shift Item 9 is a source of conservatism as the plume will not be directed toward the receptors for the entire 24-hour period due to almost hourly changes in wind speed and wind direction

The soil removal process will encompass several steps including excavation, transport, storage, processing, and dumping Most of the emissions are expected from the excavation phase of the removal action The modeling equations used are from Table 24 of the NTGS (EPA, 1989a) They are

$$\text{Backhoe Excavation Emission Rate (kg/hr)} = 0.45 (s)^{1.5} (M)^{-1.4}$$

$$\text{Dumping Emission Rate (kg/Mg)} = k(0.0016) \left(\frac{U}{2.2}\right)^{1.3} \left(\frac{M}{2}\right)^{1.4}$$

$$\text{Scraper Excavation Emission Rate (kg/hr)} = 2.2 \times 10^{-6} (s^{1.4}) (W^{2.5}) Sp$$

Where

s	=	the silt content of the soil (32.5 wt %) (Chap II),
M	=	the gravimetric moisture content of the soil (14.9 wt %) (Chap II),
k	=	the particle size multiplier from Table 23 of NTGS for 15 microns or less, value is 0.35 dimensionless,
U	=	the mean wind speed (5 m/sec) from Table 1.1 of the Air Quality Management Plan Rocky Flats Plant (EG&G),
W	=	the mean weight of the scraper (40 tons), and
Sp	=	the mean speed of the scraper (15 mph)

The end result of the air emission models are emission rates of 1.9 kg/hr for the backhoe, 55.2 kg/hr for the scraper, and 9.8×10^{5} kg/Mg for the dump truck. If a dumping rate of 8 ton/hr (7.3 Mg/hr) is used (EPA, 1989a) an emission rate of 7.2×10^{-4} kg/hr can be calculated. The emissions rate for the dump truck is four orders of magnitude lower than the backhoe rate and as such is assumed to be inconsequential. Therefore, no emissions estimates were determined from the dumping of the soils. The models were developed using worst-case empirical data and are therefore intrinsically conservative. The emission rates are mean values but are conservative due to the conservative nature of the models.

Separate 95 percent UCLs were calculated for the surficial and vadose zone soils. Use of the total soil excavation volumes, as discussed within Part IV of this document, will add conservatism to the emission estimates due to the assumed heterogeneous nature of the contamination in the soils. The following paragraphs describe how the removal times for the surficial and vadose zone soils were determined for all chemicals.

The removal time is the length of time it takes to remove contaminated soils. This time period is used to determine the total amount of dust that is emitted during the soil excavation. In calculating the removal times for the surficial and vadose zone soils, the type of equipment that will be used to remove the soils must be assumed. There are two areas that will be excavated. The first is under the pond liners and the second is the area of other soils around the SEPs. The soils underlying the liners will be removed using backhoes, and therefore the backhoe removal rate is used for that section. The other soils are to be removed using scrapers, and so the removal rate for the scraper must be used for that section. The choice of these pieces of equipment is based on the area to be excavated, the ability of the equipment to perform the removal, and professional judgement. Typical removal rates for the backhoe and scraper can

be found from NTGS, Table 32 (EPA, 1989a) An average bucket size for the backhoe and scraper is assumed, so average removal rates are used It is assumed that each bucket load will be half-full This assumption adds an additional source of conservatism to the overall result Based upon these assumptions, the excavation rate for the backhoe is determined to be 300 m^3/day The total number of days for the excavation of the soil by the backhoe was calculated from the volume of soil and the excavation rate The removal rate for the scraper is 235 m^3/day as calculated by the same method used for the backhoe The equation used to calculate the removal times is

$$Removal\ Time\,(hr) = \frac{Volume\,(m^3)}{Equipment\ Removal\ Rate\,(\frac{m^3}{day})} * Workday\,(\frac{hr}{day})$$

To determine the dispersion factors the CAP88-PC model was used One function of this air modeling program is that it provides dispersion factors (χ/Q) for user input distances A ground release and a contaminated area with a width of 3,600 m were assumed The model also took into account the actual atmospheric conditions at the RFETS (prevailing wind patterns, average wind speeds, etc) The χ/Q values used for 100 m and 2,000 m are 2 8E-5 sec/m^3 and 6 2E-7 sec/m^3, respectively

The subchronic intakes of the on-site and off-site receptors are determined by the following formula

$$Intake\ (mg\,(pCi)) = \frac{\chi}{Q}\,(\frac{sec}{m^3}) * BR\,(\frac{m^3}{sec}) * RT\,(hr) * ER\,(\frac{mg\,(pCi)}{hr})$$

Where

χ/Q	=	the dispersion factor defined previously,
BR	=	the breathing rate as previously defined,
RT	=	the removal time as previously defined, and
ER	=	the emission rate as previously defined

Intakes were calculated for each PCOC for both the surface and vadose zone soils, as appropriate Intakes are either in mg or pCi, depending upon whether the emission rate is in mg/hr for non-radioisotope chemicals or pCi/hr for radionuclides

Worker intakes were calculated using a Nearfield Box Model (DOE, 1992b) This model is capable of determining the air concentrations close to the release point The Nearfield Box model is shown below

$$C_a = Q / (H_b W_b U_m)$$

Where

Q	=	the contaminant emission rate (mg/sec) or (pCi/sec),
H_b	=	the downwind breathing height (2 m),
W_b	=	the width of contaminated area (3600 m),
U_m	=	the mean wind speed (5 m/sec), and
C_a	=	the contaminant air concentration (mg/m^3) or (pCi/m^3)

Once the air concentrations have been determined, the dose can be calculated using the following equation (DOE, 1992b)

$$Intake = C_a * BR * RT$$

Where

Intake	=	the amount inhaled (mg for chemicals and pCi for radionuclides),
C_a	=	the contaminant air concentration as defined earlier,
BR	=	the breathing rate as previously defined, and
RT	=	the removal time as previously defined

Tables IV 10-2 through IV 10-5 provide the final intake estimates and cancer risks for the excavation of the SEPs and the other soils The cancer slope factors and reference doses that were used in these tables were found in several sources, IRIS, HEAST, and MEPAS As appropriate, these values are displayed in Tables III-B 7 and III-B 8 of Appendix III B IRIS (Integrated Risk Information Source, Micromedix 1994) is an EPA data base that provides up-to-date hazard information for many chemicals, this source was the first choice for information If IRIS could not provide the applicable information, HEAST (Health Effects Exposure Assessment Summary Tables) for 1993 was used (EPA, 1992b) The final source, MEPAS, (Multimedia Exposure Pathway Assessment System)(Strenge et al, 1989), is an older reference that was originally created to model exposures, however, it was not used for this purpose as the models have become outdated The accompanying documentation to MEPAS does, however, provide chemical toxicity information for a wide number of chemicals The overall hierarchy for selecting the slope factors and reference doses was IRIS, followed by HEAST, and finally falling back on the MEPAS values Using these three references, it was possible to find toxicological information for all of the chemicals in the soils of the SEPs

The subchronic daily intake (SDI) is calculated by taking the subchronic intake (SI) that was found from the models and dividing these by the receptor body weight and the appropriate averaging time

$$SDI = \frac{SI}{Body\ Weight * Averaging\ Time}$$

The averaging time is dependent on if the chemical is a carcinogen or not If the chemical is a carcinogen then the averaging time is the receptor lifetime as given in Table IV 10-1 For a non-carcinogen the averaging time that is used is the time within which the remediation is expected to be completed For this analysis this was assumed to be six months (182 days)

Tables IV I-1 through IV I-4 also present the non-cancer hazard quotients for each chemical The hazard quotients estimate a chemical's potential for non-carcinogenic effects This potential is evaluated by comparing the intakes, calculated over a specified time period (e g removal time) with a reference dose derived for a similar exposure period The ratio of exposure to toxicity is called a hazard quotient according to the following equation

Noncancer Hazard Quotient = SDI/RfD

Where

SDI	=	subchronic daily intake, and
RfD	=	the chemical specific reference dose

The non-cancer hazard quotient (or just hazard quotient) assumes that there is a level of exposure (i e , RfD) below which it is unlikely for even sensitive populations to experience adverse health effects If the subchronic daily intake (SDI) exceeds the threshold (i e , if hazard quotient exceeds unity) there may be concern for potential non-cancer effects As a rule, the greater the value of SDI/RfD above unity (1 0), the greater the level of concern

To assess the overall potential for noncarcinogenic effects posed by more than one chemical, a hazard index (HI) approach has been developed by EPA This approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures The overall HI for the mixture of chemicals is just the summation of all the individual hazard quotients

While any single chemical with an exposure level greater than the toxicity value will cause the hazard index to exceed unity, for multiple chemical exposures the hazard index can also exceed unity even if no single chemical exposure exceeds its RfD The assumption of dose additivity reflected in the hazard index is best applied to compounds that induce the same effects by the same mechanisms Applying the hazard index to cases where the known compounds do not induce the same effect may overestimate the potential for effects

Tables IV I-1 through IV I-4 also provide the total subchronic intakes (SI) for the various chemicals The SDI was not directly calculated so the equation for the hazard quotient was

modified to include the "normalization" of the SI to SDI The equation for hazard quotient then becomes the following

$$Hazard\ Quotient = \frac{SI}{BW*AT*RfD}$$

Where

SI	=	the subchronic intake
BW	=	the body weight of the receptor
AT	=	the averaging time of six months (182 days)
RfD	=	the chemical specific reference dose

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (i e , excess individual lifetime cancer risk) The slope factor converts estimated intakes averaged over a lifetime of exposure directly to incremental cancer risk Under this assumption, the slope factor is a constant, and risk will be related directly to intake Thus, the following risk equation was used in this assessment

$$ICR = SDI * SF$$

Where

ICR	=	Incremental Cancer Risk,
SDI	=	Subchronic Daily Intake (mg/(kg*day)), and
SF	=	chemical specific slope factor (mg/(kg*day))[1]

This equation is only valid for risks estimated at less than one in one hundred (1 0E-2) For greater (> 1 0E-02) risks, another equation could be used This was unnecessary for this assessment

Because the slope factor is often a 95 percent UCL of the probability of a dose response (based on experimental animal data), the carcinogenic risk will generally be an upper-bound estimate This means that the "true risk" is not likely to exceed the risk estimate derived through this model and is likely to be less than predicted The calculation of the overall cancer risk is done by finding the sum of the individual cancer risks for each contaminant

Tables IV I-1 through IV I-4 provide the total subchronic intakes (SI) for the various chemicals The SDI was not directly calculated so the equation for the hazard quotient was modified to include the "normalization" of the SI to SDI This is basically the identical normalization that was used for the non-carcinogens The equation for incremental cancer risk then becomes the following

$$ICR = \frac{SI*SF}{BW*AT}$$

Where

SI	=	the subchronic intake
BW	=	the body weight of the receptor
AT	=	the lifetime of the receptor provided in Table IV 10-1
SF	=	the chemical specific slope factor

The quantification of the actual radiation dose from the internal deposition of the various radionuclides was performed by multiplying the dose conversion factor (DCF) of the radionuclide by the intake (pCi) that was calculated earlier The use of the DCFs provides a method in which the radiological dose equivalent in mrem can be calculated for those quantities of radioactive material which might be inhaled (ICRP 30, 1982) Tables IV I-5 through IV I-8 present the results of the radiation dose calculation The highest dose to any receptor was calculated for the worker (3 2 mrem) and the on-site personnel (3 2 mrem) The other receptors and their respective doses were, off-site adult resident, 0 07 mrem, off-site child resident, 0 05 mrem

Results of the conservatively estimated atmospheric dispersion associated with the removal of the asphalt liners and the soils under and around the SEPs indicates no significant increase in the overall cancer risk or noncarcinogenic effects to the workers, on-site personnel, or the off-site public The increase in the cancer risk is equal to or less than 1 0E-5 for all of the hypothetical receptors The hazard index is equal to or less than 1 0E-2 for all hypothetical receptors The overall lifetime radiation dose equivalent for inhalation intakes to the receptors is less than 4 mrem All these estimates are within the EPA-defined acceptable risk ranges The final results for the SEP excavation are presented in Table IV 10-3

IV.10.3.2 Building 788 Air Dispersion Modeling

Various assumptions were used in the models, including

1) Mass of a reference adult is 70 kilograms (kg) (Shleien, 1992),
2) Mass of a 6 year old child is 19 7 kg (EPA, 1990),
3) Downwind exposure height is 2 meters (m),
4) Cross wind width of the contaminated area is 225 ft,
5) Average breathing rates are 1 2 m^3/hour (light activity) for the adult (Schleien, 1992) and 0 83 m^3/hour for the child (EPA, 1990),
6) Respirable particles are less than 15 microns in diameter (EPA, 1989a),
7) Workday is 24 hours (three 8 hour shifts),
8) Receptors include a worker (among the excavation equipment), on-site personnel (worker) 100 m from the excavation, an off-site resident at the nearest fenceline (2000 m), and a child at the fenceline (2000 m),

9) Receptors remain in the plume 24 hours/day (maximum dose from the removal activities),
10) An airborne release fraction (ARF) of 1 0E-3 was used for the Building 788 model, [This fraction represents the fraction of dust that could become airborne (Mishima, 1993)],
11) A respirable fraction (RF) of 1 0 was used for the Building 788 model [This represents the fraction of dust that can be inhaled by the receptor (Mishima, 1993)],
12) The dust layer is 1/10 mm on all surfaces,
13) Only 50 percent of the building walls have dust adhering to the surface, and
14) The density of the dust is that of a soil, 0 6 g/cm^3 (Perry, 1986)

The demolition of Building 788 will be completed by systematic dismantling of the building structure and removal of the various equipment An estimation of the amount of contaminated dust that is on the building and equipment surfaces was made by estimating the overall surface area of the building from construction drawings and using the dimensions and volumes of the equipment provided in the EG&G Building 788 Radiological Characterization Plan The overall surface area was found to be approximately 4,000 m^2 With the assumption of a dust layer of 1/10 mm (1 0E-4 m), the volume of the dust layer is 0 4 m^3 The total mass of the dust layer can then be found by using the dust density of 0 6 g/cm^3 to yield 2 0E5 g of dust (this being conservative)

Assuming 2 0E5 g of dust, the amount of respirable particles of each contaminant that are airborne was determined by the multiplication of the 95 percent UCLs and the dust mass calculated above The end result is the amount of each constituent airborne (in respirable particles) in either units of pCi for the radionuclides or mg for the chemicals The subchronic intake for each of the receptors was calculated using the following formula

$$Intake = Breathing\ Rate * \frac{\chi}{Q} * ARF * RF * Amount\ of\ Chemical$$

Where

Amount of Chemical = the mg of chemical or pCi of radionuclide airborne
(All other parameters were previously defined)

The factors in this equation for the breathing rates and χ/Q are identical to those used in the SEP modeling (Sec IV 10 3 1) This equation was used for the chemical constituents For the radionuclides, the CAP88-PC software was used to determine the on-site adult, off-site adult, and off-site child effective-dose equivalents and incremental cancer risks The inputs to this program consist of the amount of pCi present for release (calculated above), the distance

to the receptors, and the meteorological information provided for RFETS The results of the CAP88-PC model are presented in Table IV I-14

The modeling of the worker intake was done in the same manner as outlined in Sec IV 10 3 1, by using the Nearfield Box Model Also, the calculations of the hazard index and the incremental cancer risks were completed in the same manner as outlined in Sec IV 10 3 1

The results of the atmospheric dispersion associated with the demolition of Building 788 indicate no significant increase in the overall cancer risk or carcinogenic effects to the workers, on-site personnel, or the off-site public The increase in the cancer risk is equal to or less than 1 0E-6 for all of the hypothetical receptors The hazard index is less than 1 0E-1 for all hypothetical receptors The overall lifetime radiation dose equivalent for inhalation intakes to the receptors is less than 3 mrem These estimates are all below the EPA-defined acceptable risk ranges The model results for the non-radionuclide contaminants are presented in Tables IV I-9 through IV I-12 For radionuclides, the results are given in Tables IV I-12 and IV I-14 A final summary of the Building 788 air impacts is given in Table IV 10-4

Based on previously conducted radiological surveys, Building 964 is assumed to be clean Therefore, no air quality modeling was developed for Building 964 and no impact to air quality from the demolition of Building 964 is expected

IV.10.3.3 Crushing and Dumping Air Dispersion Modeling

This section outlines the modeling that was done in order to estimate the possible health effects to hypothetical receptors from the crushing and dumping of the soil/pondcrete/sludge mixture Assumptions for this model are no different than those used in Section IV 10 3 1 with the addition of assuming a time-based emission factor for the dumping of 8 ton/hr (EPA 1989a) This number is the maximum emissions factor from the NTGS document The scenario of interest is the possible emissions from the crushing and mixing operations and then the subsequent dumping of the mixture into the trucks for transport and dumping into the final disposal area An accident condition involving the crushing and mixing operations was also evaluated that will result in the loss of the tent structure covering these operations

The first step in evaluating the emissions is to determine a 95% UCL for the mixture The mixture 95% UCL is found by utilizing the weight fractions, presented in Table IV 10-7, and the 95%UCLs for the specific source Note that the weight fractions presented in Table IV 10-7 do not include any additional drying additives that may be used in pretreating the sludges and pondcrete

TABLE IV.10-7
SLUDGE, PONDCRETE, AND SOILS DATA

Source	Mixture (lbs)	Weight Fraction	Specific Gravity (g/cm^3)	Mass (g)	Volume (cm^3)	Volume (yd^3)
SEP 207 A	2 58E+03	5 61E-06	1 02	1 17E+06	1 15E+06	1 49E+00
SEP 207 B-North	2 15E+05	4 68E-04	1 02	9 75E+07	9 55E+07	1 24E+02
SEP 207 B-Center	8 06E+04	1 75E-04	1 03	3 66E+07	3 55E+07	4 62E+01
SEP 207 B-South	5 10E+04	1 11E-04	1 02	2 32E+07	2 27E+07	2 95E+01
SEP 207 C	4 58E+05	9 98E-04	1 44	2 08E+08	1 44E+08	1 88E+02
Clarifier	6 04E+04	1 31E-04	1 25	2 74E+07	2 19E+07	2 85E+01
Pondcrete	2 22E+07	4 84E-02	1 31	1 01E+10	7 69E+09	1 00E+04
Vadose Soils	3 68E+08	8 01E-01	1 68	1 67E+11	9 94E+10	1 29E+05
Surficial Soils	2 42E+07	5 27E-02	1 68	1 10E+10	6 54E+09	8 50E+03
Liners	4 40E+07	9 58E-02	2 2	2 00E+10	9 08E+09	1 18E+04
Total	4 59E+08	1 00E+00	N/A	2 08E+11	1 23E+11	1 60e+05

With the weight fractions and the 95%UCLs known, a composite mixture 95% UCL is determined using a basic summation formula

Composite 95% UCL = Σ [specific weight fraction * specific 95% UCL]

The specific weight fractions come from Table IV 10-7 and the sources for the weight fractions are matched up with the 95% UCLs for each source The end results are a chemical specific 95% UCL for each contaminant within the mixture These chemical 95% UCLs are then used as the source information for the emissions modeling Table IV 10-8 presents the total weighted 95% UCLs that are used, note that the values are in units of mg/kg for the chemical contaminants, and pCi/kg for the radionuclides

TABLE IV.10-8
TOTAL WEIGHTED 95% UCLS FOR THE SLUDGE/PONDCRETE/SOIL MIXTURE
VALUES ARE IN UNITS OF MG/KG (CHEMICALS) OR PCI/KG
(RADIONUCLIDES)

Constituent	95% UCL	Constituent	95% UCL
2-Butanone	5 4E-02	Strontium 89/90	4 3E-01
Acetone	2 4E-01	Sulfide	3 3E+01
Americium 241	4 0E+00	Toluene	1 7E-01
Arochlor-1254	1 7E-01	Tritium	4 3E+00
Arsenic	4 6E+00	Uranium 233	3 3E+00
Barium	1 0E+02	Uranium 234	1 2E+01
Benzo(a)anthracene	4 4E-02	Uranium 235	5 2E-01
Benzo(a)pyrene	4 6E-02	Uranium 238	1 6E+01
Benzo(b)fluoranthene	2 0E-02	Zinc	1 1E+01
Benzo(g,h,i)perylene	3 5E-02		
Benzo(k)flouranthene	2 2E-02		
Beryllium	2 2E-01		
Bis(2-ethylhexyl)phthalate	6 0E-01		
Cadmium	2 2E+02		
Calcium	2 0E-02		
Cesium 134	2 0E-02		
Cesium 137	4 5E-02		
Chloroform	1 0E-02		
Chromium	6 3E+01		
Chrysene	5 0E-02		
Cyanide (total)	1 4E+01		
Di-n-butyl phthlate	2 1E-01		
Fluoranthene	2 0E-02		
Indeno(1,2,3-cd)pyrene	3 8E-02		
Lithium	1 3E+01		
Manganese	2 0E+02		
Mercury	1 5E+00		
Methylene Chloride	2 5E-02		
Nitrate	1 6E+03		
Nitrite	1 5E+03		
Phenanthrene	2 0E-02		
Plutonium 239/240	1 8E+02		
Potassium	2 3E+03		
Pyrene	4 0E-02		
Radium 226	1 2E+00		
Silicon	2 0E+02		
Silver	2 8E+00		
Sodium	4 8E+03		

Using the source term, the overall intake to the hypothetical receptors can be evaluated This is done in a similar fashion as the excavation of the soils Using the emission rate equation for dumping that was presented earlier a rate of approximately 2E-4 kg/Mg (Mg is Mega-grams) is found This is then used to generate chemical specific emission rates using the following equation

$$\textit{Chemical Emission Rate}(mg/hr) = EF * ER * 95\% UCL$$

Where

EF	=	the Emission Factor of 8 ton/hr (7 3 Mg/hr)
ER	=	the Dumping Emission Rate of 2E-4 kg/Mg times 2
95% UCL	=	the 95% UCL from Table IV 10-8

Note that the value for ER is multiplied by 2 in order to account for dumping the mixture twice (into the truck and into the SEPs) The resulting chemical emission rate can then be used to estimate the overall intake to the hypothetical receptors using the appropriate breathing rates, dispersion factors (both used previously) and the time estimate for the completion of the dumping activities To calculate the time estimate, the total weight of the dry sludge from Table IV 10-7 in pounds is converted to tons and then divided by the Emission Factor The result of this calculation is approximately 26,000 hours This time estimate may appear to be unreasonably long, however, this would be for just one truck to complete the entire dumping operation Obviously more than one truck will be used during the project and therefore the actual time will be less, this does not, however, change the emission estimate If four trucks were used the time would be quartered but the emission rate would increase by four times, and the end result would be the same amount of emissions

The intake for all receptors (on-site, off-site, and worker) is then determined using the same intake equations as presented in Section IV 10 3 1, the only difference being the removal time which is 26,000 hours Also the determination of the hazard quotient and the cancer risk for each of the chemicals is performed in the same manner as previously in Section IV 10 3 1 The end result will be the overall hazard quotients and cancer risks to each receptor as a result of the disposition of the mixed materials

Once the dumping phase has been calculated the crushing and mixing phase of the operation shall be addressed This discussion describes the operation as it might occur normally within a tent structure (containment) while utilizing a HEPA (High Efficiency Particulate Air) filter unit to control the dust emissions (normal operations) A second scenario for a hypothetical accident condition involving the loss of the containment occurs with the subsequent release of dust to the atmosphere was also evaluated For these scenarios, the following assumptions were utilized One is that the entire mass of the wet sludge is available for dispersal (this assumption will be discussed further) Also the ARF (Airborne Release Fractions) and RF (Respirable Fractions) used in these scenarios are taken from "An Assessment of the Risk of Transporting Plutonium Dioxide and Liquid nitrate by Train" (PNL 1977) In this study

the material of interest was plutonium dioxide powder which should be more dispersible (easier to be made airborne) than the soil/sludge/pondcrete mix and is therefore believed conservative The value for the ARF is 1E-03 and for the RF a value of 1E-03 is used (both are unitless) Additionally, the efficiency of a HEPA filter is typically assumed to be 99 97%

The normal operations phase will have dust emissions that are inherent when concrete blocks of any size are to be crushed The actual emission rate from such an operation is not readily known, therefore in order to better protect any potential receptors, a tent enclosure with a HEPA filter should be used to control potential dust emissions The release of dust emissions from this enclosure can then be modeled using a "black box" approach This means that the crushing operation is modeled as if it were taking place inside a box and the emissions from this box are then estimated This approach allows flexibility in the operations that occur inside the enclosure, the estimation will be legitimate as long as there is a HEPA filter in place to filter the air before it is released In order to do this the entire mixture mass was employed as the source term The total amount of material that is inhaled by the hypothetical on-site and off-site receptors can be found using the following equation

$$Intake = \frac{Total\ Mixture\ Mass}{1000\ g/kg} * RF * ARF * HEPA * \frac{\chi}{Q} * BR * 95\%\ UCL$$

Where

Total Mixture Mass is from Table IV 10-7 in units of grams
RF is the Respirable Fraction defined earlier
ARF is the Airborne Release Fraction defined earlier
χ/Q is the dispersion factor as in Sect IV 10 3 1
BR is the Breathing Rate as in Sect IV 10 3 1
95% UCL is the chemical specific 95% UCL as in Table IV 10-8
HEPA is 1 minus the HEPA efficiency of 0 9997
Intake is the amount inhaled in units of milligrams or pCi, as appropriate

For this calculation the total mixture mass is used as the source term because all of this material will be crushed and/or mixed together in order to produce a homogeneous mixture

The total amount of material that is inhaled by the hypothetical worker receptor can be found using the following equation

$$Intake = \frac{\frac{Total\ Mixture\ Mass}{1000\ g/kg} * RF * ARF * HEPA * BR * 95\%\ UCL}{H * W * U}$$

Where

All of these parameters have been defined earlier either in this section or in Sections IV 10 3 1 or IV 10 3 2

This equation is similar to the one used in Section IV 10 3 1 and IV 10 3 2 The difference is that now an emission rate is not needed to yield the amount of material that is likely to be dispersed Once the intake has been calculated the hazard indices and the cancer risks are found in the same manner as in Section IV 10 3 1 The results of the normal operations phase, which includes the crushing/mixing and dumping operations, are presented in Tables IV I-15 to IV I-22 with a result summary in Table IV 10-5 The first block of tables presents the chemical and radionuclide specific results and the summary shows the individual receptor results

The accident scenario that was postulated occurs if, during normal operations, the tent enclosure undergoes a catastrophic failure that results in 100% loss of containment This loss of containment accident will use as its source term the entire mixture mass, as was done for the normal operations scenario This situation is not the most probable as operations will be halted if such an event were to occur, thereby resulting in only a small fraction of the mixture being available as a source term The entire mass is used since this is a scoping calculation If the results of this accident show little risk, then the actual risk will be substantially less The results of the accident condition are presented in Tables IV I-23 to IV I-30 with a result summary in Table IV 10-6 The first block of tables presents the chemical and radionuclide specific results and the summary displays the individual receptor results

The equations that are used to estimate the intakes to the receptors from the loss of the containment are similar to the ones used for the normal operations phase The only difference is that the HEPA fiter term is not used in the accident condition Then, as before, the hazard indices and cancer risks are calculated using the methodology presented in Section IV 10 3 1

The final results of both the normal operations and the accident condition yield results that are less than the potential health risk from the excavation phase The hazard quotients that have been calculated for both normal operations and the accident condition are orders of magnitude lower than that of the excavation phase The incremental cancer risk is one order of magnitude or more lower than the excavation phase and the radiological dose is also several orders of magnitude lower These results indicate that the excavation phase poses the most significant health threat and that health threat is also minimal based on these very conservative calculations

These calculations are based on conservative assumptions However, even with such conservative assumptions the results are below the EPA guidelines for risk values (10^{-4} to 10^{-6}) The results could be lowered by several orders of magnitude with the use of less conservative (more realistic) assumptions As such these calculations are for scoping purposes only However, these calculations predict that the impact to the air quality from the proposed IM/IRA is negligible

IV.10.4 Impact to Ground Water Quality

Potential adverse impacts to ground water resulting from existing OU4 site conditions and the implementation of the preferred IM/IRA were evaluated using quantitative fate and transport models The purpose of these analyses was to demonstrate that the implementation of the preferred IM/IRA would provide long-term protection for ground water and surface water The purpose of modeling downward contaminant migration through the proposed final engineered cover into the consolidated materials, which includes liners, sludge, pondcrete, surface soil, and vadose zone soil was to determine the type and magnitude of potential impacts to ground water quality resulting from the downward leaching of contaminants

The influence of downward advective (leaching) processes was quantitatively explored by using data from the HELP model (Section IV 3 1 1) and the one-dimensional finite difference vadose zone leaching model, VLEACH, developed for the EPA The goal of this analysis was to determine whether the recommended IM/IRA cover would provide adequate protection for ground water by minimizing infiltration and further contaminant migration for the 1,000-year performance period

IV.10.4.1 Vadose Zone Leaching Model - VLEACH

A simple, one-dimensional vadose zone leaching model was selected to provide conservative estimates of the potential for downward migration of contaminants Four scenarios were modeled in the VLEACH code The first, second, and third scenarios include the migration contaminants through the proposed final engineered cover, consolidated contaminated materials which includes liners, sludge, pondcrete, surface soils and vadose zone soil, and the subsurface drainage layer The first scenario simulates normal precipitation conditions, the second includes a 300% increase in precipitation, while the third represents a 100-year storm event with normal temperature and vegetation data The fourth scenario includes modeling the site with no action, as it exists today

The use of a one-dimensional model is a very simple evaluation of unsaturated conditions at this site Given the aforementioned considerations, VLEACH Version 1 02 (IGWMC, 1991) was chosen to model downward contaminant migration through the materials consolidated beneath the final engineered cover A more complex model, VS2DT, was selected to exemplify a more detailed and realistic setting and has the capability to simulate the dispositioning of several types of contaminated media with different properties beneath the final engineered cover

This modeling will be completed as part of the detailed design, and is explained in Section IV 10 5

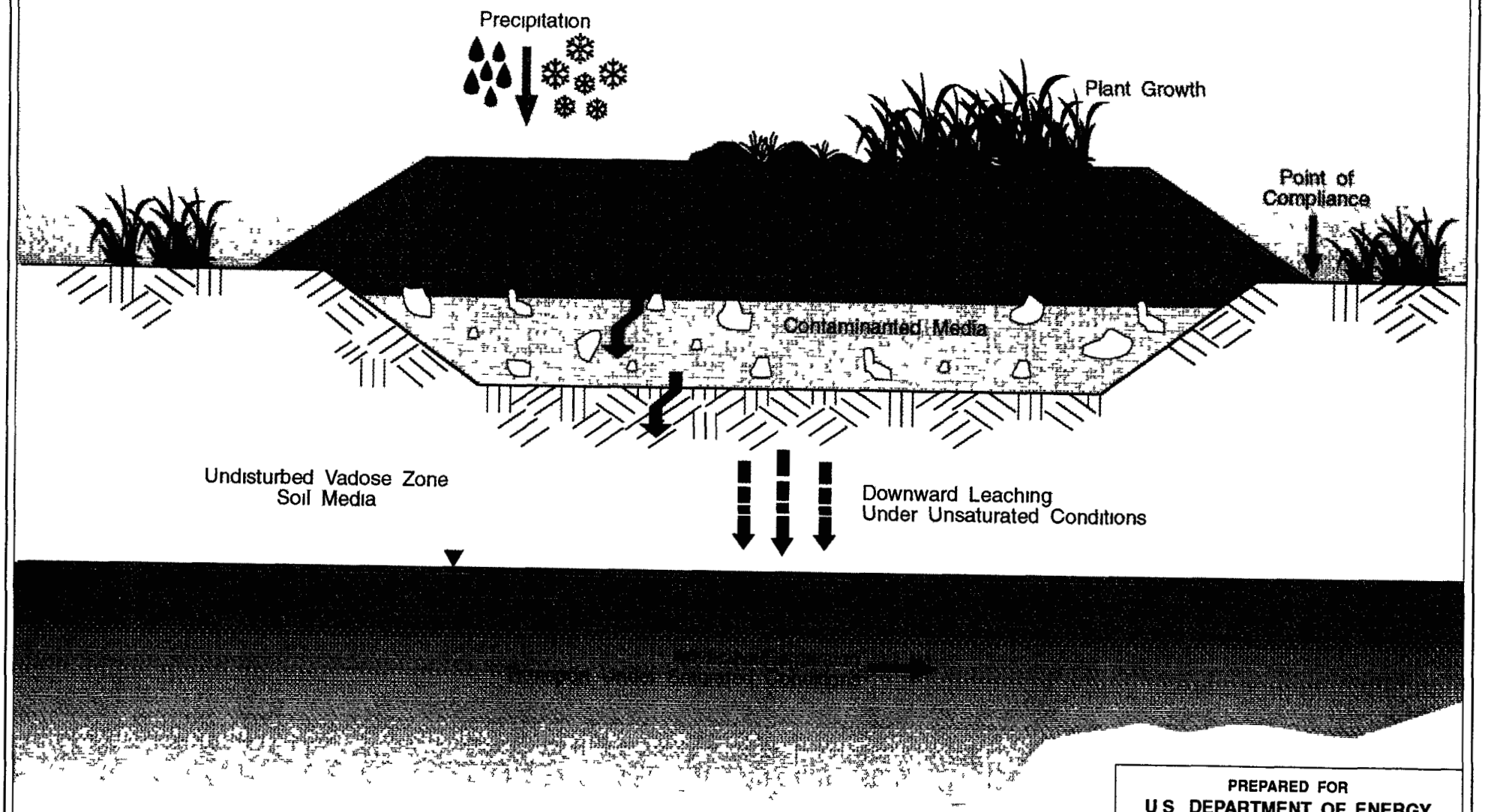
VLEACH is a one-dimensional finite difference model which simulates contaminant leaching through the 1,000-year cover, the consolidated contaminated materials, and the subsurface drainage layer by simultaneously solving several mass balance equations For the no action scenario, the model simulates contaminant leaching through the existing pond liners and vadose zone soil beneath the SEPs The model is capable of simulating four main processes typically governing fate and transport in the vadose zone

- Liquid-phase downward advection,
- Solid phase adsorption,
- Vapor-phase equilibrium, and
- 3-phase equilibrium

Figure IV 10-1, Analyses of Ground Water Quality Impacts Potential Effects of Precipitation Infiltration, presents a generalized schematic of the natural processes included in the VLEACH model

VLEACH couples existing site conditions (both physical and chemical properties) with analyte-specific properties to simulate contaminant behavior under unsaturated conditions over the user-defined period of time The VLEACH model requires several analyte-specific input parameters (e g , K_{oc}, K_H, D_{air}) as well as site-specific characteristics that may influence the behavior of contaminants within unsaturated soils In general, the data requirements for VLEACH fall into four categories chemical parameters, soil properties, site properties, and model parameters Chemical parameters are analyte-specific and depend upon the assumptions governing the nature of site contamination which are incorporated into model simulations For example, assumptions made regarding the chemical speciation of each contaminant to be modeled must be developed Thus, all chemical-specific parameters used in the VLEACH model must then be related to the assumed chemical species The remaining site-specific parameters focus on the extent of site contamination and the physical vadose conditions at OU4 that may influence the behavior of the modeled contaminants

The VLEACH model can be constructed to subdivide a specific site into separate units or "polygons" with distinct chemical and/or physical characteristics Each polygon is then represented by a stack of vertical cells that extend from the surface receiving precipitation to the piezometric surface In this way, the model may be developed to adequately describe heterogeneous site conditions, assuming instantaneous equilibrium (i e , the model does not include potential kinetic considerations), however, it is important to note that the VLEACH model is subject to several major assumptions that should be considered during model development and interpretation of results The VLEACH model assumes that the media within a particular model polygon is completely homogeneous and behaves as a uniform porous



PREPARED FOR
U S DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Figure IV 10-1

Solar Evaporation Ponds
Operable Unit No 4, IM/IRA EA DD
Analysis of Ground Water Quality Impacts
Potential Effects of Precipitation Infiltration

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medium, with a constant moisture content profile and no preferential flow pathways Further, the model does not support *in situ* production or degradation of contaminants The model also assumes that contaminant partitioning between soil gas, vadose zone pore water, and solid media can be described by simple linear relationships These are limiting assumptions designed to simplify computations

VLEACH calculates the contaminant present in each cell assuming instantaneous equilibrium between the three model phases, soil gas, vadose zone pore water, and solid soil matrix The model output, a series of mass balance calculations and cumulative mass fluxes across the liquid phase into ground water, provides valuable information about the potential effectiveness of the recommended IM/IRA final engineered cover

IV.10.4.2 Governing Transport Equations

The VLEACH model incorporates three major processes into contaminant fate and transport calculations Contaminants in the liquid phase are subject to downward advection via leaching vadose zone pore water, contaminants in the soil gas are subject to gas diffusion, and the mass of contaminants present in each phase (including the solid soil matrix) is re-equilibrated between each phase based on the given distribution coefficients, assuming instantaneous equilibrium All of these processes are affected by both the physical and chemical characteristics of the OU4 site as well as the modeled contaminants themselves The following is a summary of the key equations included in the VLEACH model code to approximate changing contaminant concentrations under the influence of leaching processes over time Table IV 10-9 summarizes the variables used in the following equations

Downward Advection

Downward advection of contaminants through vadose zone soil is driven by the flux of recharging ground water Mass flux due to downward advection of recharging ground water can be described by the following partial differential equation

$$\frac{\partial C}{\partial t} = -\left(\frac{q}{\theta}\right)\frac{\partial C}{\partial z}$$

Within the numerical VLEACH model code, however, this partial differential equation is approximated by the following finite difference equation, which considers the asymmetric nature of advection

$$\frac{C_i^{t+\Delta t} - C_i^t}{\Delta t} = \frac{-q}{2\Theta\Delta t}\left[\left(C_i^{t+\Delta t} - C_{i-1}^{t+\Delta t}\right) + \left(C_i^t - C_{i-1}^t\right)\right]$$

TABLE IV.10-9
DEFINITIONS OF VARIABLES USED IN LEACHING EQUATIONS

M_T	=	Total mass of contamination in model cell [M]
ΔZ	=	Thickness of cells in VLEACH calculations [L]
n	=	Total porosity of soil [dimensionless]
θ	=	Water-filled porosity of soil [dimensionless]
P_b	=	Bulk density of soil [L^3/M]
K_D	=	Distribution coefficient for soil-water partitioning [IM/L^3]
K_H	=	Henry's constant for air-water partitioning [dimensionless]
C_s	=	Contaminant concentration in sorbed phase [M/L^3]
C_l	=	Contaminant concentration in liquid phase [M/L^3]
C_g	=	Contaminant concentration in gas phase [M/L^3]
C_{INF}	=	Contaminant concentration in infiltrating water [M/L^3]
C_{CELL}	=	Contaminant concentration in water in bottom cell [M/L^3]
C_{NCELL}	=	Contaminant concentration in water in bottom cell [M/L^3]
C_{ATM}	=	Contaminant concentration in atmospheric air above soil surface [M/L^3]
C_{gw}	=	Contaminant concentration in ground water (with respect to gas phase exchange between water table and vadose zone [M/L^3]
f_{oc}	=	Fraction organic carbon in soil [dimensionless]
K_{oc}	=	Organic carbon partition coefficient [L/M^3]
D	=	Effective diffusion coefficient [L^2/T]
D_{AIR}	=	Free air diffusion coefficient [L^2/T]
q	=	Darcian flux of percolating water [L/T]
In finite difference equations		
$C_{il}^{t+\Delta t}$		
C	=	Refers to concentration of gas or liquid, depending on the equation [M/L^3]
$t + \Delta t$	=	Refers to the time step at which the concentration is calculated
i-l	=	Refers to the cell number in which the concentration is calculated

The concentration of a contaminant within each individual cell which comprises a defined polygon is calculated using this equation These equations are then solved simultaneously using the Thomas algorithm The mass flux from ground surface to ground water is then computed

$$J_{\tau}=qC_{firstcell}$$

$$J_{BOTTOM}=qC_{lastcell}$$

Gas Diffusion

Diffusion of contaminants into the soil gas phase is given by the following partial differential equation (Fick's Second Law)

$$\frac{\partial C}{\partial t}=D\frac{\partial^2 C}{\partial z^2}$$

As with the downward advection equation, the VLEACH model code approximates this partial differential equation using the following finite difference equation

$$\frac{C_i^{t+\Delta t}-C_i^t}{\Delta t}=\frac{D}{(\Delta z)^2}(C_{i-1}^{t+\Delta t}-2C_i^{t+\Delta t}+C_{i+1}^{t+\Delta t})$$

The mass flux due to gas diffusion from ground surface to ground water is then computed using the following flux equations

$$J_T=(n-\Theta)D\frac{(C_{ATM}-C_i)}{\Delta z}$$

$$J_{BOTTOM}=(n-\Theta)DK_H\frac{(C_{lastcell}-C_{groundwater})}{\Delta z}$$

Equilibration Amongst Phases

The VLEACH model estimates the concentration within each phase by solving several mass partitioning equations simultaneously These equations couple chemical-specific characteristics with site-specific conditions to estimate the mass and concentration of contaminant within each phase at each discrete time step The following equations are solved concurrently to estimate the concentration of each modeled contaminant within the soil gas phase, the pore water phase, and the solid soil phase, respectively

$$M_T=\Delta z(\Theta C_i+C_g(n-\Theta)+\rho_b C_s)$$

$$C_{gas}=\frac{M_T}{\Delta z[\frac{\Theta}{K_H}+(n-\Theta)+\rho_b(\frac{K_D}{K_H})]}$$

$$C_{liquid}=\frac{M_T}{\Delta z[\Theta+K_H(n-\Theta)+\rho_b K_D]}$$

$$C_{soil}=\frac{M_T^{\cdot}}{\Delta z[\frac{\Theta}{K_D}+(n-\Theta)(\frac{K_H}{K_D})+\rho_b]}$$

The VLEACH model output reports the change in mass within the defined vadose zone profile and the cumulative mass flux to the ground water due to downward advection and gas diffusion

IV.10.4.3 Physical Input Parameters for VLEACH

The following discussion briefly describes the soil properties, site properties, and other model parameters used to simulate downward migration of contaminants in unsaturated soils using the VLEACH model Input parameters used in the VLEACH modeling effort are related to site-specific properties that define the extent of site contamination, and the physical conditions at OU4 These properties influence the behavior of the modeled contaminants Note that some site-specific model input parameters are based on available data from the OU4 RFI/RI program

The VLEACH model was configured to simulate leaching from one "polygon" within the boundaries of OU4 This polygon was represented by a vertical stack of leaching cells that extend from the top of the final engineered cover to the mean seasonal high ground water elevation for the final engineered cover scenario For the no action scenario, the polygon extends from the top of the liners as they exist today to the mean seasonal high ground water elevation The polygon includes the general site of the preferred IM/IRA final engineered cover The areal extent of this polygon is therefore approximately 499,452 square feet

The VLEACH model code was used to assess potential adverse impacts to ground water quality due to leaching of contaminants from unsaturated soils Contaminant concentrations and depth to ground water are defining characteristics of the polygons used in the VLEACH model simulation runs These characteristics define the number and nature of the vertical stack of cells within the polygon By definition, the number of cells within the polygon multiplied by the height of each individual cell is the depth to the piezometric surface within the polygon The depth to ground water for VLEACH modeling purposes was estimated at 27 feet (top of the final engineered cover to the mean seasonal high ground water elevation) for the recommended cover scenario (10 feet clean soil, 14 feet of waste zone, and 3 feet of subsurface drainage layer) The depth to groundwater for the no action scenario was estimated at 11 feet (1 foot liner and 10 feet of vadose zone soil) Each polygon was then defined by a stack of vertical cells of height one foot so that the total combined height of the cells equaled the estimated depth to the piezometric surface (seasonal high ground water elevation) for the polygon

Given the lack of site specific K_d values (which mathematically describes the extent to which an analyte sorbs to some other material, usually the solid soil matrix), values were based on literature information, as described in the notes of Table IV 10-10 K_d values govern the concentrations at which contaminants leach from the consolidated contaminated materials beneath the final engineered cover Solubility limits were also extracted from the literature as described in Table IV 10-10 Recharge rates under both the no action and the proposed final engineered cover were defined by the output from the HELP model described in Section IV 3 1 1 The following site conditions were incorporated into the model

TABLE IV 10-10
MODEL CHEMICAL SPECIFIC INPUT PARAMETERS

Contaminant	K_d	Solubility Limit
Arsenic	3 [a]	2 4 mg/L [6]
Cadmium	6 [a]	0 2 mg/L [1]
Chromium	40 [a]	0 7 mg/L [7]
Nitrate as N	0 [b]	113000 mg/L [2]
Am-241	100 [a]	1 4E3 pCi/L [3]
U-235	40 [a]	1 5 pCi/L [4]
Pu-239/240	43 [c]	5 3 pCi/L [5]

Notes for K_d values

a Taken from Looney et al (1987) *Estimation of Geochemical Parameters for Assessing Subsurface Transport at the Savannah River Plant*, E I du Pont de Nemours & Co , Savannah River Laboratory, Aiken S C , DPST-85-904

"This is the recommended value for K_d Note that the actual K_d value may differ significantly for this number depending on the chemical form(s) (species) which are present The value given is based on the predominant form expected (or the most mobile form if it comprises a significant fraction) All results should be reviewed on a site specific basis to determine the magnitude of possible error due to unusual conditions such as high ligand concentration, very high or low pH, low exchange capacity in soil, or very high or very low Eh Low concentrations of some constituents may be overlooked if a mobile species constitutes a small fraction of the total mass "

b Nitrate is assumed to be totally conserved, i e , to be completely non-reactive with respect to the solid phases of the soil

c Taken from Miner et al , (1982) *Plutonium Behavior in the Soil/Water Environment*, Rockwell International, Rocky Flats Plant, Golden CO, RFP-2480, UC-70 Nuclear Waste Management, DOE/TIC 4500 (Rev 69) Value represents lowest found for three Colorado DOE site soils

Notes for solubility limits

1 Based on $CdCO_{3\,s}$ and $[CO_3^{2-}]$ = 1 mg/L as suggested by Part II - RFI/RI (Feb 15, 1994), Part II 3 3 6 6 (Column Leaching Tests) Assuming $\gamma_{CO_3^{2-}}$ = 0 584, $\gamma_{Cd^{2+}}$ = 0 599, and $Cd_T \approx 2 \times (Cd^{2+})$

Figure IV 10-10 (continued)

2 Based on $NaNO_3$ solubility (65 g/100 cc) Nitrate should be considered effectively infinitely soluble because of the low relative abundance of cations available to form specific nitrate salts Most concentrated observed pore water is undersaturated with respect to $NaNO_3$

3 Based on AmOHCO3 and $Am_2(CO_3)_3$ $2H_2O$ Source Triay (1991) *Radiochim Acta*, 52/53, 141

4 Based on solubility of UO_2CO_3 as modeled by SOLMIN88 in pore water frm borehole BH40456AE (U_T) allocated to isotopes according to observed proportion (U-233/234 U-235 U-238 - 1 0 1 1)

5 Value represents the highest observed OU4 groundwater concentration of Pu-239/240 No reliable solubility limit is available

6 Based on solubility of $Cr(OH)_3$ under moderately oxidizing conditions at neutral pH Source Rai and Zachara (1984) *Chemical Attenuation Rates, Coefficients, and Constants in Leachate Migration, Vol 1 A Critical Review*, Batelle, Pacific Northwest Laboratories, EPRI EA-3356

7 Based on solubility of scorodite ($FeAsO_4$ $2H_2O$) at neutral pH Dove and Rimstidt (1985) *The solubility and stability of scorodite, $FeAsO_4$ $2H_2O$* Am Min , v 70, 838-844

- Area 499,452 sq ft ,
- Cell height one foot,
- Bulk Density of soil 1 7 grams/cubic centimeter,
- Total effective porosity 0 370, and
- Volumetric water content 0 24
- Recharge rate
  1,000 year final engineered cover (normal conditions) - 0 0068 in/yr
  1,000 year final engineered cover (300% increase in precipitation) - 0 0075 in/yr
  1,000 year final engineered cover (100-year storm event) - 0 0071 in/yr
  No action - 3 96 in/yr

IV.10.4.4 Modeled Contaminants

All contaminants were considered for inclusion in the modeling effort COCs were calculated based on surface and vadose zone soils, and were not calculated for liners, sludge and pondcrete Therefore, those contaminants not listed as COCs but exhibiting higher contaminant concentrations in liners, sludge and pondcrete than in soils were included in the modeling exercises This was performed to evaluate potential groundwater impacts due to consolidation of liners, sludge and pondcrete in addition to surface and vadose zone soils beneath the final engineered cover

Potential contaminants to model were also screened on the basis of their physical and chemical properties that may enhance or inhibit downward migration through unsaturated soil Mobility, source concentration, toxicity and data availability were factors used to determine whether a specific analyte should be included in the VLEACH model to estimate downward mass flux into ground water over time Seven contaminants were chosen to evaluate the potential impacts to ground water quality The contaminants that were modeled were the radionuclides Americium-241, plutomium 239/240, and uranium-235, the metals cadmium and chromium, and the inorganics nitrate, and arsenic

IV.10.4.5 Chemical Input Parameters for VLEACH

Once the contaminants to be included in the models were identified, several chemical-specific characteristics which define the analyte's ability to partition amongst phases were defined based on empirical data in the literature and some site-specific calculations Each of these characteristics describes the behavior of the assumed chemical species in question The free air diffusion coefficient (D_{air}) and Henry's Constant (K_H) govern how readily the contaminant species partitions into soil gas The distribution coefficient for soil-water partitioning (K_d) or the fraction organic carbon in soil (f_{OC}) and organic carbon partition coefficient (K_{OC}) define how the contaminant partitions into the solid soil medium (e g , governs adsorption) Given the lack of site-specific K_d measurements, K_d information was based on literature values Table IV 10-10 summarizes the chemical-specific characteristics used in the VLEACH model for each of the modeled contaminants

The distribution of modeled contaminants within each vertical cell of the polygon was also incorporated into the VLEACH model The concentrations of each modeled analyte was calculated from a weighted volumetric average of mean surface soil, vadose zone soil, liner, sludge, and pondcrete concentrations Based on volumetric estimates, the waste zone will be comprised of 3% sludge, 5 2% surface soils, 6 1% pondcrete, 7 2% liners and 78 5% vadose zone soils Waste zone analyte concentrations are presented in Table IV 10 11

The cells representing the final engineered cover or first ten feet within the model were assumed to have contaminant concentrations of zero The next 14 feet were modeled as the waste zone with contaminant concentrations as presented in Table IV 10 11 The subsurface drainage layer was assumed to extend 3 feet beneath the waste zone with contaminant concentrations of zero

Results from VLEACH simulation runs demonstrate whether significant concentrations of modeled contaminants are capable of leaching from contaminated, unsaturated soils and to what degree natural attenuation processes effectively preclude downward migration into the ground water It should be noted, however, that VLEACH has only the capability to simulate advection Molecular diffusion and dispersion are not considered in the computer code and tend to govern transport when infiltration rates are very low, as is the case with the rates through the final engineered cover

The VLEACH model was run for a 1,000-year lifecycle with results evaluated at ten year intervals, predicting leaching activities for the entire lifecycle of the 1,000-year performance criteria The maximum contaminant concentration during the 1,000-year lifecycle was converted to a depth averaged concentration in five feet of ground water directly beneath the final engineered cover The effects of vertical mixing within the unconsolidated material above the weathered bedrock (i e , Rocky Flats Alluvium in the area of IHSS 101) are therefore accounted for in the modeled results

The output from VLEACH indicated contaminant concentrations directly beneath the final engineered cover did not exceed ground water protection comparison criteria for the three scenarios including the final engineered cover as shown on Table IV 10-12 Modeling results under the no action scenario suggest, however, that downward leaching of several contaminants into ground water is a significant contaminant transfer mechanism at the site Plutonium 239/240, arsenic, cadmium, and chromium have exceeded ground water comparison criteria at the POC for the no action scenario

IV.10.4.6 Vadose Zone Leaching Model - VS2DT

The VS2DT (Variably Saturated Porous Media, Contaminant Transport) computer code/model will be primarily used as a tool for design of the contaminated material consolidation and the final engineered cover VS2DT-based modeling results are also expected to confirm or

TABLE IV 10-11
AVERAGE CONTAMINANT CONCENTRATIONS

Constituent	207A Sludge	207B North Sludge	207B Center Sludge	207B South Sludge	207C Water	207C Sludge	Clarifier Water	Clarifier Sludge	Weighted Treated Sludge by Mass	Liners Mean	Surface Soil Mean	Vadose Zone Soil Mean	Pondcrete Mean	Combined Waste Actual
Totals	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Arsenic	4 02E+04	8 08E+03	2 31E+04	1 95E+04	4 02E+02	3 05E+04	3 24E+02	9 97E+03	2 71E+03	1 35E+03	3 41E+03	4 30E+03	7 12E+03	4 17E+03
Cadmium	1 30E+06	7 10E+03	5 63E+04	2 13E+04	2 51E+02	7 67E+04	2 29E+02	4 21E+06	2 54E+04	2 87E+03	1 93E+04	1 46E+04	1 41E+06	9 92E+04
Chromium	6 58E+05	2 03E+04	6 31E+04	3 62E+04	1 90E+03	5 92E+05	3 67E+02	2 89E+06	5 50E+04	9 49E+03	1 82E+04	1 41E+04	8 41E+05	6 57E+04
Radionuclides	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
U 235	5 02E+02	1 74E+02	1 11E+03	9 31E+02	4 47E+01	1 57E+02	4 47E+01	1 57E+02	4 51E+01	5 28E+01	3 26E+01	3 09E+01	2 20E+03	1 65E+02
Am 241	1 45E 04	0 00E+00	3 67E 04	4 05E 04	2 01E 06	2 13E 04	2 01E 06	2 13E 04	2 09E 05	6 41E 07	2 14E 04	1 69E 05	NA	2 51E 05
Pu 239	6 72E 02	7 15E 02	5 08E 02	7 50E 02	7 52E 03	9 44E 02	7 52E 03	9 44E 02	1 19E-02	8 66E 04	9 63E 03	1 12E 03	1 39E+01	8 49E 01
Miscellaneous	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg	ug/kg
Nitrate[5]	3 43E+04	6 67E+03	6 41E+04	8 14E+04	2 09E+06	6 93E+06	7 06E+06	3 39E+05	1 27E+06	NA	8 06E+04	2 82E+04	3 52E+05	8 59E+04

Notes

1 Assumption 5 000 cubic yards of treated sludge 10 000 cubic yards of pondcrete 11 800 cubic yards of liners 127 000 cubic yards of vadose zone soil and 8 500 cubic yards of surface soil will be placed beneath the engineered cover

2 The volume of liquid in the 207A and the B series SEPs is 0 gallons The mass of liquid in C Pond is 1 816 000 kg and in the clarifier is 5 212 kg

3 The mass of salts and sludge in each pond is as follows

SEP 207A	1 169 kg
SEP 207B North	97 443 kg
SEP 207B Center	36 565 kg
SEP 207B South	23 150 kg
SEP 207C	322 022 kg
Clarifier	21 635 kg

4 For calculation purposes it is assumed that the sludge in the clarifier is similar to the sludge in SEP 207C and that the sludge in SEP 207A is similar to the sludge in the 207B series and therefore since data was not available for specific radionuclide concentrations in SEP 207A or the clarifier the average concentration of the SEP 207B series was used for SEP 207A and the concentration from SEP 207C was used for the clarifier

5 Nitrate analysis performed after TCLP leach test

6 All data except for specific radionuclide isotopes was taken from the following report
Halliburton NUS Environmental Corporation Pond Sludge Waste Characterization Report and Clarifier Sludge Waste Characterization Report " March 1992

7 Data for specific radionuclide isotopes was taken from the following report
Roy F Weston Weston Characterization Report " September 18 1991

TABLE IV.10-12
VLEACH MODEL RESULTS

Contaminant	Initial Annual Leachate Concentration				Ground Water Comparison Criteria[1/]
	No Action	1,000-Year Engineered Cover	300% Increase in Precipitation	100-Year Storm Event	
Americium-241	0 079 pCi/L	8 32E-10 pCi/L	1 23E-09 pCi/L	9 94E-10 pCi/L	2 11 pCi/L
Plutonium 239/240	0 258 pCi/L	4 06E-08 pCi/L	6 57E-08 pCi/L	5 03E-08 pCi/L	0 207pCi/L
Uranium-235	0 251 mg/L	1 69E-08 pCi/l	2 48E-08 pCi/L	2 0E-08 pCi/L	2 98 pCi/L
Arsenic	0 182 mg/L	1 56E-07 mg/L	2 27E-07 mg/L	1 84E-07 mg/L	0 05 mg/L
Cadmium	0 313 mg/L	4 63E-07 mg/L	6 77E-07 mg/L	5 48E-07 mg/L	0 0182 mg/L
Chromium	0 149 mg/L	3 11E-09 mg/L	4 58E-09 mg/l	3 70E-09 mg/L	0 0182 mg/L
Nitrate	25 76 mg/L	0 080 mg/L	0 101 mg/L	0 089 mg/L	58 4 mg/L

1/ The ground water comparison criteria were the highest of either background concentrations, state ground water standards, or the RFETS programmatic preliminary remediation goals

validate the results of the VLEACH-based modeling, which are presented in Section IV 10 4 of this document

Many factors can potentially influence the long-term performance of the contaminated material consolidation and final engineered cover including, for instance, size, shape, height, and water-tightness of the final engineered cover, placement of the materials, and compaction of the materials VS2DT incorporates mathematical models which address these items and allow the design team to perform sensitivity analyses, i e , to quantify the impact of changing one or more of the above parameters on the overall performance of the whole system

In the case of the proposed IM/IRA, the conceptual model for a release includes minor but finite percolation of normal precipitation through the final engineered cover and the eventual exit of moisture through the subsurface drain which underlies the consolidated contaminated materials As the moisture passes through the consolidated materials, it will have an opportunity to acquire contaminants and thus convey them to the outside of the system Upon exiting the subsurface drain, contaminated moisture could enter the ground water system and potentially gain access to the surface environment Mathematical expressions are available which describe the movement of moisture through unsaturated layered materials comprising the final engineered cover, the contaminated materials consolidated beneath the final engineered cover, as well as flow through the underlying saturated ground water zone In addition, various equations, based on empirical data, may be used to describe the complex transfer of contaminants from the consolidated materials to the downward-migrating moisture Site-specific chemical and physical information is required for each layer of the consolidated materials to serve as input parameters for these equations

Several industry-accepted computer codes are available, each of which considers specific aspects of the overall model for moisture movement in the consolidated contaminated materials, the final engineered cover, and in the saturated subsurface Applicable codes include HELP, VLEACH, MYGRT™, and VS2DT No one code is currently sufficient to model all the aspects of the engineered system, and the appropriate combination of codes changes as the goals and requirements of predictive modeling change VLEACH results have been used in conjunction with HELP to demonstrate overall protectiveness of the system assuming a worst-case scenario Final design specifications and quantitative environmental impacts will emerge from modeling based on the application of VS2DT in conjunction with HELP and VLEACH The HELP and VLEACH codes have been described previously The VS2DT code is briefly described below

> VS2DT (Version 2 0) was developed by the U S Geological Survey and predicts the extent of contaminant leaching from a volume of unsaturated porous material Relative to VLEACH it is a sophisticated two-dimensional, multi-layer, variably saturated code that uses K_d (or more complex) coefficients to calculate contaminant concentrations in downward-percolating moisture The significant advantage of this code over VLEACH is that it allows individual layers of consolidated contaminated materials to be differentiated and for site-specific and material-specific parameters to be assigned to each layer In addition to allowing a more quantitative prediction (not just the "worst-case")

of leachate quality and quantity, VS2DT has the capability of facilitating design details such as the best placement of various materials beneath the final engineered cover VS2DT will provide support to engineering the consolidated contaminated materials Sensitivity analysis will be performed on physical characteristics such as porosity and moisture content to establish the level of compaction that will be specified during construction Predictions from VS2DT will also serve to validate the previous VLEACH results

All models and computer codes require input parameters that are specific to the site, materials, and conditions These requirements become more stringent as the complexity of the model and code increase and as the expectations of model output increase VS2DT is intended to consider more details of the materials that will be consolidated beneath the final engineered cover and will be used as a design tool during the Title II design Required physical and chemical parameters will be determined on all distinct waste form layers to be consolidated beneath the final engineered cover An iterative modeling/design approach will be employed to ensure the optimal design of each waste form for its placement beneath the final engineered cover

IV.10.5 Surface Water Quality

The preferred IM/IRA activities at OU4 would not be expected to adversely affect surface water quality either in the short-term or long-term Short-term protection of surface waters adjacent to OU4 (North Walnut Creek) is ensured since the existing ITS is not expected to be affected by the installation of the final engineered cover Runoff will be prevented from impacting North Walnut Creek as the ITS will continue to collect and divert runoff to the three surge tanks (located north of OU4) for subsequent treatment However, in the unlikely event that the ITS should fail to capture and divert runoff, one of the most significant sources of contaminated runoff water could be the seep areas north of the SEPs The preferred IM/IRA includes the removal of contaminated soils that could potentially be flushed by a highly elevated ground water elevation and placement of a subsurface drainage system in the excavated zone The excavated contaminated soils would then be placed above the subsurface drain This measure ensures that even in the conservative case of unprecedented ground water elevation, soils would not contact ground water, thus, the potential for COC mobilization by this route would be eliminated Adverse impacts to South Walnut Creek would be mitigated by providing adequate stormwater management controls etc , during construction and other activities related to the IM/IRA implementation

Long-term protection is ensured since the preferred IM/IRA final engineered cover will minimize precipitation infiltration from contacting contaminants and will incorporate surface drainage features to prevent run-on/run-off and to provide erosion control (see Section IV 3 1) The preferred IM/IRA will ultimately result in a decrease in the risk of contaminants reaching surface water by eliminating the possibility of precipitation run-off contacting contaminated soils As previously discussed, contaminant mobilization via ground water elevation would also be precluded by the installment of the subsurface drain above the ground water elevation

The no action alternative will continue to allow precipitation to contact contaminated surface soils and percolate into the surface and vadose soils and thus fail to prevent water/contaminant contact in both the short- and long-term Precipitation may cause surface water degradation by runoff discharging into local streams The no action alternative will not prevent rising ground water from contacting contaminated subsurface soils Simple numeric catastrophic dissolution calculations were used to determine the threat of contaminated soils to ground and surface water (see Appendix III D for modeling results) The catastrophic calculations were based on a hypothetical ground water elevation that could rise to contact and flush contaminated soils left in place allowing for COC mobilization These results suggest that the potential exists for incremental increases in concentrations of COCs in ground water In turn, this ground water could affect local surface water via seeps or direct ground water discharge

The U S Army Corps of Engineers performed a wetlands assessment in 1994, and delineated three small wetland areas along the intersection of the piezometric surface with the topographic surface in OU4 where there are groundwater seeps A map showing the small wetland areas is provided in Part I of this document It should be noted that these areas will be protected during the Phase I IM/IRA construction activities by silt fences and haybales since they are outside of the areas that will be remediated However, they may be impacted by the Phase II program The DOE is planning to establish a wetlands banking program in Bear Creek State Park Through this program, the DOE will provide a new wetland area within the park to replace those that are impacted at the RFETS The new wetlands bank will be larger than the sum of the RFETS impacted wetlands The 0 12 acres of OU4 wetlands will be included in the wetlands banking program It is expected that clean fill and other materials for the final engineered cover would not be extracted from sensitive wetland areas Therefore, the preferred IM/IRA action would have no effect on wetland resources outside the RFETS OU4 area, and effects on wetlands within the OU4 area will be mitigated through the wetlands banking program

Implementation of the preferred IM/IRA would have minimal impact on flood plains The closest 100-year flood plain to the SEPs is a minimum of approximately 600 feet to the northwest and would not be in the zone of influence of the final engineered cover Clean fill material excavated for covering portions of OU4 would not be taken from sensitive areas such as flood plains within the RFETS

The decontamination and demolition of Building 788 located on the berm between SEP 207-A and SEP 207-C is not anticipated to have adverse impacts to local surface water Based on the distance from 788 to the closest stream and air dispersion modeling conducted in Section IV 10 3, it is predicted that the entire release of the 788 hazard constituent inventory to the environment would be negligible compared to existing site media concentrations The modeling concludes that the demolition of Building 788 presents no significant increase in the overall carcinogenic or toxic risk to any potential human receptors All building removal activities will preclude the release of the inventory to the environment since treatment, including size reduction, of contaminated equipment will occur in contained areas Section IV 3 2 1 of the

IM/IRA Decision Document discusses building removal procedures and contamination control measures Ground water would not be expected to be adversely impacted by the removal of Building 788

Although no modeling was conducted pursuant to Building 964, it is assumed that the demolition of the facility presents no significant increase in the overall carcinogenic or toxic risk to any potential human receptors All building removal activities will preclude the release of any residual contamination present to the environment since treatment or decontamination (if required), including size reduction, of contaminated rubble will occur in contained areas Section IV 3 2 of the IM/IRA Decision Document discusses building removal procedures and contamination control measures Ground water would not be expected to be adversely impacted by the removal of Building 964

IV.10.6 Impact from the Commitment of Irreversible and Irretrievable Resources

Pursuant to the DOE NEPA regulations (10 CFR 1021) requiring discussion of irreversible and irretrievable commitments of resources, the preferred IM/IRA would not be expected to result in substantial loss of valuable resources However, all of the materials for the construction of the final engineered cover will be irrevocably and irretrievably committed to the implementation of the remedial action Energy resources consumed during the construction period would also be irretrievable but small compared to consumption due to daily activities at the RFETS

There appears to be no commercially exploitable metallic mineral resources in the RFETS security zone (FEIS RFP, 1980) Unmined uranium reserves (from the Schwartzwalder uranium mine) are located 4 miles southwest of the RFETS but future mining operations would not be impacted by RFETS remedial activities

Other resources that have been developed in the vicinity of the RFETS, such as sand, gravel, crushed rock, and coal, would not be expected to be impacted by the preferred IM/IRA action due to the small area involved (less than 30 acres) Quarrying operations (sand, gravel, and crushed rock) do exist locally, some even in the RFETS buffer zone, but, with the estimated millions of cubic yards of unmined sand and gravel available in the Golden quadrangle there is little potential for the OU4 IM/IRA action negatively impacting the industry (FEIS RFP, 1980) Although coal was mined historically in the area between Golden and Boulder, no mining has occurred since 1950 For the same reasons as discussed previously, it is likely coal mining would not be impacted by the IM/IRA

Implementation of the preferred IM/IRA will however limit potential future land use options Due to the constructed cover and monitoring well requirements, commercial, industrial, and residential land use will be permanently prohibited on the final engineered cover It is assumed that grading and reseeding of the OU4 area will result in an acceptable appearance of the remediated site, consistent with adjacent lands Reseeding may promote normal ecological succession in the vicinity of the SEPs

The no action alternative would not be expected to negatively impact energy or mineral resources Under the no action alternative it is reasonable to assume SEP land would continue to have no substantial ecological, economical, or recreational use Land within OU4 but outside the SEPs IHSS is currently undeveloped and will remain so for the foreseeable future as part of the RFETS The ecosystem in the SEPs area has been greatly disturbed over the past several decades and would remain inaccessible to most regional indigenous plant and wildlife species In addition to the plant species being disturbed by physical stressors, the vegetation at the RFETS has been historically suppressed via routine herbicide treatments Generally, only first-succession plant species are present in the SEPs area

IV.10.7 Natural Phenomena Hazards Mitigation

This section discusses potential long term Natural Phenomena Hazards (NPH) at the RFETS and their possible impact on the final engineered cover system NPH are acts of nature such as earthquakes, wind/ tornados, floods, precipitation (rain or snow), volcanic eruptions, meteorite impacts, lightning strikes, extreme cold or heat, which pose a threat or danger to workers, the public, or to the environment by potential damage to structures, systems, and components (DOE Order 5480 28) An updated NPH evaluation is required for structures at RFETS by DOE Order 5480 28

Section IV 1 2 (Classification of the Selected Alternative) describes the ranking process contained in DOE Order 6430 1A and designates the final engineered cover as a System Category 3 Using the Performance Category methodology contained in DOE Order 5480 28, as outlined in DOE-STD-1021-93, the final engineered cover is ranked as a Hazard Category 2 (HC2) or Moderate Hazard (MH) Facility with an SSC Performance Category of 2 Criteria for NPH design input and NPH design criteria will be addressed during detailed design efforts

Damage from excessive snow loadings, lightning strikes, tornado generated missile impacts, or meteorite impacts have been considered and are discounted, given that the proposed final engineered cover is a solid structure Externally generated failures (collapse by snow loading) or penetration of the facility by tornado generated missiles is not probable Therefore, these NPH are not credible to plan for The final engineered cover would not be effected by a lightning strike, excluding any electronic monitoring equipment that would be in place during the first 30 years of its operation The probability per year of a meteorite impact at a plutonium storage facility at RFETS has been computed to be approximately $8\ 88 \times 10^{7}$, or less than once in a million years (Selvidge, 1977, in Rockwell, 1981), thereby nullifying this event as credible

The most recent volcanism in Colorado occurred near Dotsero, about 120 miles west of Rocky Flats Using the carbon-14 method, the U S Geological Survey estimates this small scale basalt flow eruption occurred 4,150 (+/- 300) years ago (DOE, 1981, Tweto, 1980) No NPH effects from this localized volcanism can be identified at RFETS The last major volcanic eruptions in Colorado had ceased by the end of the Miocene Epoch (~5 million years before

present), thus nearby volcanism can also be discounted as a credible NPH at RFETS (DOE-STD-3009-94)

Temperature variations at RFETS can be quite extreme Temperatures of greater than 100 degrees Fahrenheit have been recorded during the months of July and August, while temperatures below -20 degrees Fahrenheit have been recorded during the months of December and January These temperature extremes will have no effect on the proposed final engineered cover

Other NPH events, such as glacial activity, occur on time scales measured in tens of thousands of years and are not instantaneous Therefore, the 1,000-year design life of the engineered cover will not be impacted by a glacial event Re-activation of alluvial fan depositional processes along the front range, through glaciation or a dramatic climatic change, would not affect the RFETS or the Rocky Flats vicinity This is due to the fact that when the Rocky Flats Alluvium was being deposited, and when Coal Creek Canyon was being excavated, the watershed for Coal Creek Canyon and the Rocky Flats area was much larger Headward erosion by South Boulder Creek (to the north), Ralston and Clear Creek (to the south), have captured much of the drainage basin that formally contributed to the Coal Creek Canyon/Rocky Flats watershed Presently, Coal Creek drains a smaller watershed than it did at the time of Rocky Flats Alluvium deposition Therefore, if a substantial source of additional water became available (as compared to the present), the volume of water and debris is unlikely to be sufficient to re-initiate Rocky Flats Alluvium scale alluvial deposition

IV.10.7.1 Effects of Wind

McDonald (1985) and Fujita (1978) established frequency of occurrence relationships for "fastest-mile wind speeds" at RFETS using statistical analysis of site-specific peak gust velocities for the period 1964 through 1976 The "fastest-mile wind speed" is the average speed of one mile of air passing an anemometer located 30 feet above the ground Peak gust velocities are approximately 1 25 times greater than "fastest-mile wind speeds", which are also referred to as "sustained" winds (EG&G, 1994, McDonald, 1985) The current Design Basis Wind criterion (UCRL-15910 DOE, 1990, DOE 6430 1, 1983) for a high hazard facility is 161 mph sustained winds at a frequency of occurrence at 10^{-4}/yr, or 10,000 year return period

The proposed final engineered cover is not a high hazard facility, and the structure would not be adversely affected by sustained winds of this magnitude or frequency High winds do have the potential to increase the rate of erosion, but will not cause an instantaneous failure of the final engineered cover The design of the final engineered cover includes a surface vegetation layer with pea gravel, which is expected to significantly reduce erosion from wind

IV.10.7.2 Effects of Flooding

The watershed up-gradient of Rocky Flats is small and RFETS is protected by a diversion canal west of the site The developed areas of RFETS all lie considerably above modern stream

drainages and display good drainage characteristics (i e storm drains and canals have been designed and constructed to accommodate runoff) There are no dams or tributary streams that would cause flooding at RFETS if they failed or overflowed (EG&G, 1994, Rockwell, 1981)

Annual precipitation at RFETs is generally light, averaging approximately 15 inches The maximum yearly precipitation recorded over a 24 year period (1953 through 1976) was 24 87 inches in 1969 The maximum amount of precipitation over a 24 hour period was 6 53 inches in May of 1876 When taken together, the hydrological data indicate that the engineered cover will not be flooded by a postulated site-specific 100-year storm event (EG&G, 1994, Rockwell, 1981) However, portions of the ITS proximal to North Walnut Creek, do lie in the 100-year storm event floodplain (EG&G, 1992a)

IV.10.7.3 Effects of Earthquakes

In order to define a seismic hazard (damage to structures by earth vibration) for the final engineered cover at RFETS an estimated earthquake hazard must first be established Defining an earthquake hazard is dependent upon many variables Some of the most critical relationships to ascertain have been discussed by Coats and Murray (1984), Blume & Associates (1974), Boore and Joyner (1978), Krinitzsky (1981), Hays (1980), Nuttli (1972, 1980), Algermissen (1969, 1976), dePolo and Slemmons (1990), and many others In summary, these relationships include

1 The presence or absence of identifiable faults capable of producing earthquakes, and the activity or frequency of movement along these faults,

2 measured or estimated maximum magnitudes and intensities for potential earthquakes,

3 the boundaries for zones of seismic activity in which maximum earthquakes are assigned and floated (attenuated or amplified) throughout other zones,

4 the peak, near, and far field motions (acceleration, velocity, displacement, duration, predominant period) that are associated with postulated earthquake events, and

5 the effects (amplification, scattering or absorption of energy) that site characteristics (soil composition and thickness, bedrock, water table, topography, etc) have on the resultant ground motions from an earthquake

In order to estimate these variables and their effects on the OU4 final engineered cover, the following sections present data on the location of faults proximal to RFETS, the measured magnitudes and intensities of earthquakes that have occurred within 100km of RFETS during the last 123 years, estimates on frequency of earthquake occurrence and associated intensities, estimated near source earthquake ground motions, and attenuation of ground motion parameters from a far-field source The effects of site characteristics (item number 5) cannot be addressed without site specific field data which is presently unavailable The end result of exploring these

parameters (items 1 through 4) is to gain an estimate on the probable force, or energy, the OU4 final engineered cover would need to be designed for in order to remain intact during a near- or far-field earthquake

The standard procedure (DOE-STD-1022-94) for assigning the ground motions that are appropriate for any given site combine the state of theoretical knowledge with the state of engineering practice However, seismic hazard analysis is limited by the following

- The paucity of strong ground motion records for large earthquakes, particularly in Colorado where no large (magnitude {M} > 6) earthquakes have occurred recently (last 80 years, or since seismographs have been available to measure strong ground motions),
- the limited geologic and seismologic data near causative faults (faults that are capable of conducting movement along their traces within a relevant time frame), and
- the spread (types of data, method and area in which it was gathered) in the available data

Acknowledging these deficiencies, the seismic hazard analysis presented in this section is based upon data from the National Earthquake Data Base (NOAA, 1994) This data source is the most widely used and accepted for seismic hazard analysis

This analysis is predominantly deterministic, or poissonian with respect to the variable of time The deterministic empirical relations presented work under the pretense that in any period of time there is the same probability that a large earthquake will occur A deterministic approach assumes that an earthquake of a given estimated magnitude or intensity can occur at a certain location (Sections 10 7 3 1, and 10 7 3 2) The estimated ground motion resulting from the postulated earthquake is then attenuated from the source to the site (Sections 10 7 3 4, and 10 7 3 5), and finally the effects of the earthquake are determined for the site (Section 10 7 3 6), in this case the OU4 final engineered cover

Probabilistic determinations consider the effects of time, or account for statistical parameters that consider an earthquake is more likely to occur the longer the time elapsed since the last major earthquake The probabilistic approach, quantifies the uncertainty in the number, size, and location of possible earthquakes (Coats and Murray, 1984) The results of regional probabalistic determinations by other authors are presented (Section IV 10 7 3 3, Intensity and Frequency Relations for the Rocky Flats Seismic Zone) in order to give the reader a sense of the frequency earthquakes of a given magnitude are likely to occur in the seismic zone where RFETS and the OU4 final engineered cover are located

A probabalistic seismic investigation was conducted at the RFETS in 1974 (Blume and Associates, 1974), however due to the continued acquisition of geologic data this report is considered out of date DOE Order 5480 28 requires a revaluation of seismic hazards at DOE sites every 10 years Therefore, as a component of the Systematic Evaluation Program, a

Seismic Investigation Program is being carried out by EG&G The results of this investigation should be available in early 1995

Identifiable Faults Capable of Producing Earthquakes Near RFETS

An earthquake is created by some disruptive event such as the release of naturally accumulated strain by failure along fault planes, explosion, or an artificial strain release by lubrication of fault planes resulting from deep well fluid injection The source mechanism of an earthquake is difficult to identify based on current detection capabilities

Many smaller faults may occur between major faults and can be difficult to identify or characterize with respect to seismic hazard Many of these smaller faults have no surface expression and/or are difficult to identify as active "Floating" or "random earthquakes" which represent the earthquake hazard associated with background seismicity, and commonly not related to specifically identified faults, can pose significant hazards and typically have magnitudes in the range of 2 to 6 5 associated with them (dePolo and Slemmons, 1990) An example of this type of activity occurred as recently as December 25, 1994, along a fault thought to extend approximately from Castle Rock, to Lakewood, Colorado This event had a local Richter magnitude of 4 associated with it (Denver Post, Rocky Mountain News, 12-26-94)

Several faults are known to exist in the vicinity of Rocky Flats (EG&G, 1992b, EG&G 1991, Van Horn, 1976, Blume, 1974, Spencer, 1961) However, to date, none of the faults investigated have been found to be capable according to the guidelines in DOE-STD-1022-94 (movement within the last 1 million years, displacing alluvial sediments), albeit all the known or inferred faults have not yet been characterized or investigated

A search in the immediate Rocky Flats vicinity for surficial and near subsurface physiographic features associated with active faulting was conducted by EG&G in 1993 and 1994, Dames and Moore (1981) and Blume and Associates (1974) The earlier reports (Dames and Moore, 1981, Blume, 1974) are now out of date but provide a basis for the more recent studies

A summary of the investigative methods and results of the sitewide geologic characterization program and the 1993-1994 Seismic Investigation Program (conducted as a component of the Systematic Evaluation Program), is provided in the Sitewide Geologic Characterization Report (personal communication EG&G, 1995) The Sitewide Geologic Characterization report describes the location of seven inferred shallow bedrock faults that extend to unknown depths These inferred faults trend north-northeast and are assumed to be high angle reverse faults The dip (angle by which a stratum or other planar feature deviates from the horizontal) of the fault planes is not yet known but are schematically shown on cross-sections with a dip of 60 degrees Estimated throw (vertical displacement) on these faults varies from 10 to 120 feet, heave (horizontal displacement) has not been estimated, and lengths of the inferred fault traces vary from 1,000 feet to almost 2 miles

Based on the results of the sitewide geologic characterization program, a suspected fault of primary interest to the design efforts of the OU4 final engineered cover is estimated to extend approximately 8,000 feet (~1 5 miles) from Woman Creek across OU1 and OU4 to McKay Ditch and is presumed to pass beneath the center of the 207-B series SEPs Core samples from five boreholes provide geologic evidence supporting the existence of this fault The capability of this inferred fault is not yet known An approach for confirming the presence or absence, and nature of this geologic feature is broadly outlined in Section IV 10 7 3 7

Two additional inferred faults are of interest to the OU4 final engineered cover design effort These faults lie to the west and east of OU4 respectively The western fault was investigated through trenching and borehole installation activities and was not found to be capable (movement within the last one million years) The location of the eastern fault coincides with the "bedrock step" identified in OU2 through shallow seismic-reflection and borehole data (EG&G, 1991, DOE, 1993) The top of bedrock surface drops approximately 40 feet in elevation along a northeastern-southwestern striking zone less than one-quarter of a mile in width across this step The topographic surface in this zone does not mirror the bedrock elevation change, suggesting possible pre-, syn-, or post-Rocky Flats Alluvium displacement along the inferred fault trace Additional characterization is necessary to determine the capability and nature of this fault Based upon results of trenching across the western fault, it should be assumed that the other inferred faults could be preferential pathways for groundwater and contaminant migration (personal communication EG&G, 1995)

In Sections IV 10 7 3 4 and IV 10 7 3.5, empirical models are presented that estimate ground motion experienced at RFETS from a proximal and a remote source, such as the faults described in the preceding paragraphs and the Golden Fault southwest of Rocky Flats Attenuating energy from the Golden Fault is modeled here to approximate a floating or random seismic event, such as the Christmas day 1994 event which occurred along a previously unknown fault This is not to suggest that the Golden Fault is capable, albeit there is debate over the capability of the Golden Fault (Simon, 1969, 1972, Scott, 1975, 1960, Machette, 1978, Van Horn, 1976, Kirkham, 1977, Dames & Moore, 1981, and many others) The Golden Fault is used as a "model" floating or random fault because its location and existence have been well documented and recent movement has been suggested by some investigators

Measured Maximum Magnitudes and Intensities

Tables IV 10-13 and IV 10-14 summarize the earthquake magnitude and intensity data for the region within a 100 kilometer radius of RFETS respectively (NOAA, 11-1994) The NOAA data file contains records from November of 1871 to September 1990 (the last seismic event in the 100 km radial area through November, 1994) Included in the NOAA data are the earthquakes attributed to deep well injection at the Rocky Mountain Arsenal during period 1962

TABLE IV.10-13
SUMMARY OF EARTHQUAKE MAGNITUDE AND OCCURRENCE

MAGNITUDES (LOCAL)	NUMBER OF EVENTS
1 0 - 2 0	6
2 0 - 3 0	137
3 0 - 4 0	49
4 0 - 5 0	37
5 0 - 6 0	2

TABLE IV.10-14
SUMMARY OF EARTHQUAKE INTENSITY AND OCCURRENCE

INTENSITY	NUMBER OF EVENTS
II	22
III	82
IV	69
V	49
VI	32
VII	2

through 1968 The NOAA data and Tables IV 10-13 and IV 10-14 contain events attributed to deep well injection at the Rocky Mountain Arsenal (determined from purely temporal and spacial relationships) because it is not possible to decipher syn- or subsequent natural events from artificial ones

A survey of the NOAA data reveals Modified Mercalli Intensity values (MM) ranging from II to VII (see Table IV 10-15 for a description of MM Intensity values), and a maximum body wave magnitude (Mb) of 5 3, which was reported on August 9, 1967 The maximum body wave event occurred during deep well injection operations and its epicenter was within five miles

of the Rocky Mountain Arsenal The largest magnitude event that cannot be attributed (spacially) to pumping activities at the arsenal had a body wave magnitude of 4 8 and occurred on September 14, 1965, southeast of Denver The greatest intensity event recorded in the NOAA data file that cannot be attributed to activities at the Rocky Mountain Arsenal, is estimated to have been an MM VII event (with an estimated local Richter magnitude of 6 5) and is thought to have occurred in northwestern Colorado (NOAA, 1994, Dames & Moore, 1981)

The disparity between the number of recorded events in Tables IV 10-13 and IV 10-14 is due to the lack of proximal modern seismic instrumentation prior to 1909 Further, the Modified Mercalli Intensity Scale is based upon what people felt and the associated damage to structures Modified Mercalli Intensity descriptions and relations to acceleration and magnitude are presented in Table IV 10-15 If there were no people in the vicinity of an event to feel it, and/or no structures on which to gauge effects, no MM Intensity assignments can be made, even if modern seismic instrumentation recorded an event

The summarized data in Tables IV 10-13 and IV 10-14 indicate that the most common events in the Rocky Flats area have a local (Richter) magnitude of between 2 and 3, and a MM Intensity of III The largest events observed or felt in this region had a local (Richter) magnitude of between 5 and 6, and an MM Intensity of VII Events of this level occurred twice during the time period of record

Intensity and Frequency Relations for the Rocky Flats Seismic Zone

A historical magnitude-frequency model, a probabalistic seismic source zone model, and a map depicting the seismicity of a 100 square km area around RFETS based on the NOAA data are presented in this section

The historical-seismicity method uses earthquake magnitude-frequency relations and can be thought of as a probabalistic method (Gutenberg and Richter, 1942, 1956) It has been demonstrated by many studies that earthquake frequency for large regions can be represented by the following equation from Richter (1958)

$$\log N = a - b M$$

where

N is the number of earthquakes of magnitude **M** or greater per unit time

a is the seismicity index, determined from least squares analysis for an area and is dependent upon the size of the geographic area, the level of activity, and the length of the time period considered

b is the seismic severity index and appears to be related to the nature of the tectonic activity causing earthquakes

TABLE IV.10-15
INTENSITY AND RELATIONSHIP TO ACCELERATION AND MAGNITUDE

Modified Mercalli Intensity Scale	Description of Effects**	Maximum Horizontal acceleration (g)	Richter Magnitude
I	Not felt or, except rarely under especially favorable circumstances Under certain conditions, at and outside the boundary of the area in which a great shock is felt sometimes, birds, animals, reported uneasy or disturbed, sometimes dizziness or nausea experienced, sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly	–	M2___
II	Felt indoors by few, especially on upper floors, or by sensitive, or nervous persons Also, as in grade I, but often more noticeably sometimes hanging objects may swing, especially when delicately suspended, sometimes trees, structures, liquids, bodies of water, may sway, doors may swing, very slowly, sometimes birds, animals reported uneasy or disturbed, sometimes dizziness or nausea experienced	–	M3___
III	Felt indoors by several, motion usually rapid vibration Sometimes not recognized to be an earthquake at first Duration estimated in some cases Vibration like that due to passing of light, or lightly loaded trucks, or heavy trucks some distance away Hanging objects may swing slightly Movements may be appreciable on upper levels of tall structures Rocked standing motor cars slightly Movements may be appreciable on upper levels of tall structures Rocked standing motor cars slightly	0 003 to 0 007	
IV	Felt indoors by many, outdoors by few Awakened few, especially light sleepers Frightened no one unless apprehensive from previous experience Vibration like that due to passing of heavy or heavily loaded trucks Sensation like heavy body striking building or falling of heavy objects inside Rattling of dishes, windows, doors, glassware and crockery clink and clash Creaking of walls, frame, especially in the upper range of this grade Hanging objects swung, in numerous instances Disturbed liquids in open vessels slightly Rocked standing motor cars noticeably	0 007 to 0 0015	M4___
V	Felt indoors by practically all, outdoors by many or most, outdoors direction estimated Awakened many, or most Frightened few - slight excitement, a few ran outdoors Buildings trembled throughout Broke dishes, glassware, to some extent Cracked windows - in some cases, but not generally Overturned vases, small or unstable objects, in many instances, with occasional fall Hanging objects, doors, swing generally or considerably Knocked pictures against wall, or swung them out of place Opened, or closed, doors, shutters, abruptly Pendulum clocks stopped, started or ran fast, or slow Moved small objects, furnishings, the latter to slight extent Spilled liquids in small amounts from well-filled open containers Trees, bushes, shaken slightly	0 001 to 0 03	
VI	Felt by all, indoors and outdoors Frightened many, excitement general, some alarm, many ran outdoors Awakened all Persons made to move unsteadily Trees, bushes, shaken slightly to moderately Liquid set in strong motion Small bells rang - church, chapel, school, etc Damage slight in poorly built buildings Fall of plaster in small amount Cracked plaster somewhat, especially fine cracks in chimneys in some instances Broke dishes, glassware, in considerable quantity, also some windows Fall of knick-knacks, books, pictures Overturned furniture in many instances Moved furnishings of moderately heavy kind	0 03 to 0 09	M5___

Modified Mercalli Intensity Scale	Description of Effects**	Maximum Horizontal acceleration (g)	Richter Magnitude
VII	Frightened all, general alarm, all ran outdoors Some, or many, found it difficult to stand Noticed by persons driving motor cars Trees and bushes shaken moderately to strongly Waves on ponds, lakes, and running water Water turbid from mud stirred up Incaving to some extent of sand or gravel stream banks Rang large church bells, etc Suspended objects made to quiver Damage negligible in buildings of good design and construction, or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc Cracked chimneys to considerable extent, walls to some extent Fall of plaster considerable to large amount, also some stucco Broke numerous windows, furniture to some extent Shook down loosened brickwork and tiles Broke weak chimneys at the roof-line (sometimes damaging roofs) Fall or cornices from towers and high buildings Dislodged bricks and stones Overturned heavy furniture, with damage from breaking Damage considerable to concrete irrigation ditches	0 07 to 0 22	M6___
VIII	Fright general, alarm approaches panic Disturbed persons driving motor cars Trees shaken strongly - branches, trunks, broken off, especially palm trees Ejected sand and mud in small amounts Changes temporary, permanent, in flow of springs and wells, dry wells renewed flow, in temperature of spring and well water Damage slight in structure (brick) built especially to withstand earthquakes Considerable in ordinary substantial buildings, partial collapse, racked, tumbled down, wooden houses in some cases, threw out panel walls in frame structures, broke off decayed piling Fall of walls Cracked, broke, solid stone walls seriously Wet ground to some extent, also ground on steep slopes Twisting, fall, of chimneys, columns, movements, also factory stacks, towers Moved conspicuously, overturned, very heavy furniture	0 15 to 0 3	
IX	Panic general Cracked ground conspicuously Damage considerable in (masonry) structures built especially to withstand earthquakes Threw out of plumb, some wood-frame houses built especially to withstand earthquakes, great in substantial (masonry) buildings, some collapse in large part, or wholly shifted frame buildings off foundations, racked frames, serious to reservoirs, underground pipe sometimes broken	–	
X	Cracked ground, especially when loose and wet, up to widths of several inches, fissures up to a yard in width ran parallel to canal and stream banks Landslides considerable from river banks and steep coats Shifted sand and mud horizontally on beaches and flat land Changed level of water in wells Threw water on banks of canals, lakes, rivers, etc Damage serious to dams, dikes, embankments Severe to well-built wooden structures and bridges, some destroyed Developed dangerous cracks in excellent brick walls Destroyed most masonry and frame structures, also their foundations Bent railroad rails slightly Tore apart, or crushed endwise, pipe lines buried in earth Open cracks and broad wavy folds in cement pavements and asphalt road surfaces	0 45 to 1 5	
XI	Disturbances in ground many and widespread, varying with ground material Broad fissures, earth slumps, and land slips on soft, wet ground Ejected water in large amounts charged with sand and mud Caused sea-waves ("tidal" waves) of significant magnitude Damage sever to wood frame structures, especially near shock centers Great to dames dikes, embankments often for long distances Few, if any, structures (masonry) remained standing Destroyed large well-built bridges by the wrecking of supporting piers, or pillars Affected yielding wooden bridges by the wrecking of supporting piers, or pillars Affected yielding wooden bridges less Bent railroad rails greatly, and thrust them endwise Put pipe lines buried in earth completely out of service	0 5 to 3	M8___
XII	Damage total - practically all works of construction damaged greatly or destroyed Disturbances in ground great and varied, numerous shearing cracks Landslides, falls of rock of significant character, slumping of river banks, etc , numerous and extensive Wrenched loose, tore off, large rock masses Fault slips in firm rock, with notable horizontal and vertical offset displacements Water channels, surface and underground disturbed and modified greatly Dammed lakes, produced waterfalls, defected rivers, etc Waves seen on ground surfaces Distorted lines of sight and level Threw objects upward into the air	0 5 to 7	M9___

This empirical linear relationship is commonly modified to an earthquake intensity-frequency relation using MM Intensity data, this relation is

$$\log N = a - b I$$

where

I is the number of earthquakes of MM Intensity I through XII

Algermissen (1969) studied earthquake recurrence relations in several regions of the United States One area addressed was the central portions of Wyoming, Colorado, and New Mexico From several least squares regressions it was found that the following recurrence relation applied to the Wyoming, Colorado, New Mexico area

$$\log N = 3.66 - 0.68 I$$

Algermissen (1969) statistically found the average number of earthquakes of a particular MM Intensity occurred every 100 years per 100,000 km^2 in the Wyoming, Colorado, New Mexico area Algermissen's results are presented in Table IV 10-16

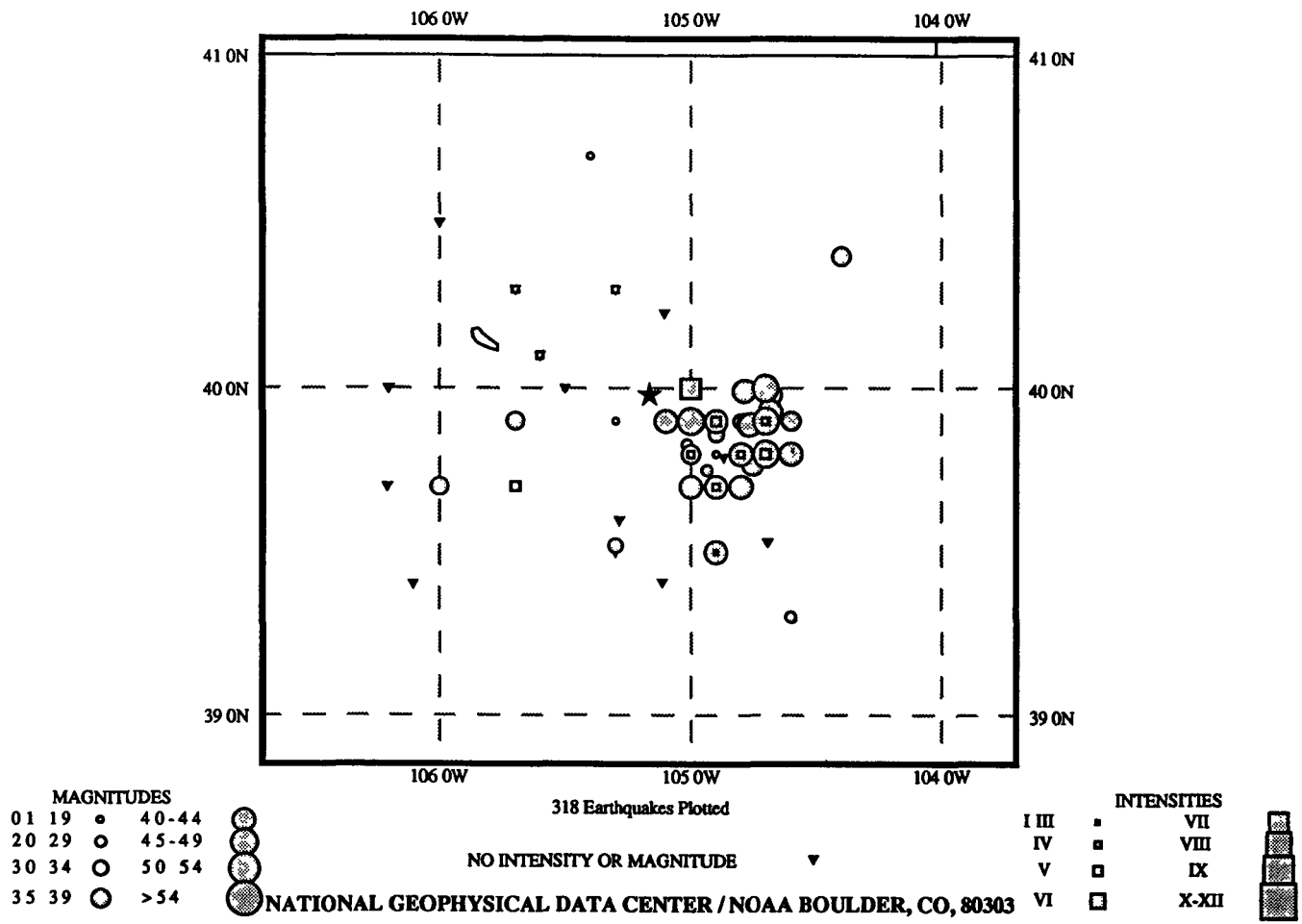
TABLE IV.10-16
NUMBER OF EARTHQUAKES PER 100 YEARS IN THE WYOMING, COLORADO, NEW MEXICO AREA

MM Intensity	V	VI	VII	VIII
Number of Earthquakes every 100 years in Wyoming, Colorado, and New Mexico	32 8	6 85	1 42	0 31

Using the same methodology, Algermissen and Perkins (1976) defined 71 smaller regions within the conterminous United States as seismic source zones Each zone was defined on the basis of historic seismicity and the distribution and activity of faults Future earthquakes are considered equally likely to occur anywhere in the source zone It was determined that the zone in which RFETS is located (central Colorado Rockies only) had the following seismic parameters

* 21 5 MM Intensity V events per 100 years
* a projected maximum MM intensity of VII
* a corresponding maximum magnitude of 5 5

Figure IV 10-2 is a map depicting the location and size of seismic events listed in the NOAA data Some of the events shown may be due to human activities such as explosive detonations, mining, injection wells, and have associated shallow focal depths



Not To Scale

PREPARED FOR
U S DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Figure IV 10-2

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Seismicity within 100 km of
Rocky Flats, Colorado

As shown on Figure IV 10-2, a zone of dense seismic activity is discernable and broadly coincides with the Rocky Mountain Arsenal The City of Denver is located at approximately 105 W longitude, 39 7 N latitude The location of the RFETS is shown on this figure by a star, and Lake Grandby is shown as an irregularly circled area northeast of 106 W longitude, 40 N latitude

The Design Response Spectrum and Peak Motions: Acceleration, Velocity, Displacement, Predominant Period

For seismic hazard investigations ground motion input for seismic evaluation and design is generally defined in terms of a design response spectrum The following summary of near-field ground motions such as seismic wave velocity, ground displacement, and seismic wave period is made in terms of a design response spectrum, but is equally applicable in terms of a lateral force coefficient (building code approach based upon a design response spectrum)

The inferred near-field faults at the RFETS (described in Section IV 10 7 3 1) can not be modeled to estimate magnitude/intensity-acceleration relationships because peak ground acceleration within 10 km of the causative fault is independent of magnitude Peak ground acceleration in the near-field is a function of the local distribution of stress, dynamic stress drop, epicentral depth, and epicentral intensity (Hays, 1980) Further, there is little information on the dip, length, displacement, and capability of these faults

The design response spectrum is a broad banded spectrum with liberal frequency and period content It expresses the peak linear response of a series of single-degree-of-freedom oscillators at a specified damping level A spectrum is typically anchored by a value of peak ground acceleration, or alternately effective (or design) peak ground acceleration The "effective peak acceleration" can be thought of as the peak ground acceleration after very high frequencies that have little influence on most structural responses (because they attenuate very rapidly) have been filtered out and may be more representative than peak ground acceleration (especially for stiff structures) Since the OU4 final engineered cover is a stiff structure with a higher natural frequency, effective peak ground acceleration may be the most representative ground motion parameter (Newmark, 1973, Hays, 1980, Kennedy, 1980)

Site-independent or site-dependant spectra can be generated, the former for regional use and the latter for site specific use The site-independent spectrum is usually anchored to one parameter of ground motion The site-dependant spectrum is anchored to one or more parameters, and is geared to the local site conditions because the amplitude of the ground motion, and how it is amplified or attenuated is a function of site specific shear wave velocity, material density and damping, thickness of unconsolidated material, water content, and where the surface or bedrock topography is irregular, the geometry of the unconsolidated deposits and underlying rock (Kennedy, 1980) The most recent site dependent design response spectrum was constructed for RFETS in 1984 by Coats and Murray, although this spectrum is now out of date (as per DOE Order 5480 28) it will be used in this analysis

Studies of ground motion characteristics, combined with geological investigations and related damage assessments from past earthquakes have shown the characteristic period at which maximum damaging effects occur is approximately equal to the fundamental period of the soil column overlying rocklike (shear wave velocity of approximately 2500 feet/second or greater at small strains) formations (Scholl and Kustu, 1980, Hays, 1980) Therefore, since the OU4 final engineered cover can be thought of as a stiff structure lying ontop of a stiff soil column, it would be more susceptible to damage from a high frequency-low period seismic energy wave (which would attenuate very rapidly) Thus, a near- field, high frequency-low period seismic wave would effect the cover more adversely than a far-field, low frequency-high period seismic wave

To summarize these site-specific data deficiencies before near-field ground motions are modeled, the effective peak acceleration for RFETS, which may be a more representative parameter in comparison to peak ground acceleration, is not known, nor has it been estimated It is not known how the unconsolidated material at RFETS (alluvium, colluvium, weathered sandstone and claystone) modifies seismic input (attenuation or amplification) The fundamental period of soil column above bedrock is also not known However, an empirical site period relation will be applied in order to estimate near-field ground motions such as acceleration and velocity

A single-layer method has been proposed for empirically estimating the characteristic site period, Ts (Seed, 1975, Hays, 1980), this equation is

$$Ts = (4 \bullet H)/(R \bullet B)$$

where

H is the depth of soil over bedrock,

B is the shear wave velocity of the soil layer as measured under low strain conditions in the field,

R is a correction factor to allow for the reduction is shear wave velocity when the soil is excited by high-strain ground motion during an earthquake

To estimate the impact a near-field seismic event would have on the engineered cover, shear wave velocities need to be considered for the materials beneath the structure For design purposes, the seismic period is considered to be the most critical for the waste materials in the interval between bedrock and the asphalt layer at the base of the engineered cover

In 1993 DOE conducted a low-strain geophysical refraction survey throughout OU4 (DOE, 1995, Part II of this document) The data collected during this survey indicated up to four layers of different unconsolidated materials with varying thickness and velocity lie beneath the SEPs During construction of the engineered cover most of these layers will be removed The unconsolidated layer above the bedrock claystone will have a maximum thickness of approximately 5 to 10 feet, these materials have a shear velocity of approximately 2,200 feet per second (fps) Upon this surface a three foot thick lateral subdrain layer will be constructed of gravel Although no shear wave velocity is known for the subdrain materials, an estimate of

1,200 fps can be made for this layer It is assumed that this layer should behave similar to the loosely unconsolidated sand which crops out north of the SEPs Above the subdrain, approximately 15 feet of soil will be compacted to approximately 90 percent proctor Although no shear wave velocity is known for the compacted soils an estimate of 2,200 fps can be made for this layer It is assumed that this layer should behave similar to the unconsolidated soils which surround the SEPs Using a weighted average for the maximum thickness of approximately 28 feet, an average shear wave velocity of approximately 2,100 fps is obtained

Using these values to solve for Ts in the empirical characteristic site period equation, yields a value of 0 06 seconds for the area beneath the SEPs Using this characteristic site period, ranges of values for velocity, acceleration, and displacement can be extrapolated from the site specific design response spectrum (Coats and Murray, 1984) and are presented in Table IV 10-17 This value is of very high frequency, and may attenuate very rapidly, therefore having little influence on the structural response of the final engineered cover

Alternatively, site-independent work by Seed (1975) determined the fundamental period of any site (Ts) will vary from a minimum allowable value of 0 5 s for shallow stiff soil deposits to a maximum of 2 5 s for deep, soft soil deposits Without actual data on amplification and attenuation properties of unconsolidated material at the RFETS, this value (0 5 s) may serve to provide a better value of effective peak ground acceleration Table IV 10-17 presents the ground motion value ranges (2% to 10% critical damping) extrapolated from the site specific design response spectrum using the calculated site period and the value suggested by Seed (1975)

Ground acceleration is commonly measured in g's, where "g" is acceleration due to gravity The acceleration of gravity is approximately 9 79 meters/second/second, when the ground accelerates faster than this, the force of gravity is exceeded and unanchored objects on the ground, no matter what their weight, go flying or are suspended momentarily

TABLE IV.10-17
ESTIMATED PEAK GROUND MOTIONS FOR A NEAR-FIELD SEISMIC EVENT

Characteristic Site Period (seconds)	Acceleration (g's)	Velocity (cm/sec)	Displacement (cm)
0 06	~1 2-1 8	~11 5-15 0	~0 1-0 15
0 5	~2 0-3 0	~152 4-228 6	~10 1-15 2

The spectral values presented in Table IV 10-17 represent the combined horizontal and vertical components of each response For seismic design evaluations the horizontal or lateral component is the most critical and useful parameter In the near-field the vertical component of each response is commonly much greater than the horizontal component Thus, the g values presented in Table IV 10-17 are most likely overly conservative, in that they represent the estimated lateral and vertical force of a near-field earthquake

However, the values in Table IV 10-19 suggest that a very near-field seismic wave (possibly generated from the inferred fault subjacent to the SEPs), with an associated high frequency-low period would do less damage (0 1-0 15 cm vs 10 1-15 2 cm displacement) to the final engineered cover in comparison to a moderate-field (possibly generated from the inferred OU2 fault) seismic wave with a lower frequency-higher period

Attenuation of Peak Motions: Intensity and Acceleration

Many authors have historically based attenuation functions for areas outside of California on MM Intensity data Using MM Intensity data, regional seismic attenuation can be determined by several techniques, some of these will be applied in this section to determine MM Intensity values at RFETS from a distant source

Peak ground acceleration is not a simple function of MM Intensity, but is more directly related to epicentral intensity (Hays, 1980) The following discussion is intended to provide a sense of the source-distance relationship, and how this relationship correlates with the peak horizontal ground acceleration component of spectral acceleration (g's)

An empirical method developed by Gupta and Nuttli (1976) derived the following relationship for the central United States in the area between the Rocky Mountains and the Appalachians

$$I(R) = I_0 + 3.7 - 0.001R - 2.7 \log R, \quad \text{for } R > 20\text{km}$$

where
R is distance from source to site
I_0 is MM Intensity at source
I(R) is MM Intensity at a distance R (epicentral distance)

Table IV 10-18 displays the MM Intensity that RFETS might experience for MM Intensity events at various distances using EQ 1

TABLE IV.10-18
MM INTENSITY EVENTS

Row	MM Intensity at Source	R in km	R in miles	MM Intensity Felt at Site
1	IV	20	12 5	IV
2	V	20	12 5	V
3	VI	20	12 5	VI
4	VII	20	12 5	VII
5	IV	50	31	III
6	V	50	31	IV
7	VI	50	31	V
8	VII	50	31	VI
9	VII	350	217	III

Rows 1 through 4 illustrate the near-field source MM Intensities that might be felt from energy released from the Golden Fault model Rows 5 through 8 represent moderate-field source MM Intensities that may be experienced at the site, such as from seismic events spacially related to the Rocky Mountain Arsenal, or floating events such as the Christmas day 1994 event Row 9 illustrates the MM Intensity that might be felt at RFETS in the case of a distant far-field, high-intensity, large magnitude earthquake

Methods have also been developed to obtain peak horizontal ground acceleration from MM Intensity data Trifunas and Brady (1975) derived the following relationship from empirical relations between MM Intensity and peak horizontal ground acceleration using data from the Western United States

$$\log A_h = -0.014 + 0.30\ I\ MM, \text{ for } I\ MM > I$$

where

A_h is horizontal peak ground acceleration in cm/sec^{-2}

The result of applying this equation to the attenuation results of Table IV 10-18 is presented in Table IV 10-19

TABLE IV.10-19
ATTENTUATION RESULTS

MM Intensity at site	Predicted horizontal ground acceleration in cm/sec^{-2}	Predicted horizontal ground acceleration in "g"s
III	7 69	0 008
IV	15 34	0 015
V	30 62	0 031
VI	61 09	0 062
VII	121 89	0 124

Effect of Near- and Far Field Earthquakes on the OU4 Final Engineered Cover

The preceding sections have presented data on the location of faults proximal to RFETS, magnitudes and intensities of earthquakes that have occurred within 100km of Rocky Flats during the last 123 years, estimates on frequency of earthquake occurrence and associated intensities, estimated near source earthquake ground motions, and attenuation of ground motion parameters from a far-field source The end result of exploring these parameters was to gain an estimate of the probable g force RFETS and specifically the OU4 final engineered cover would experience during a near- or far-field earthquake This data is used in this section to examine the effects of a postulated earthquake on the OU4 final engineered cover

Tables IV 10-20 and IV 10-21 present a seismic sensitivity analysis, using slope stability as a limiting parameter This analysis was performed using Version 5 0 of the XSTABL program developed by I S Designs, Inc , of Moscow, Idaho XSTABL performs two-dimensional limit equilibrium analyses and incorporates a random surface generator for searching out the critical failure surface for a given slope using Spencer's Method This model is considered "state of the art" for slope stability modeling and has been validated and verified by DOE's design team Further information regarding the computer model can be found in Appendix IV H, and the XSTABL Reference Manual Modeling parameters such as shear strengths and field densities were acquired from laboratory testing on samples obtained during the geotechnical drilling program, the results of this program are fully outlined in Appendix IV H

Table IV 10-20 presents data that was developed under the assumption that fractured bedrock terminates 40 feet below the final engineered cover Thus, this modeling scenario is applicable if there are no faults subjacent to the final engineered cover

TABLE IV.10-20
ESTIMATED ENGINEERED COVER PARTIAL FAILURE LIMITS ASSUMING NO SUBJACENT FAULTS

Horizontal Acceleration (g's)	Engineered Cover Failure
0 05	NO
0 10	NO
0 15	NO
0 20	NO
0 25	NO
0 30	NO
0 35	POSSIBLE
0 40	YES

Comparing the failure limit (conservatively placed at 0 35 g) in Table IV 10-20, to the predicted ground acceleration in g's (0 124 g) for a worst case far-field energy release (MM Intensity VII) that is attenuated to RFETS (Table IV 10-19) suggests that seismically induced slope failure will not occur

Table IV 10-21 presents data that was developed under the assumption that fractured bedrock has no lower bound beneath the final engineered cover Thus, this modeling scenario is applicable if there are faults subjacent to the final engineered cover

TABLE IV.10-21
ESTIMATED ENGINEERED COVER PARTIAL FAILURE LIMITS ASSUMING SUBJACENT FAULTS

Horizontal Acceleration (g's)	Engineered Cover Failure
0 05	NO
0 10	NO
0 15	POSSIBLE
0 20	YES
0 25	YES

Comparing the failure limit (conservatively placed at 0 15 g) in Table IV 10-21, to the predicted ground acceleration presented in Table IV 10-17 for a worst case near-field (1 2 to 1 8 g) or moderate-field (2 0-3 0) energy release at RFETS (Section 10 7 3 5), suggests that seismically induced slope failure could occur

Course of Action for Further Investigations

The results of this analysis indicate that seismic activity is the only credible NPH that could have the potential to negatively impact the OU4 final engineered cover The results of the seismic analysis indicate that under the current known conditions the final engineered cover as it is conceptually designed could withstand the effects of the credible seismic events However, the suspected identification of new faults in the vicinity of the SEPs has the potential to require design modifications to the final engineered cover if the inferred faults are proven to exist, and if any new faults are determined to be capable

Confirming the location, trend, and nature of suspected or inferred faults proximal or subjacent to the OU4 area (Section 10 7 3 1) is important to the IM/IRA design process Further, ascertaining the capability of confirmed faults and updating the design response spectrum for the RFETS is required by DOE Order 5480 28

If the final results of the currently ongoing seismic evaluation program determine that new faults are suspected in the vicinity of the SEPs, then the DOE will initiate field programs to confirm or deny their existence If any new faults are confirmed then the DOE will initiate field programs to determine if any fault is capable

Several different types of geophysical techniques can be used to confirm or identify faulting Each technique has limitations relevant to the particular site but is capable of supplying non-intrusive information that can direct pertinent intrusive investigations In this manner the more costly and slower intrusive investigation costs can be kept to a minimum The two basic geophysical investigation forms are surface and subsurface types of investigation The subsurface types of investigation use boreholes to gain additional knowledge about the lithology around a borehole or between adjacent boreholes These techniques typically include borehole geophysical logging, Vertical Seismic Profiles (VSPs), and tommography To initially define and confirm a fault trace, surface geophysics is typically the most appropriate tool Large faults can be identified using gravity, magnetic, or seismic refraction data Because of the subtle expression of the faults at the RFETS these geophysical tools are too rough and instead a near surface seismic reflection survey can be designed to delineate suspected faults Previous reflection survey investigations of faulting have shown that the design aspect impacts the depth of investigation and the quality of information obtained The beneficial results from a reflection survey are identification of a fault (location and extent), a better estimate of the potential seismic moment magnitude as estimated through the size-fault-area relationship (previously above), and possibly the latest occurrence of movement as seen in "bedding" offset

If the non-intrusive seismic reflection results confirm the suspected location of an inferred fault, then intrusive field work will be initiated A subsurface characterization program using inclined or conventional boreholes would then be initiated for any fault that remains suspected in order to confirm or preclude their existence Once this has been accomplished, a trenching program would be a cost effective and defensible means to physically characterize and access the capability of each fault If the inferred faults are shown to exist and determined to be capable, then additional design criteria may be needed to mitigate any seismic hazard

The two destructive forces associated with earthquakes are shaking (acceleration) and displacement Just like there is no standard procedure for assigning the probable peak motions or duration of shaking from a future earthquake at any given site, any effort to strengthen a structure against an unknown force is built upon assumptions Generally, buildings are stiffened with the use of shear walls Shear walls reduce the deflections of the upper floors by increasing the natural frequency of the structure Typical stiffening procedures attempt to fortify weak members by cross-linking members or adding special no-window walls to structures (Green, 1978) These typical features would lessen the functional aspects of the Engineered Cover by permitting ground water movement along the structural support members Another possibility is to encapsulate the waste in concrete Because the natural frequency of a predicted earthquake is estimated to be high, the Engineered Cover should endure the shaking similar to compacted earthen dams (Wiegel, 1970) Typical failure of earthen dams is due to liquefaction, a very unlikely event for the Engineered Cover because of its high topographic position and the functioning aspects of the lateral subdrain To continue functioning subject to the predicted displacement forces that tend to shear structures apart, the amount of displacement associated with an earthquake must be taken into account Given the nature of the gravel lateral subdrain, it is anticipated that most of the shearing force will be dissipated internally The amount of maximum displacement associated with the largest predicted earthquake for the Engineered Cover is approximately 15 cm (Section IV 10 7 3 4) This amount of displacement can be accounted for by adding a like amount of gravel to the lateral subdrain

IV.10.8 Transportation Impacts

Implementation of the preferred IM/IRA action would be expected to cause minor direct and indirect impacts to the transportation system, both on and off the RFETS Shipments of construction materials are anticipated to be made entirely by trucks Therefore, it is reasonable to assume that traffic on the state, county, and RFETS roads may experience relatively minor delays due to this increase in construction materials, supplies, workers, and equipment entering and exiting the facility These offsite transportation impacts would be less severe under the preferred IM/IRA alternative in comparison to other potentially reasonable alternatives as there is no required removal of contaminated materials to areas outside the RFETS for disposal

IV.10.8.1 Offsite Impacts

Impact on the highways surrounding the RFETS is anticipated to be minimal State Highway 93 will be the thoroughfare used by construction delivery trucks The vehicles will enter and exit at the west gate of the RFETS located off Highway 93 The Colorado Department of Transportation (CDOT) 1992 traffic data shows that between State Highway 128 to the north of the RFETS and Cheyenne Street in Golden to the south of the RFETS, an average of 215 combined unit trucks (i e , tractor/trailer vehicles, etc) were counted on Highway 93 per day (CDOT, 1993) Total vehicle traffic for this section of Highway 93 averaged 13,700 ADT, therefore combined unit (c u) trucks accounted for 1 6% of total traffic Based on a conservative estimate, the IM/IRA would result in a maximum increase of 60 c u trucks per day for this highway (120 c u counts) translating to c u trucks accounting for 2 4% of total traffic Assuming 1992 traffic statistics are adequate estimates for the IM/IRA startup, the conservative number of 60 vehicles spread over 10 hours (avoiding delivery during peak rush-hours) would not be expected to have a noticeable impact on local transportation infrastructure Informal discussions with CDOT resulted in the same conclusion (CDOT, 1994) In addition, the traffic lights at the west gate and the state highway 93/72 intersection and the left and right turn lanes into the RFETS will further mitigate potential adverse impacts to traffic (DRCOG, 1994)

IV.10.8.2 Onsite impacts

It is expected that the impact of the increased traffic at the RFETS would be small The approximately 15,200 truck loads (at 18 cubic yard payloads) of material required for cover construction and backfill activities will be delivered over a 12 to 18 month period During the most intense delivery periods, a maximum of 6 trucks per hour (ten hours per day) will unload at an area adjacent to OU4 These deliveries would occur ahead of construction needs for each cover layer, logistical issues will be addressed as appropriate Such issues include coordination of activities and deliveries of materials with other RFETS projects to minimize delays and traffic congestion on site Deliveries would not be expected to be allowed during peak rush-hours in the mornings and evenings thereby avoiding disruption to traffic flow during heaviest volumes

The security gates and the RFETS roads within or adjacent to OU4 would receive the greatest direct impacts from the preferred IM/IRA The relatively concentrated area of truck operations and the time required to clear security procedures account for the expected site congestion and delays The time required for a single truck to enter the RFETS, deliver its load, and exit the facility will be greatly reduced by the modification to the site security system that allows for easier access than currently exists A separate construction vehicle access point will reduce impacts to on site traffic flow in that construction vehicles will stay off main site roadways to access the proposed construction gate The most dramatic increase in usage may occur on the dirt road west of SEP 207-C, the access road east and northeast of the SEPs, and the paved road south of the SEPs

Human health impacts normally incident to transportation include possible traumatic injuries and fatalities resulting from vehicular operations in addition to vehicle emissions (DOE,

1991a) Rao et al (1982) estimated risks resulting from truck transportation based on nationwide Department of Transportation (DOT) statistics The accident-related risk estimates were average values that accounted for traffic differences between urban, suburban, and rural areas (DOE, 1991a) Using the risk estimate for trucking accidents (4 83E-8 per mile) (Rao, 1982) approximately 210,000 truck shipments (one-way distance of 50 miles) would be required to result in one additional traumatic fatality This value provides a reasonable reference point to assess IM/IRA transportation impacts since it is anticipated that the materials for the final engineered cover construction will be obtained from quarries within a 50-mile radius of the RFETS, and will be delivered by trucks Comparing this value to the projected 15,200 or fewer truckloads of construction material required to implement the preferred IM/IRA, human health impacts due to traffic accidents would not be expected

Dust resuspension due to the increased traffic on OU4 roads, especially the dirt road to the east of SEP 207-C, could also result in the potential for short-term adverse health effects to the workers These temporary impacts to human health could result from the inhalation or ingestion of the dust particulates (i e , respiratory distress) These potential negative impacts could be mitigated through dust suppression techniques (frequent watering of the roads, etc), erosion protection, air monitoring, and personnel protection measures Long-term health impacts resulting from inhalation of contaminated particulates have been indirectly assessed in the PRG calculations for OU4 (see Section IV 10 1) As previously mentioned, the final engineered cover would result in long-term beneficial impacts to human health by eliminating significant exposure pathways The decontamination and demolition of Buildings 788 and 964 would occur at the beginning of IM/IRA implementation and would not be expected to interfere with other OU4 and RFETS-related traffic The requirements for transport vehicles and demolition equipment for building removal would be negligible compared to the rest of the IM/IRA transport needs The no action alternative would not require shipments of construction materials and so would result in no noticeable increase in traffic

IV.10.9 Short-Term Versus Long-Term Impacts

The environmental restoration of the OU4 area could result in short-term degradation of habitats of topsoil borrow sites Required removal of clean fill is expected to be less than 100,000 cubic yards This potential can be mitigated as it is expected that clean fill material will be procured from commercial mining/quarrying sites that hold the proper permits It is anticipated that the material would be removed in a manner that would minimize long-term impacts by such procedures as

- Excavating only above the ground water elevation to avoid affecting ground water,
- Grading and revegetating borrow areas to be consistent in appearance with adjacent lands,
- Avoiding excavation in sensitive areas such as wetlands, flood plains, and areas that potentially provide habitat to threatened or endangered or other species of concern, and

- Locating stockpiles of construction materials and clean fill in areas void of vegetation and wildlife These areas will include the SEPs themselves and disturbed vacant lots to the east of the SEPs

SEP habitat is essentially nonexistent due to the extensive industrial activity in the area over the last 20 years In the long-term, the preferred IM/IRA action for the OU4 area would be expected to have a positive impact on the local hydrology, vegetation, and wildlife by eliminating industrial disturbance

As discussed in the previous media quality impact sections, the no action alternative will not remove or isolate the contamination source and consequently will not limit the potential for adverse human health or ecological risks It is reasonable to assume that in the short and long-term, the potential for degradation of the biotic components will continue and acceptable cleanup levels will be more difficult to achieve in the future

IV.10.10 Impact to Cultural/Historical and Archeological Resources

The proposed actions would have no impact on archaeological and/or historic resources Recent resource cultural surveys have revealed that no sites found on the 5,900-acre RFETS are eligible for National Register of Historic Places designation (Burney et al, 1988 & EG&G 1992) The State Office of Archaeology and Historic Preservation has concluded that the areas within the 384-acre security-fenced zone of the RFETS are so highly disturbed that little cultural resource information would be available (DOE, 1991a)

IV.10.11 Cumulative Impacts

Cumulative impacts are the result of the accumulation of incremental effects of past, present, and reasonably foreseeable future actions These impacts must be considered because minor impacts from specific projects may, when collectively considered, result in substantial effects to the environment

At present, there are no other activities scheduled for the OU4 area that would be expected to cause significant impacts to the area Ongoing and anticipated hydrogeological characterization activities will be limited to short term sampling events It is assumed that construction activities at various OUs in the RFETS will continue in the future However, these actions are not all likely to overlap due to the lengthy process of project design, approval, and implementation Therefore, short-term future cumulative effects would not be substantial Long-term cumulative impacts, i e , IM/IRA action in conjunction with other site restoration activities, will facilitate future beneficial use of the RFETS land and fulfill mandated cleanup objectives (refer to IV 10 1 for discussions on impacts to human health)

Regarding past and present actions, the IM/IRA alternative would result in cumulative impacts to ground water, surface water, air quality, vegetation, wildlife, land use, and

transportation in and immediately around the OU4 area However, these impacts would be small or immeasurable, and in many cases favorable to the current OU4 situation when viewed over the long term

It is anticipated that the no action alternative would result in continued risk of adverse impacts to the environment, specifically to the biotic components in the OU4 area (refer to Sections IV 10 1 and IV 10 2) Potential pathways to terrestrial plant and animal receptors may exist provided the COCs remain accessible to plant roots, burrowing animals (invertebrates and higher trophic level organisms), or foraging animals Higher food web organisms, most likely migratory, that consume plant and animal species that have accumulated site contaminants could therefore also be exposed indirectly to these contaminants As mentioned in previous impact discussions, adverse impacts to abiotic media (ground and surface water, air) would not be expected to be consequential, although mobilization of COCs in the soil through ground water flushing (extreme elevation into previous unsaturated soils) could result under the no action scenario The evaluation of potential ground water elevation exclusions as a mechanism of soil contamination transfer to ground water is presented in Appendix III D Hydrogeologic investigations will be conducted and addressed during the Phase II *RFI/RI*

IV.10.12 Comparison of the Preferred IM/IRA to the No Action Alternative

The potential adverse and beneficial impacts of the two alternatives are expected to be significantly different in both the magnitude and degree to which they affect the quality of the human environment Implementation of the preferred IM/IRA is not expected to have any substantial adverse impacts to human health or the environment and is consistent with long-term remediation goals for the RFETS In the instances where potentially small impacts may occur, appropriate mitigation measures may be employed

The no action alternative could potentially have adverse impacts to both human health and the environment through the continued migration of contaminants which exceed the risk-based concentration levels The contaminants (if left as is) would remain available for exposure to humans and biotic components of the environment and thus potentially allow for direct or indirect receptor exposure and intake A comparison of how the two alternatives could impact human health and the environment is presented in Table IV 10-22 It should be noted that the no-action alternative cannot be selected as the OU4 IM/IRA due to the fact that this alternative failed the threshold comparison criteria (compliance with ARARs, and overall protection of human health and the environment) presented in Section III 5 2

IV.10.13 Agencies Consulted, Including Coordination with Federal, State, Regional, and Local Agencies.

The following agencies were contacted for information during preparation of this IM/IRA-EA Decision Document

Colorado Department of Transportation

TABLE IV.10-22
SUMMARY OF POTENTIAL IMPACTS: PREFERRED IM/IRA VERSUS NO ACTION

Impact	Preferred IM/IRA	No Action
Human Health	Minimize existing risks due to long-term potential exposure to surficial soil, vadose zone soil, sludges, and pondcrete contamination	Failure to achieve PRGs that are protective of human health
	Short-term risks due to worker exposure to soil materials, sludges and potentially pondcrete that exceed PRGs during remediation	Short-term risks due to worker exposure to soil contamination during grading and reseeding activities
	Potential adverse effects to workers as a result of encountering unknown utilities or uncharacterized areas of high contamination	Potential adverse effects to workers as a result of encountering unknown utilities or uncharacterized areas of high contamination
	Risks to workers associated with soil excavation, relocation, treatment processes and construction activities (e g , increased fugitive dust generation, increased transportation requirements)	Risks to workers associated with grading (e g , increased fugitive dust generation, increased vehicular use)

TABLE IV.10-22 (Continued)
SUMMARY OF POTENTIAL IMPACTS: PREFERRED IM/IRA VERSUS NO ACTION

Impact	Preferred IM/IRA	No Action
Environment	Temporary physical disruption of industrial area during construction of engineered barrier, more than 27 acres affected by soil excavation, material staging, and construction activities Temporary physical disruption of borrow area used for clean fill material Increase in local traffic requirements, increased dust generation during construction, and increased potential for erosion due to changes in surface topography at both OU4 and borrow area Three small wetlands will require protection during construction Wetlands banking is being considered as a mitigative measure Mitigative measures may be required for the Preebles Meadow Jumping Mouse, which is being considered for listing as a federal endangered species No floodplains will be affected	Physical disruption of industrial area during regrading activities Remaining uncontrolled contaminants could negatively affect colonizing vegetation and wildlife and impact receiving surface water and ground water No wetlands, floodplains, critical habitats, or threatened and endangered species will be negatively impacted by construction activities

TABLE IV.10-22 (Continued)
SUMMARY OF POTENTIAL IMPACTS: PREFERRED IM/IRA VERSUS NO ACTION

Impact	Preferred IM/IRA	No Action
Air Quality	Atmospheric dispersion calculations demonstrate little risk due to exposure to site contaminants to remediation workers, on-site workers, or the public during soil excavation and construction activities Potential increase in PM_{10} emissions at both OU4 and borrow areas during construction	Failure to mitigate the potential of contaminated airborne particulates could result in inhalation Potential increase in PM_{10} emissions at both OU4 and borrow areas during regrading activities
Groundwater Quality	Negligible downward migration of site contaminants consolidated under engineered cover (VLEACH calculations) Little potential for significant re-mobilization of contaminants consolidated under engineered cover Potential effects on local hydrogeology by reducing percolation and changing topography in a potential recharge area	Downward migration of site contaminants into groundwater Groundwater concentrations exceed comparison criteria at the point of compliance (VLEACH calculations) Minimal effects on local hydrogeology due to changes in drainage patterns from grading in a potential recharge area Potential degradation of ground and surface water during the rise of the water table causing groundwater to contact previously unsaturated soils

TABLE IV.10-22 (Continued)
SUMMARY OF POTENTIAL IMPACTS: PREFERRED IM/IRA VERSUS NO ACTION

Impact	Preferred IM/IRA	No Action
Surface Water Quality	No surface water bodies exist within the boundaries of OU4 The subsurface drainage layer will prevent COC mobilization caused by a rise of the water table Consolidation of soil contamination under engineered cover will minimize or eliminate precipitation run-off	No surface water bodies exist within the OU4 area Protection of adjacent surface water bodies from contaminated run-off from OU4 limited to ITS system Potential degradation of ground and surface water during high water table contacting previously unsaturated soils
Cultural, Historical and Archaeological Resources	No resources present	No resources present
Transportation	Minor increase in traffic volume and patterns during construction activities, negligible impact on surrounding transportation infrastructure	Slight increase in traffic volume and patterns, although less than those expected under the preferred IM/IRA
Short-term v Long-term uses	Short-term disruption of industrial area and borrow area required to minimize potential risks associated with exposure to site contamination Construction of engineered cover will preclude unrestricted use of area underlying and adjacent to engineered cover	Short-term disruption of industrial area and borrow area required during regrading activities Need for long-term institutional controls to minimize risks associated with exposure to remaining, available site contamination

TABLE IV.10-22 (Continued)
SUMMARY OF POTENTIAL IMPACTS: PREFERRED IM/IRA VERSUS NO ACTION

Impact	Preferred IM/IRA	No Action
Irreversible & Irretrievable Commitments	Clean fill from borrow areas, construction materials, and area underneath and adjacent to engineered cover	Clean fill from borrow areas used in grading activities
Direct/Indirect Effects	As described above Remediation of OU4 sludges currently stored onsite will be expediated Short-term direct increase in remediation jobs, indirect job loss due to eliminating production functions at RFETS	As described above Short-term direct increase in remediation jobs, indirect job loss due to eliminating production functions at RFETS
Cumulative Impacts	Implementation of the preferred IM/IRA is consistent with the long-term mission of remediating the RFETS Engineered cover will isolate contaminants preventing upward and negligible downward migration Implementation may interfere slightly with other activities in progress at the RFETS	Implementation of no action would impede or at least delay site-wide goals to remediate the RFETS

NOTICE:

The following page has been misnumbered when originally printed. Page IV-197f should be numbered IV-196f. No pages are missing from this document.

The Administrative Record Staff

TABLE IV.10-22 (Continued)
SUMMARY OF POTENTIAL IMPACTS: PREFERRED IM/IRA VERSUS NO ACTION

Impact	Preferred IM/IRA	No Action
Mitigation Measures	Implementation may require short-term changes in access points at OU4 to expedite construction activities Delivery of construction materials would not occur during the peak morning or evening rush hour Dust suppression during construction activities Erosion protection measures Construct subsurface drain to prevent potentially rising ground water from leaching contaminants from consolidated material Wetlands banking is being considered as a mitigative measure due to three small wetlands requiring protection during construction	Implementation may require short-term changes in access points at OU4 to expedite grading activities Dust suppression during grading activities Erosion protection measures

NOTE The no action alternative cannot be selected because it fails to meet the CERCLA threshold criteria (Part III)

IV.11 REGULATORY REQUIREMENTS

According to Part 18 of the IAG, portions of the response actions called for and conducted entirely within the boundaries of the RFETS are exempt from the procedural requirement to obtain federal, state, or local permits This permit exemption is intended to avoid delay of the onsite response actions due to procedural requirements of the permit process Although this provision exempts the need for new permits to execute the IM/IRA, Part 11 of the IAG and Section XV of the IAG Scope of Work require that all units used to treat, store, or dispose of hazardous and/or mixed waste are subject to the substantive and procedural requirements of the CHWA including permitting requirements In addition to the CHWA permit/closure requirements, the DOE must identify the permits which would otherwise be required, identify the associated permitting requirements, and explain how the IM/IRA will comply with these identified requirements

This section is intended to identify the regulatory requirements associated with the IM/IRA in accordance with the above IAG provisions and to demonstrate compliance with these regulatory requirements Subsection IV 11 1 provides a list of the permits that would be required of implementation of the preferred IM/IRA Subsection IV 11 2 describes how the preferred IM/IRA will comply with the ARARs, including the substantive permitting requirements, identified in Section III 5 2 Subsections IV 11 3 and IV 11 4 provide additional details describing ARAR compliance for the State of Colorado Requirements for Siting Hazardous Waste Disposal Sites (6 CCR 1007-2, Part 2) and the proposed regulations for Corrective Action Management Unit (CAMU) designations (6 CCR 1007-3, 264 552), respectively Subsection IV 11 5 presents the request for a temporary unit designation and Subsection IV 11 6 presents a discussion of the consistency of the proposed remedial action with potential final remedies

IV.11.1 Permit Identification

Based on the scope of the proposed IM/IRA, the following permitting requirements would need to be addressed

- Modification of the existing CHWA/RCRA Part B Permit to incorporate provisions for the closure of the SEPs, the closure of RCRA Units 21 and 48, and Building 964, and corrective actions required to remediate the OU4 sources and soils,

- Issuance of a post-closure care permit application to address post-closure ground water monitoring, final engineered cover performance assessments, and maintenance programs, and

- Modification of the existing storm water permit application under the NPDES program, if required, to address proposed changes to the drainage system as a result of installing the final engineered cover

As stated in Section IV 11, DOE must comply with both the procedural and substantive CHWA/RCRA permitting aspects for the closure of the SEPs This Decision Document constitutes the closure plan required to be submitted to modify the SEP closure and corrective action provisions specified in the existing Part B permit To fulfill CHWA/RCRA permitting requirements, the State shall open a public comment period for this proposed OU4 IM/IRA Decision Document to satisfy the public comment requirements for draft closure plans A post-closure care and monitoring plan will be prepared and submitted to CDPHE/EPA prior to closure of the SEPs Part V of the IM/IRA is the precursor of the post-closure care permit application and conceptualizes the post-closure monitoring program The implementation strategy to achieve compliance with the provisions of the CHWA/RCRA Part B permit and the hazardous waste closure/post-closure requirements are addressed in Section IV 11 2

In addition to modification of the existing Part B permit, the closure of the SEPs with hazardous waste in-place constitutes the development of a hazardous waste disposal site As such, the closure activities are required to comply with the siting and design provisions for obtaining a Certificate of Designation under 6 CCR 1007-2, Part 2 Pursuant to Part 18 of the IAG, the DOE does not have to comply with the procedural requirements to obtain a Certificate of Designation for the onsite response action, however, the preferred IM/IRA must comply with the substantive requirements of this regulation The implementation strategy to achieve compliance with these design provisions is addressed in Section IV 11 3

Per 40 CFR 122 26, DOE submitted a NPDES Storm Water Discharge Permit Application This permit application addresses the sitewide monitoring program for all storm water discharges Although the requirements of this permit application are not specific to OU4, the changes to the drainage will be evaluated to determine if the surface water monitoring program needs to be modified If required, the permit application will be amended to reflect the drainage changes

IV.11.2 Implementation/Compliance Strategy

The regulatory requirements to be satisfied during the implementation of the preferred IM/IRA were identified in Section III 5 2 This section identifies what actions will be taken to ensure compliance with these ARARs/TBCs For each identified ARAR/TBC, an overview of the requirement and the implementation strategy to ensure compliance is presented in Table IV 11-1 Similar regulatory requirements were combined together if a common implementation strategy assures compliance with the combined requirements The implementation strategy may also provide a reference to the section in the decision document that demonstrates compliance with the ARAR/TBC

IV.11.3 Siting Requirements

As stated above, DOE does not have to comply with the procedural requirements to obtain a Certificate of Designation but must comply with the substantive requirements of 6 CCR 1007-2, Part 2 The substantive requirements are being invoked to ensure that the hazardous

wastes are effectively isolated from natural environmental pathways to ensure the long-term protection of public health Table IV 11-2 identifies the Part 2 criteria and provides cross-references to the appropriate sections of this decision document that demonstrate compliance with the criteria The Part 2 criteria were paraphrased for the purpose of Table IV 11-2 to better reflect the applicability to the preferred IM/IRA

IV.11.4 Request for CAMU Designation

On July 31, 1994, the State of Colorado promulgated a final rule (6 CCR 1007-3, 264 552) for CAMUs similar to the federal rule to promote more expeditious cleanups at many sites The CAMU designation is allowed for the purpose of implementing corrective actions as necessary to address releases of hazardous waste or constituents from any solid waste management unit at the facility The CAMU rule requires that cleanup operations be protective of human health and the environment, but allows the operations to be tailored to the actual site conditions

The State of Colorado rule defines remediation wastes and CAMU as follows

> "Remediation waste means all solid and hazardous wastes, and all media (including ground water, surface water, soils, and sediments) and debris, which contain listed hazardous wastes or which themselves exhibit a hazardous waste characteristic, that are managed for the purposes of implementing corrective action requirements under Section 264 101, Section 265 5, Section 25-25-308, and RCRA Section 3008(h) [42 USC 6928(h)] For a given facility, remediation wastes may originate only from within the facility boundary, but may include waste managed in implementing RCRA Sections 3004(v) [42 USC 6924(v)], 3008(h), Section 264 101, Section 265 5, or Section 25-15-308 for release beyond the facility boundary "

> "Corrective Action Management Unit or CAMU means an area within a facility that is designated by the CDPHE under Part 264 Subpart S for the purposes of implementing corrective action requirements under 264 101, 265 5, Section 25-15-308, CRS, and RCRA Section 3008(h) A CAMU shall only be used for the management of remediation wastes pursuant to implementing such corrective action requirements at the facility "

As noted in the preamble to the Federal rule (see 58 FR 8664), "new or as-generated wastes (either hazardous or non-hazardous) that are generated from ongoing industrial operations" are not included in the definition of a remediation waste As such, the CAMU is not proposed to be used for the consolidation and management of these wastes The DOE does not consider sludge and pondcrete to be "new or as generated wastes " The sludge and pondcrete were contained in the SEPs and were removed when the DOE initiated SEP closure/remediation activities in 1986 These materials had to be removed from the SEPs due to agreements reached with the CDPHE and so that the soils beneath the SEPs could be characterized via the Phase I RFI/RI program

TABLE IV.11-1
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Location- Floodplain and Wetland Impacts	Federal agencies are to avoid construction within a floodplain or wetland unless there are no practical alternatives If it is necessary to locate any of the remediation facilities within a floodplain or wetland, all practicable measures are to be taken to minimize any impacts to the floodplain or wetland Actions must minimize destruction, loss, or degradation of wetlands, as defined by Executive Order 11990, Section 7 A floodplain or wetland assessment must be published in the Federal Register prior to taking any action within the floodplain/wetland to allow time for public review and comment 10 CFR 1022 (CRS 25-12-101 to 25-12-108) (Applicable) Executive Orders 11988 & 11990 [To be considered]	Part I 4 8 2 identifies wetlands within the OU4 boundary Per Part IV 10 6, no flood plains have been identified in OU4 The preferred IM/IRA construction activities will avoid any floodplain areas Therefore, a floodplain assessment does not need to be prepared and special precautions do not need to be established
Location-Historic and Archeological Preservation	The Secretary of the Interior must be notified in writing whenever DOE finds or is notified in writing by an appropriate historical or archaeological authority that the activities in connection with a project may cause irreparable loss or destruction of significant scientific, prehistorical, historical, or archaeological data Any data that may be lost or destroyed must be preserved by the DOE or the Department of Interior 36 CFR 65 & 800 (CRS 20-8-40) [Applicable] DOE Environmental Compliance Guide (DOE/EP-0098) [To be Considered]	Per Part IV 10 9 historic or archeological sites will not be impacted as a result of implementing the preferred IM/IRA Therefore, notifications and provisions to preserve artifacts are not required
Location - Endangered Species Act	Practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife Taking is defined to include harassment, harm, pursuit, hunting, wounding, trapping, death, capture, or collection Threatened or endangered species indigenous to Colorado should be protected to maintain and enhance their numbers 50 CFR 402 (CRS 33-2-101 to 33-2-107) [Applicable]	Per Part IV 10 2, the Preebles Meadow Jumping Mouse has been identified along Wallnut Creek If the 1995 habitat study indicates the Preebles Meadow Jumping Mouse forages in the OU4 buffer zone, remediation plans for the buffer zone may be terminated or rescheduled
Location - Hazardous Waste Disposal Facilities	Part 2 requirements described in Sections 2 1 through 2 9 provide performance criteria for the siting, design, construction, and operation for a hazardous waste disposal site 6 CCR 1007-2, Part 2 [Applicable]	Part IV 11 3 provides the details to demonstrate compliance with the Part 2 requirements

TABLE IV.11-1 (Continued)
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, General - Public Health and the Environment	DOE Activities are to be conducted so that radiation exposures to members of the public are maintained below acceptable limits This proposed regulation also addresses the management of real and personal property to control exposures to residual radioactive materials DOE facilities have the capability, consistent with the types of operations conducted, to monitor routine and non-routine releases and assess doses 10 CFR 834 (Proposed) [To be Considered] DOE Order 5400 5 [To be considered]	As demonstrated in Part IV 10 3, the calculated lifetime offsite exposure to an individual of the public resulting from potential fugitive emissions during excavation activities was determined to be negligible
Action, General - Worker Protection	At DOE facilities, the radiation protection standards contained in 10 CFR 835 for occupational workers, unborn children, minors, and onsite members of the public shall not be exceeded 10 CFR 835 [Applicable] DOE Order 5480 11, Section 9 [To be considered]	Occupational workers and onsite members of the public are required to wear dosimeters and personal protective equipment when entering a radiologically controlled area Radiation monitoring is also required for all individuals exiting a radiologically controlled area The personal protective equipment and monitoring will be used to ensure that occupational exposure limits are not exceeded, no additional controls are anticipated at this time If monitoring during implementation of the preferred IM/IRA indicates a potential concern, additional work practices and engineering controls will be implemented Details regarding the personal protective equipment and radiation monitoring requirements will be identified in the task-specific health and safety plan
Action, General - Worker Protection	The health and safety requirements provided in 29 CFR 1910 120 apply specifically to workers engaged in the handling of hazardous waste/materials at uncontrolled hazardous waste sites Implementation of remedial activities is required to be conducted by OSHA-trained personnel and under OSHA requirements All remediation employers are required to develop and implement a written safety and health program for their employees involved in hazardous waste operations 29 USC §§ 657 and 667 [Applicable] 29 CFR 1910 120 [Relevant and Appropriate]	The preferred IM/IRA will be conducted in accordance with the provisions of this regulation As required by 29 CFR 1910 129(b)(4), a task-specific health and safety plan will be prepared prior to the initiation of construction activities

TABLE IV.11-1 (Continued)
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, General - Worker Protection	Federal agencies are required to establish and maintain an effective and comprehensive occupational safety and health program which is consistent with the standards promulgated under the Occupational Safety and Health Act Specifically, 29 CFR 1926 Subpart P provides guidelines (including requirements for egress, safety, and protective systems) for workers engaged in activities related to excavations 29 USC § 668 [Applicable] 29 CFR 1926 [Relevant and Appropriate] DOE Order 5483 1A [To be Considered]	A project-specific health and safety plan will be developed to implement the preferred IM/IRA
Action, Operational - Interim Status Hazardous Waste Facilities	General requirements of this section apply to all owners and operators of hazardous waste facilities, except as 40 CFR Section 265 1 provides otherwise Security, training, and inspection programs will need to be maintained and revised, if necessary to ensure that public health and the environment are adequately protected during the closure activities The location (40 CFR 265 18) and construction quality assurance (40 CFR 265 19) standards do no apply to the closure of the SEPs 40 CFR 265, Subpart B (6 CRR 1007-3, 265, Subpart B) [Applicable]	Existing site procedures will be reviewed and revised accordingly to ensure that the preferred IM/IRA is implemented to comply with these provisions Security fencing will be maintained around the SEPs

TABLE IV.11-1 (Continued)
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, Closure - Surface Impoundment	The owner or operator must close the facility in a manner that (1) minimizes the need for further maintenance and (2) controls, minimizes, or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste decomposition products to the ground or surface waters, or to the atmosphere 40 CFR 265 111 (6 CRR 1007-3, 265 111) [Applicable] At closure, the owner or operator must (1) remove or decontaminate all waste residues, contaminated containment system components (liners, etc) contaminated subsoils, structures, and equipment contaminated with waste and leachate, and manage them as required, or (2) close the impoundment and provide post-closure care for a landfill under Subpart G and 40 CFR Section 265 310 40 CFR 265 228 (6 CRR 1007-3, 265 228) [Applicable]	As provided in 40 CFR 265 228, the SEPs will be closed by installing an engineered cover The engineered cover is designed to minimize the need for further maintenance and to preclude the escape of hazardous waste constituents that may have an adverse impact on human health and the environment The minimization of maintenance will be accomplished by (1) minimizing subsidence through consolidation, size reduction, and compaction of materials beneath the cover, (2) implementing a construction quality control program to ensure that the engineered cover is constructed in accordance with approved specifications, (3) limiting the slope of the cover and establishing uniformed vegetation to minimize the potential for erosion due to runoff, and (4) consolidating the contaminated media thus minimizing the area requiring maintenance As presented in Part III 5 1, the preferred IM/IRA reduces current risks associated with OU4 to protect human health and the environment
Action, - Disposal or Decontamination	During the closure, all contaminated equipment, structures, and soils must be properly disposed of or decontaminated These materials shall be managed based on the results of characterization 40 CFR 265 114 (6 CCR 1007-3, 265 114) [Applicable]	Part IV 4 details the waste management plan for the materials and equipment expected to be generated as a result of the preferred IM/IRA
Action - Establishment of a CAMU/TU	The CAMU shall facilitate the implementation of a reliable, effective, protective, and cost effective remedy without creating unacceptable risks to humans or the environment 6 CCR 1007-3, 264 552 defines the requirements for obtaining the CAMU designation by the State of Colorado The TU will facilitate the implementation of the CAMU by providing a temporary area for the processing of remediation waste 40 CFR 264 552 (6 CCR 1007-3, 264 552) [Applicable] 40 CFR 264 553 (6 CCR 1007-3, 264 553) [Applicable]	Part IV 11 4 discusses the CAMU requirements and identifies compliance Part IV 11 5 discusses TU requirements and identifies compliance

TABLE IV.11-1 (Continued)
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, - LDR Treatment Standards	Hazardous waste with concentrations in excess of the land disposal restrictions (LDRs) cannot be placed into a land disposal unit unless the waste is treated, a variance is provided in accordance with the provisions of 40 CFR 268, or the CAMU designation is approved by CDPHE/EPA 40 CFR 268, Subpart A to D (6 CCR 1007-3, 268, Subpart A to D) [Applicable]	As discussed in Part III 5 2, there is a remote possibility that some of the contaminated soil and/or media may exceed LDR treatment standards, however, adequate characterization information (i e , TCLP results) is not currently available to definitely demonstrate that LDRs would not apply Compliance with the LDR standards is based on CDPHE/EPA approving the CAMU designation If a CAMU designation is not obtained, additional characterization information will be obtained as required to demonstrate LDR compliance
Action, General - Waste Determination	A person who generates a solid waste must determine if that waste is a hazardous waste using the procedures identified in 40 CFR 262 11 An overview of the hazardous waste determination procedures is presented in 40 CFR 260, Appendix I 40 CFR 262 11 (6 CCR 1007-3, 262 11) [Applicable]	Any waste streams generated during the IM/IRA for storage and/or disposal will be assessed for hazardous wastes by review of the OU4 RFI/RI data base, review of process/historical records, and sampling and analysis (as required) Hazardous waste determinations will not be conducted for contaminated media (including contaminated soils, rubble and debris, investigation-derived materials, and other remediation waste) which is consolidated within the confines of the designated CAMU (if approved by CDPHE/EPA)
Action, General - Air Discharges	Any owner or operator of land that has been cleared of greater than one acre in non-attainment areas from which fugitive emissions will be emitted shall be required to use all available and practical methods which are technologically feasible and economically reasonable to minimize such emissions in accordance with the requirements of 5 CCR 1001 - Regulation 1, Section III D The RFETS is located in a non-attainment area for particulates 5 CCR 1001 - Regulation 1, III D [Applicable]	Dust suppression measurements (i e , water sprays, restriction of work during periods of high winds when fugitive particulate emissions are visible, etc) will be employed as required to minimize fugitive particulate emissions Air monitoring will be performed during field activities to ensure that all activities comply with the DOE's plan for prevention of contaminant dispersion (PPCD)
Action, General - Air Discharges (Radionuclides)	Emissions of radionuclides to the ambient air from DOE facilities shall not cause any member of the public to receive an effective dose equivalent in excess of 10 mrem per year above background This limit is based on an effective dose equivalent as calculated per the International Commission on Radiological Protection's Publication No 26 40 CFR 61, Subpart H [Applicable] 10 CFR 834 (Proposed) [To be Considered] DOE Order 5400 5 [To be Considered] DOE Order 5820 2A Chapter III [To be Considered]	As demonstrated in Part IV 10 3, public exposure resulting from potential fugitive emissions was determined to be less than 10 mrem/yr In addition, dust suppression measurements (i e , water sprays, restriction of work during periods of high winds when fugitive particulate emissions are visible, etc) will be employed as required to minimize fugitive particulate emissions Air monitoring will be performed during field activities to ensure that all activities comply with the PPCD

TABLE IV.11-1 (Continued)
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, General - Storm Water Management	Industrial facilities (as defined in 40 CFR 122 26) are required to submit an NPDES Stormwater Discharge Permit Application to US EPA by October 2, 1992 This permit application is to identify the sitewide monitoring program (including monitoring parameters and locations) for all storm water discharges 40 CFR 122 26 (5 CCR 1002-3, 122 26) [Applicable]	Part IV 11 1 discusses permitting requirements If required, sitewide NPDES permit will be modified prior to construction activities All monitoring will be done in accordance with the NPDES permit
Action, General - Tank Systems	The requirements of this subpart apply to owners and operators of facilities that use tank systems for storing or treating hazardous waste 40 CFR 264/265, Subpart J (6 CCR 1007-3, 264/265 Subpart J) [Applicable]	Either new or existing tanks will be used to process and/or store hazardous waste generated as a result of remediation activities If existing tanks are utilized, they will be inspected for sufficient integrity to prevent failure as well as ensuring the tank system is adequate Existing site procedures will be reviewed for Section J compliance
Action, General - Container Management	The requirements of this subpart apply to owners and operators of all hazardous waste facilities that store containers of hazardous waste 40 CFR 264/265, Subpart I (6 CCR 1007-3, 264/265, Subpart I) [Applicable]	Hazardous waste containers will be managed in accordance with approved handling procedures and be stored at RCRA approved storage areas and/or designated temporary units
Action, Closure - Time Allowed for Closure	The owner or operator must complete final closure activities in accordance with the approved closure plan and within 180 days after receiving the final volume of hazardous waste CDPHE can extend the closure period 40 CFR 265 113 (6 CCR 1007-3, 265 113) [Applicable]	The time required to complete the closure activities associated with the preferred IM/IRA is approximately 29 months after approval of the Decision Document The justification for this schedule is provided in Part IV 6 3
Action, Closure - Certification	Within 60 days after completion of closure, the owner or operator must submit to CDPHE by registered mail a certification that the SEPs have been closed in accordance with the specifications in the approved closure plan 40 CFR 265 115 (6 CCR 1007-3, 265 115) [Applicable]	A professional engineer will be responsible for overseeing the closure activities to ensure that they comply with the CDPHE/EPA approved Decision Document A field log will be maintained to document the professional engineers observations The field observations, along with the engineered cover construction quality control results and the verification sample results, will be summarized in a closure report The closure report will be certified by the professional engineer and submitted to CDPHE/EPA within 60 days after completion of closure

TABLE IV.11-1 (Continued)
ARAR/TBC COMPLIANCE DEMONSTRATION

ARAR/TBC Category	Regulatory Requirement	Implementation/Compliance Strategy
Action, Closure- Survey Plat	No later than the submission of closure certification, the owner or operator must submit to the authority with jurisdiction over local land use and to CDPHE a survey plat indicating the location and dimensions of the hazardous waste disposal unit 40 CFR 265 116 (6 CCR 1007-3, 265 116) [Applicable]	A survey plat showing the boundaries of the engineered cover will be submitted along with the closure report The survey plat will also be submitted to the authority with jurisdiction over local land use Arrangements for restricting use of the property will be provided as part of the deed filed with the local land use authority
Action, Post-Closure	Post-closure care of the hazardous waste management unit is subject to the requirements of 40 CFR Sections 264 117 to 120 and must begin after completion of closure and continue for 30 years after that date The 30 year monitoring and maintenance period can be extended or shortened based on CDPHE's review Likewise post-closure use of the property must never be allowed to disturb the integrity of the final cover or any other components associated with the final cover without prior approval from CDPHE 40 CFR 264 117 to 120 (6 CCR 1007-3, 264 117 to 120) [Applicable] Requirements for ground water monitoring listed in 40 CFR 264 Subpart F are required for land disposal facilities where hazardous wastes remain in place after closure 40 CFR 264, Subpart F (6 CCR 1007-3, 264, Subpart F) [Applicable]	Part V conceptualizes the ground water monitoring, engineered cover performance assessment, and maintenance programs A post-closure care permit application will be submitted to CDPHE/EPA prior to closure of the SEPs

TABLE IV.11-2
COMPLIANCE WITH DESIGN AND SITING REQUIREMENTS

6 CCR 1007-2, Part 2 Requirement		Implementation/Compliance Strategy
2 4 1	Design performance will assure long-term protection of human health and the environment	As discussed in Sections III 5 1 and III 5 3, the preferred IM/IRA will provide long-term protection of human health and the environment by isolating the hazardous waste from the air, direct contact, ingestion, and surface water exposure pathways The residual risks associated with the preferred IM/IRA are presented in Section IV 10 The VLEACH modeling results indicate that long-term protection of the ground water from potential contaminant migration due to precipitation and infiltration will be achieved The subsurface drainage system will be designed to provide long-term ground water protection resulting from potential contaminant migration due to the rise and fall of the ground water table
2 4 2	Designed to prevent adverse effects on ground water quality	The VLEACH modeling results indicate that long-term protection of the ground water from potential contaminant migration due to precipitation and infiltration will be achieved In addition, a drainage layer will be installed beneath the hazardous waste in the event that the ground water elevation should rise The subsurface drainage system will be designed to provide long-term ground water protection resulting from potential contaminant migration due to the rise and fall of the ground water
2 4 3	Designed to prevent adverse effects on surface water quality	The engineered cover will effectively provide long-term isolation of the hazardous waste to prevent any adverse effects on surface water quality In the short-term, the ITS will continue to be operated to preclude the migration of ground water contaminants from seeping into surface waters The need for the continued operation of the ITS will be addressed during the *Phase II RFI/RI*
2 4 4	Designed to prevent adverse effects on air quality	The engineered cover will effectively provide long-term isolation of the hazardous waste to prevent any adverse effects on air quality The short-term impacts as a result of excavation activities were determined to have an insignificant impacted to offsite air quality (see Section IV 10 3)

TABLE IV.11-2 (Continued)
COMPLIANCE WITH DESIGN AND SITING REQUIREMENTS

6 CCR 1007-2, Part 2 Requirement		Implementation/Compliance Strategy
2 4 5	Designed to prevent long-term adverse effects on public health and the environment due to migration of waste constituents in the surface and subsurface environment	See criteria 2 4 1
2 4 6	Any liner system installed to accomplish the design performance objectives shall be protected	As demonstrated by the VLEACH modeling results (see Section IV 10 4), a liner system does not need to be installed to prevent contaminant migration into the ground water due to precipitation and infiltration The subsurface drainage layer will be conservatively designed to ensure that the drainage system is adequate to prevent potential contaminant migration from entering the ground water due to fluctuations in the ground water table Therefore, protection of the liner as specified in this regulation is not required
2 4 7	Any leachate and runoff control system shall be designed with sufficient capacity such that the design performance objectives will be met	As demonstrated by the VLEACH modeling results (see Section IV 10 4), a leachate collection and runoff control system is not needed to prevent contaminant migration into the ground water due to precipitation and infiltration The subsurface drainage layer will be conservatively designed to ensure that the drainage system is adequate to prevent potential contaminant migration from entering the ground water due to fluctuations in the ground water table Therefore, protection from a leachate collection and runoff control system as specified in this regulation is not required Once the SEPs are closed, runoff controls are not required since the engineered cover will effectively preclude the potential contact of precipitation with the hazardous waste
2 4 8	The closure design will provide reasonable assurance that the long-term performance objectives are met	Section IV 10 provides information to quantify the residual risks Residual risks associated with air, direct contact, ingestion, surface water and ground water pathways will be eliminated The engineered cover and the subsurface drainage system will prevent contaminant migration into the ground water due to precipitation, infiltration, or fluctuations in the ground water table

TABLE IV.11-2 (Continued)
COMPLIANCE WITH DESIGN AND SITING REQUIREMENTS

6 CCR 1007-2, Part 2 Requirement		Implementation/Compliance Strategy
2 4 9	The design shall include ground water and surface water monitoring systems Quality controls shall be implemented to ensure proper construction materials are used	The post-closure ground water monitoring program is outlined in Section V 4 3 This section includes a description of the well construction procedures Surface water monitoring is currently conducted on a site-wide basis A post-closure care permit application will be prepared and submitted to CDH/EPA prior to closure of the SEPs
2 4 10	The design shall include procedures to be followed during construction, including supervision and certification by a professional geologist or professional engineer, to demonstrate that the facility is constructed in accordance with the approved design	The construction quality control program is described in Section IV 8 and includes provisions for oversight by a professional engineer A field log will be maintained to document the professional engineer's observations The field observations, along with the engineered cover construction quality control results and the verification sample results, will be summarized in a closure report The closure report will be certified by the professional engineer and submitted to CDH/EPA within 60 days after completion of closure
2 5 1	Demonstrate that the minimum design performance criteria (Section 2 4) will be satisfied after construction	As indicated above, the minimum performance criteria will be satisfied by installation of the engineered cover The construction quality control program and professional engineer certification will ensure that the design specifications are met
2 5 2(a)	The odor-threshold concentrations established in the State air pollution regulations shall not be exceeded under normal climatic conditions	Given the nature of the hazardous waste and the odor-threshold criteria provided in 5 CCR 1001, Regulation 2 - Odor Emissions, it is unlikely that an odor violation would occur when implementing the preferred IM/IRA
2 5 2(b)	Access routes shall be reasonably safe based on minimizing public exposure to transportation incidents	This criterion does not apply to the preferred IM/IRA, public roadways will not be used to transport hazardous waste to OU4 Traffic impacts resulting from transporting construction materials for the engineered cover to OU4 are described in Section IV 10 7
2 5 2(c)	Provide adequate fire protection on a 24-hour basis	Given the nature of the hazardous waste, adequate fire protection is available Equipment fires are considered the only credible incident RFP has adequate fire protection equipment and trained personnel to respond to this type of incident

TABLE IV.11-2 (Continued)
COMPLIANCE WITH DESIGN AND SITING REQUIREMENTS

6 CCR 1007-2, Part 2 Requirement		Implementation/Compliance Strategy
2 5 2(d)	Provide adequate security on a 24-hour basis	OU4 is within the RFP perimeter security The security is adequate to restrict access to the SEPs and will be maintained, at a minimum, until closure of the SEPs is certified
2 5 2(e)	Ensure availability of adequate professional competence and resources for the design, construction, and post-closure care	Construction material suppliers will be identified prior to initiating cover installation Staging areas will be provided to ensure material availability during construction The quality control tests will ensure that the material conforms to design specifications
2 5 2(f)	Ensure availability of adequate professional competence and resources for the design, construction and post-closure care	Professional personnel and resources will be made available to the extent required to comply with applicable laws and regulations
2 5 3	The geological and hydrological conditions of the site shall provide reasonable assurance to isolate the hazardous waste away from the natural environmental pathways that could expose the public for 1,000 years, or some demonstrated shorter period in which the wastes are transformed to an innocuous condition	The VLEACH modeling results indicate that long-term protection of the ground water from potential contaminant migration due to precipitation and infiltration will be achieved under the existing geological and hydrological conditions with the installation of the engineered cover The subsurface drainage system will be designed to provide long-term ground water protection resulting from potential contaminant migration due to the rise and fall of the ground water table In addition, the engineered cover will isolate the hazardous waste from the air, direct contact, ingestion, and surface water exposure pathways The engineered cover is designed to provide long-term protection of the public on the order of 1,000 years
2 5 4	A liner shall be provided unless it is demonstrated to be unnecessary	As demonstrated by the VLEACH modeling results (see Section IV 10 4), a liner system does not need to be installed to prevent contaminant migration into the ground water due to precipitation and infiltration The subsurface drainage layer will be conservatively designed to ensure that the drainage system is adequate to prevent potential contaminant migration from entering the ground water due to fluctuations in the ground water table Therefore, protection of the liner as specified in this regulation is not required

TABLE IV.11-2 (Continued)
COMPLIANCE WITH DESIGN AND SITING REQUIREMENTS

6 CCR 1007-2, Part 2 Requirement		Implementation/Compliance Strategy
2 5 5	A leachate collection and runoff control system shall be provided	As demonstrated by the VLEACH modeling results (see Section IV 10 4), a leachate collection and runoff control system is not needed to prevent contaminant migration into the ground water due to precipitation and infiltration The subsurface drainage layer will be conservatively designed to ensure that the drainage system is adequate to prevent potential contaminant migration from entering the ground water due to fluctuations in the ground water table Therefore, protection from a leachate collection and runoff control system as specified in this regulation is not required Once the SEPs are closed, runoff controls are not required since the engineered cover will effectively preclude the potential contact of precipitation with the hazardous waste
2 5 6	The facility shall be located to provide a buffer zone to prevent adverse effects on public health should unexpected discharges of hazardous waste occur	OU4 is centrally located within the large buffer zone of the RFP Air dispersion modeling (see Section IV 10 3) indicates that creditable emissions during excavation activities are insignificant

The preamble to the federal CAMU rule states preference of "remedies that employ techniques, such as treatment technologies, that are capable of reducing the overall degree of risk posed by the waste and constituents of the facility" (see 58 FR 8670) The preamble also establishes the fact that containment is also sufficiently effective The CAMU rule allows "remediation wastes" to be consolidated within a discrete area if the consolidation is determined to enhance remediation and protect human health and the environment A CAMU designation would facilitate the implementation of the selected remedial alternative by allowing the consolidation of the remediation wastes without imposing unnecessary requirements while still being protective of human health and the environment

The preferred IM/IRA involves the installation of an final engineered cover and a subsurface drainage layer to isolate contaminated media and soils to prevent exposures to human health and the environment The preferred IM/IRA has been determined to be protective of human health and the environment and be the most cost-effective remedy considering the nature and extent of contamination It is proposed that contaminated media and soils be consolidated within the current location of SEPs 207-A, the 207-B Series SEPs The CAMU concept is a sound approach because it will prevent the further spread of contamination through consolidation and containment while protecting human health and the environment via the final engineered cover

To effectively implement consolidation of contaminated liners, sludges, pondcrete, debris, and soils under the preferred IM/IRA, DOE is requesting that a portion of OU4 be designated as a CAMU as identified in Figure IV 11-1 The CAMU designation as promulgated by the state under 6 CCR 1007-3, 264 552 is being requested pursuant to the OU4 closure/remediation activities The following subsections provide the justification for the CAMU designation, identify how the CAMU will be implemented, demonstrate compliance with the Colorado regulation, and address CAMU closure requirements

IV.11.4.1 Justification

The CAMU is required to be designated in accordance with the criteria stated in 6 CCR 1007-3, 264 552(c) Each designation criteria is addressed below and establishes the justification for designating a CAMU within OU4 to facilitate implementation of the preferred IM/IRA

1) The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies.

The proposed IM/IRA will be reliable, effective, protective of human health and the environment, and cost-effective. By placing all of the remediation waste under the final engineered cover, exposure from surface soil, surface water runoff, and airborne contaminants will be eliminated The VLEACH model demonstrates that the potential for contaminants leaching into the ground water due to precipitation and infiltration is negligible The potential for the ground water to contact the liners, sludges, pondcrete, and contamination media due to the fluctuations in the ground water elevation will be eliminated by the installation of a

subsurface drainage layer installed beneath the CAMU The proposed IM/IRA will effectively isolate the contaminated media from inhalation, direct contact, ingestion, and surface water pathways

The sludges have been determined to be both characteristic (D006) and listed (F001, F002, F003, F005, F006, F007, and F009) hazardous waste (EG&G 1992a) Pondcrete was generated from the treatment of the hazardous sludge, and therefore, the pondcrete would need to be managed as a hazardous waste based on the application of the treatment rule [6 CCR 1007-3, 261 3(c)(2)(i)] Since listed hazardous waste was placed into the SEPs, contaminated liners and soils may need to be managed as hazardous waste based on application of the mixture rule [see 6 CCR 1007-3, 261 3(a)(2)(iii)] and EPA's "contained-in" policy [see OSWER Directive 1944 1989(30) and 58 FR 48123], respectively Although sufficient characterization information exists to demonstrate the effectiveness and protectiveness of the CAMU, additional samples would need to be collected and analyzed to demonstrate compliance with LDR prohibitions Since CAMUs are exempt from LDRs, the time and expense required for the unnecessary additional samples would not be required Eliminating this sampling event would expedite the remediation effort and reduce overall costs

Since materials to build the final engineered cover are readily available and special equipment will not be necessary, the cost of the remedy will be relatively low when compared to treatment or offsite disposal costs The CAMU will allow for the consolidation of the contaminated soil, liners, sludges, pondcrete, and debris into a smaller area, therefore, a smaller final engineered cover could be constructed, which would reduce the cost Also, operating costs will be low and will only require routine maintenance and post-closure monitoring This proposed IM/IRA complies with the State of Colorado requirements for the closure of an interim status surface impoundment and can be implemented to comply with all identified ARARs The CAMU will provide a cost-effective means of waste management through consolidation of the contaminated materials and soils while ensuring protection of human health and the environment

2) Waste management activities associated with the CAMU shall not create unacceptable risks to humans or the environment resulting from exposure to hazardous wastes or hazardous constituents.

The waste management activities (consolidation and isolation of contaminants) associated with the CAMU will not create an unacceptable risk to humans or the environment The excavation and consolidation of the liners, pondcrete, sludge, and contaminated soils could generate fugitive particulate emissions However, air modeling results (see Section IV 10 3) indicate that the potential exposure to workers, onsite personnel, and the offsite public is insignificant Therefore, the use of personal protective equipment and emission controls may not be required during some of the remediation activities, however, dust suppression will be implemented as required during these activities to mitigate airborne particulates as a good management practice In addition, ambient air monitoring may be performed in accordance with the Plan for Prevention of Contaminant Dispersion (PPCD) and the health and safety plan around the CAMU to provide surveillance of the emission controls If monitoring indicates that

particulate levels exceed predetermined levels, additional engineering controls can be implemented to reduce airborne contaminant levels Potential additional controls include dust inhibitors and wind screens

3) **The CAMU shall include uncontaminated areas of the facility, only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility.**

All remedial activities can be completed without utilizing any uncontaminated area The CAMU is located in areas where soil concentrations exceed PRGs

4) **Areas within the CAMU, where remediation wastes remain in place after closure of the CAMU, shall be managed and contained so as to control, minimize, or eliminate future releases to the extent necessary to protect human health and the environment.**

Pursuant to 6 CCR 1007-3, 265 228, the owner/operator must remove or decontaminate all contaminated wastes and manage them as hazardous wastes or the owner/operator must close the impoundment and provide post-closure care for a landfill The proposed IM/IRA would close the surface impoundment as a landfill leaving remediation wastes in place The contaminated soils and media at concentrations exceeding PRGs will be consolidated beneath the conservatively designed final engineered cover The final engineered cover will be constructed from natural materials with known durability A low permeability layer will have a hydraulic conductivity that is less than or equal to the hydraulic conductivity of the natural subsurface soils This will minimize the potential for precipitation to infiltrate into the consolidated materials Section IV 3 provides a detailed discussion of the final engineered cover In accordance with 6 CCR 1007-3, Part 265, Subpart G, the final engineered cover will control, minimize, or eliminate post-closure escape of hazardous waste to the ground water, surface water or atmosphere to the extent necessary to protect human health and the environment

A subsurface drainage layer will be installed at the mean historic high ground water elevation beneath the CAMU This system will prevent the ground water from rising into the CAMU and contacting the consolidated contaminated soil and materials With the use of this drainage system, the potential of contaminants leaching from the CAMU into the ground water due to the fluctuations in the ground water elevation will be minimized

A post-closure monitoring program will be implemented to provide an early warning system designed to identify when the potential exists for contaminant migration to enter the ground water The monitoring program is designed to detect infiltration of precipitation through the cover and the presence of contaminants in the vadose zone Monitoring wells will also be provided as an early warning to determine if contaminants may be migrating into the ground water An overview of the monitoring program is detailed in Part V

In addition to these monitoring systems, the final engineered cover will be periodically inspected to ensure that erosion control measures are intact as part of the maintenance program outlined in Part V

5) **The CAMU shall expedite the timing of remedial activity implementation, when appropriate.**

The CAMU would expedite the implementation of the remedial activities The CAMU will eliminate the need to collect and analyze additional samples for LDR determinations This additional sampling effort is not necessary since existing RFI/RI characterization information adequately demonstrates that the proposed IM/IRA is protective of human health and the environment By eliminating the need for this sampling effort, the CAMU will expedite the excavation activities by allowing continuous excavation of the liners, soil, and debris, and continuous consolidation of sludge and pondcrete Also, the CAMU allows for the consolidation of contamination into a smaller area thus reducing the time for constructing the final engineered cover

6) **The CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of remediation wastes that will remain in-place after closure of the CAMU.**

Treatment of the remediation waste to enhance the long-term effectiveness by reducing the toxicity, mobility, or volume is not required for the preferred IM/IRA Sludge and pondcrete will be processed as required to meet the performance criteria established in Section IV 2 3 for consolidation beneath the final engineered cover The final engineered cover in conjunction with the subsurface drainage system will fully meet the IM/IRA performance objectives by reducing the mobility of the remediation wastes by effectively isolating the contaminated liners, sludge, pondcrete, soil, and debris from the air, direct contact, ingestion, surface water, and ground water exposure pathways

The CAMU will enable the implementation of a remedy that will provide long-term effectiveness to protect human health and the environment The proposed IM/IRA will reduce the mobility of contaminants due to precipitation and infiltration into the CAMU as demonstrated by VLEACH modeling results (Section IV 10 4) The results show that the residual risk associated with leaving untreated contaminated media under the final engineered cover is protective to human health and the environment The proposed IM/IRA will also reduce the mobility of contaminants due to fluctuations in the ground water elevation by installing a subsurface drainage layer (and potential UITS) to minimize the ground water entering the CAMU

7) **The CAMU shall, to the extent practicable, minimize the land area of the facility upon which remediation wastes will remain in place after closure of the CAMU.**

With the CAMU, consolidation of the contaminated soils and media can occur and will significantly minimize the areal extent of OU4 upon which remediation wastes will remain in place after closure The unconsolidated area for the SEPs and the contaminated soils present within the northern hillside represent approximately 1,800,000 ft^2 However, with the consolidation of the contaminated soils the final engineered cover only requires approximately 500,000 ft^2 Of this total area for the cover, remediation waste would represent 400,000 ft^2 The consolidation of the OU4 contamination represents 78% reduction of the original remediation zone

IV.11.4.2 CAMU Implementation

To obtain a CAMU designation, the existing RCRA Part B permit is required to be modified or an order is required to be issued by CDPHE With approval of this decision document, CDPHE approves this CAMU The purpose of this section is to demonstrate compliance with the requirements required to be specified in the permit modification or order It is intended that this demonstration will fulfill CDPHE's obligations to modify the existing RCRA permit in accordance with the process specified in the IAG Table IV 11-3 provides information demonstrating compliance with the CAMU designation requirements

The CAMU does not change CDPHE's existing authority to address clean-up levels These clean-up levels (in PRGs) are presented in Section III 2

IV.11.4.3 CAMU Closure

CAMU closure requirements shall be identical to the OU4 closure requirements addressed in this Decision Document In establishing these requirements as closure requirements for the CAMU, the mandated factors have been considered [6 CCR 1007-3, 264 552(e)(2) and (4)] These factors and where they are addressed in this Decision Document are presented in Table IV 11-3 Certification of closure for the OU4 SEPs shall also constitute certification of closure for the CAMU

IV.11.5 Request for a Temporary Unit Designation

To successfully implement the processing of the sludge and pondcrete remediation wastes, the DOE requests that two temporary units (TU) be established The establishment of a temporary unit is permissible under the February 16, 1993 final ruling for CAMUs/TUs, which was adopted by the State of Colorado on July 30, 1994 The TU designation will provide the regulatory mechanism and location for processing remediation wastes (sludge and pondcrete) prior to their disposition beneath the final engineered cover

In reviewing the regulatory requirements for obtaining and implementing the TUs, the pre-amble for TUs published in 58 FR 8658 specifies that only tanks and container storage units used for the treatment or storage of remediation wastes will be eligible for designation as temporary units A review of the RFETS RCRA Part A Permit indicates that Pad 750 has interim status for the storage of solids and as revised under Revision 13, the storage of tanks on Unit 25 Pad 904 has interim status for the storage of both liquids and solids as well as interim status for the treatment (reprocessing) of pondcrete/saltcrete Therefore, Pad 904 (Unit 15B and Unit 35) meets the substantive requirements of 6 CCR 1007-3, 265 for container storage and treatment Pad 750, currently a 6 CCR 1007-3, 265 Subpart J unit (Unit 25), meets the substantive requirements for storage Therefore, Pads 750 and 904 have been selected to have the TUs based on the proximity of these pads to the SEPs, the established safeguards, and the existing RCRA interim status for the ponds The RCRA interim status for Pad 750 will have to be modified via a Class III permit modification to facilitate the processing of sludge

The TU requirements specified in 6 CCR 1007-3, 264 553 are discussed below

(a) For temporary tanks and container storage areas used for processing or storage of hazardous remediation wastes, during remedial activities required under 264 101 or RCRA section 3008(h), the CDPHE may determine that a design, operating, or closure standard applicable to such units may be replaced by alternative requirements which are protective of human health and the environment

(b) Any temporary unit to which alternative requirements are applied in accordance with paragraph (a) of this section shall be

1) Located within the facility boundary; and

A site map, Figure IV 11-1, identifies the location of the TUs These locations, Pad 750 for the processing of sludge and Pad 904 for the processing of pondcrete, are within the facility boundary

2) Used only for processing or storage of remediation wastes.

Any of the wastes processed in the two proposed TUs will have originated from the SEPs or the clarifier, and therefore, by definition, are considered remediation wastes The wastes will be either pondcrete or sludge which were removed from the SEPs in support of SEP characterization and closure activities The wastes which are currently stored on Pads 750 and 904 will remain in storage at the facility prior to processing The wastes will be processed on the two identified pads for compliance with the waste acceptance criteria for disposition beneath the final engineered cover The processed sludge and pondcrete will be temporarily stored on TU pads prior to being transported for final disposition beneath the final engineered cover

TABLE IV.11-3
COMPLIANCE WITH CAMU DESIGNATION REQUIREMENTS

CAMU Permit Requirements	IM/IRA-EA Decision Document Section Reference
(1) The areal configuration of the CAMU	Figure IV 11-1 identifies the boundary of the proposed CAMU
(2) Requirements for remediation waste management to include the specification of applicable design operation and closure requirements	Section IV 3 1 details the engineered cover and subsurface drainage layer Section IV 4 details the waste management plan, Section V identifies the monitoring and maintenance programs
(3) Requirements for ground water monitoring that are sufficient to (i) Continue to detect and to characterize the nature, extent, concentration, direction, and movement of existing releases of hazardous constituents in ground water from sources located with in the CAMU, and (ii) Detect and subsequently characterize releases of hazardous constituents to ground water that may occur from areas of the CAMU in which remediation wastes will remain in place after closure of the CAMU	Section V identifies the monitoring and assessment programs A post-closure permit application will be prepared and submitted to CDPHE/EPA prior to closure of the SEPs
(4) Closure and post-closure requirements (i) Closure of corrective action management units shall (A) Minimize the need for further maintenance, (B) Control, minimize, or eliminate, to the extent necessary to protect human health and the environment, for areas where remediation wastes remain in place, post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products to the ground, to ground water, to surface waters, or to the atmosphere	Section IV 3 1 identifies design details to minimize maintenance requirements and Section V outlines post-closure requirements A post-closure permit application will be prepared and submitted to CDPHE/EPA prior to closure of the SEPs

TABLE IV.11-3 (Continued)
COMPLIANCE WITH CAMU DESIGNATION REQUIREMENTS

CAMU Permit Requirements		IM/IRA-EA Decision Document Section Reference
(ii)	Requirements for closure of any CAMUs shall include the following, as appropriate and as deemed necessary by the CDPHE to protect human health and the environment	Section IV 1 details the excavation of the contaminated media and soil and subsequent consolidation of these materials beneath the engineered cover
(A)	Requirements for excavation, removal, treatment or containment of remediation wastes,	Section IV 3 5 and IV 3 6 detail the treatment of the sludge and pondcrete
(B)	For areas in which remediation wastes will remain after closure of the CAMU requirements for lining and/or capping of such areas,	Section IV 3 1 details the selected engineered cover and the subsurface drainage layer
C)	Requirements for removal and decontamination of equipment, devices, and structures used in remediation waste management activities within the CAMU	Section IV 4 details the waste management plan
(iii)	In establishing specific closure requirements for CAMUs under 264 552(e), the CDPHE shall consider the following factors	Section IV 11 4 identifies the CAMU designation request
(A)	CAMU characteristics,	
(B)	Volume of remediation wastes which remain in place after closure,	Section IV 3 1 1 identifies anticipated volumes
(C)	Potential for releases from the CAMU,	Section IV 10 4 identifies VLEACH modeling results
(D)	Physical and chemical characteristics of the remediation waste,	The physical and chemical characteristics of the remediation waste are provided in Section III 2 which identifies the COCs and PRGs
(E)	Hydrological and other relevant environmental conditions at the facility which may influence the migration of any potential or actual releases, and	Section I 4 identifies site characteristics and environmental setting Section IV 10 considers the potential for releases
(F)	Potential for exposure of humans and environmental receptors if releases were to occur from the CAMU	Section IV 10 identifies risk analysis and potential impact determination

TABLE IV.11-3 (Continued)
COMPLIANCE WITH CAMU DESIGNATION REQUIREMENTS

CAMU Permit Requirements		IM/IRA-EA Decision Document Section Reference
(iv)	Post-closure requirements as necessary to protect human health and the environment, shall include, for areas where remediation wastes will remain in place, monitoring and maintenance activities, and the frequency with which such activities shall be performed to ensure the integrity of any cap, final cover, bottom liner(s), or other containment system, and, in all instances, a notation to the deed to the facility property that will in perpetuity notify any potential purchaser of the property that the land has been used to manage hazardous wastes	Section V outlines the monitoring systems program A post-closure permit application will be prepared and submitted to CDPHE/EPA prior to closure of the SEPs The DOE will be responsible for providing the appropriate notation to the property deed
(f)	The CDPHE shall document the rationale for designating CAMUs and shall make such documentation available to the public	The rationale of the proposed CAMU is provided as Section IV 11 4 1
(g)	Incorporation of a CAMU into an existing permit must be approved by the CDPHE according to the procedures for CDPHE-initiated permit modifications under § 100 61 of these regulations, or according to the permit modification procedures of § 100 63 of these regulations	The CAMU is required to facilitate the closure and corrective action of the SEPs Pursuant to Paragraph 16 of the IAG, it is intended that the IM/IRA-EA decision document will fulfill the CAMU designation permitting and approval requirements imposed by the CHWA
(h)	Incorporation of a CAMU into a new permit must be approved by the CDPHE according to the permit review and issuance procedures of 100 5 of these regulations	The CAMU is required to facilitate the closure and corrective action of the SEPs Pursuant to Paragraph 16 of the IAG, it is intended that the IM/IRA-EA decision document will fulfill the CAMU designation permitting and approval requirements imposed by the CHWA
(i)	Incorporation of a CAMU, where the remediation wastes which will remain in place are hazardous wastes, into an order issued pursuant to § 265 5 must be in accordance with the permits by rule provisions of § 100 21(e) of these regulations	The CAMU is required to facilitate the closure and corrective action of the SEPs Pursuant to Paragraph 16 of the IAG, it is intended that the IM/IRA-EA decision document will fulfill the CAMU designation permitting and approval requirements imposed by the CHWA

TABLE IV.11-3 (Continued)
COMPLIANCE WITH CAMU DESIGNATION REQUIREMENTS

CAMU Permit Requirements	IM/IRA-EA Decision Document Section Reference
(j) The designation of a CAMU does not change CDPHE's existing authority to address cleanup levels, media-specific points of compliance to be applied to remediation at a facility, or other remedy selection decisions	The proposed CAMU is not intended to change CDPHE's existing authority to address cleanup levels These cleanup levels are established and approved through the PRG process

(c) In establishing standards to be applied to a temporary unit, the Department shall consider the following factors:

1) Length of time such unit will be in operation;

It is anticipated that processing operations will be completed within the 1 year time frame

2) Type of unit;

Both pondcrete and the sludges will be processed in independent tank systems set-up on the pads which currently are storing the specific remediation waste It is planned that the processing operations will be performed in self-contained, skid-mounted, pre-piped, and pre-wired packaged units Whenever possible, these units will be movable and will utilize standard "off-the-shelf" equipment Process units are further described in Sections IV 3 5 and IV 3 6

3) Volumes of remediation wastes to be managed;

The TUs will be utilized for the management and processing of pondcrete and sludge, and waste packaging The following engineered estimations identify the type of waste and the estimated volume of each material

Remediation Waste	Cubic Yards
Pondcrete	10,000
Sludge	5,000

4) Physical and chemical characteristics of the remediation wastes to be managed in the unit;

Radiological and chemical characterization data for the liquids and sludges from the SEPs and the clarifier as well as data for pondcrete, liners, and soils are presented in Table IV 10-11 Average Contaminant Concentrations

The physical characteristics of the sludge are settled solids and a liquid phase

The pondcrete was generated through a process that combined the SEP sludges with Portland cement Section 1 0 describes the pondcrete process including additives used for the block formation These pondcrete blocks are now in various forms of stability Some of the blocks remain in their original solid form where as others are disintegrating

5) Potential for releases from the unit;

Potential releases from the OU4 TUs during processing activities could possibly occur through one or more of the following sources

1) Unprocessed sludge (liquid),
2) Processed sludge (solid),
3) Pondcrete (solid),
4) Re-processed pondcrete (solid), and
5) Airborne particulates

Although releases are not anticipated during remediation activities, the contingency plan as referenced in Part IV will be implemented, as appropriate, in the event of a spill It should be noted that most of the waste forms will be in the solid phase which would be easy to control and clean up if a spill occurs

To prevent the release of airborne particulates during processing operations, a series of filters will be utilized The storage silos will be equipped with a passive venting and dust collection system to control any emissions during delivery or process operations The processing will be performed in a tent like structure with a dust collection system for the units

Both pads currently have interim status for the storage of liquids As a result of this status, the pads have asphalt berms to prevent precipitation that accumulates on the pads from reaching the perimeter ground The berms are designed with a drainage collection system which removes precipitation through a series of pipes The destination of the precipitation is contingent upon verification that no spills have occurred on the pad If it is determination that the precipitation has come in contact with a spill, the liquid will be routed to Building 374 evaporator for processing

In addition to precipitation collection efforts, the pads are subject to daily and weekly inspections and the processing equipment will be subject to inspections during periods of operation There is also an air sampling effort for occupied areas as required by 10 CFR 835

6) Hydrogeological and other relevant environmental conditions at the facility which may influence the migration of any potential releases; and

The water elevation levels measured beneath Pad 903 which is contiguous to the Pad 904 ranged from a minimum depth of 11 10 feet to a maximum depth of 20 98 feet These measurements were taken from wells no 0987 and no 1087 Well no P207389 located near the solar pond area identified water elevation levels at a minimum depth of 5 94 feet to a maximum of 8 85 feet

Based on the types materials being processed within the two TUs, it is perceived that there shall be no impacts will occur to either hydrogeological resources or the environment

This is based on the safe guards currently established for the pads as noted in above response and the safe guards to be established on the processing equipment

Section 1 4 identifies site characteristics and the environmental setting Sections II 4 and II 5 provide geological information

7) Potential for exposure of humans and environmental receptors if releases were to occur from the unit.

The sludge and pondcrete processing operations will be conducted within the confines of a tent like structure The confines of the tent will significantly reduce any possibility of a release from one of the processing units to an environmental receptor Furthermore, the storage silos will be equipped with a passive venting and dust collection system to control any emissions during delivery or process operations The dust collection system will reduce any risk associated with the process operations to the employees or a release to the environment

Under (c)(5), the text identifies current provisions to limit the potential of release from the unit

d) The CDPHE shall specify in the permit or order the length of time a temporary unit will be allowed to operate, to be no longer than a period of one year. The CDPHE shall also specify the design, operating, and closure requirements for the unit.

As noted in (c)(1), the proposed TUs will operate for a duration of one year

The design and operation of the two processing units are discussed in Sections IV 3 5 and IV 3 6

Section IV 11 5 1 further discusses the processing equipment operations and Section IV 11 5 2 details the closure requirements for the tank system

(e) The Department may extend the operational period of a temporary unit once for no longer than a period of one year beyond that originally specified in the permit or order, if the Department determines that:

(1) Continued operation of the unit will not pose a threat to human health and the environment; and

(2) Continued operation of the unit is necessary to ensure timely and efficient implementation of remedial actions at the facility.

It is currently preceived that an extension to the initial operating period will not be required

(f) Incorporation of a temporary unit or a time extension for a temporary unit into an existing permit shall be:

(1) Approved in accordance with the procedures for CDPHE-initiated permit modifications under § 100.61; or

(2) Requested by the owner/operator as a Class II modification according to the procedures under § 100.63 of these regulations.

Under the guidelines of (f)(2), the DOE shall issue an application for a Class III permit modification to the existing RCRA permit in support of the CAMU CDPHE will review and approve any modifications to the permit This decision document is the permitting mechanism for the TUs

(g) Incorporation of a temporary unit or a time extension for a temporary unit into a new permit shall be approved by the CDPHE according to the permit review and issuance procedures of § 100.5 of these regulations.

This section of the TU requirements would not be applicable

(h) Incorporation of a temporary unit or a time extension for a temporary unit into an order issued pursuant to § 265.5 must be in accordance with the permits by rule provisions of § 100.21(e) of these regulations.

This section of the TU requirements would not be applicable

(i) The CDPHE shall document the rationale for designating a temporary unit and for granting time extensions for temporary units and shall make such documentation available to the public.

Documentation is available in the DOE public reading rooms, from DOE, Rocky Flats Field Office (RFFO), or from CDPHE

IV.11.5.1 TU Processing Equipment Operations

The pondcrete size reduction and processing system will be situated on the Pad 904 (RCRA Unit 15A) for processing of pondcrete Storage space to support the process will be used in and around the tent Currently Pad 904 provides interim storage for approximately 8,000 triwall containers, 20 to 30 half-crates, and numerous drums of pondcrete currently stored in Tents 8 through 11 The pondcrete will be removed from storage, size reduced to 0 5-inch or smaller, treated with a mixture of lime and cement to adsorb any free moisture and mitigate any pathogens or gas-producing microorganisms The purpose for mixing the size reduced pondcrete with bulking agents such as sand or other additives is to produce a processed waste which satisfies the Waste Acceptance Criteria for the "Contaminated Media" layer of the OU-4

Interim Remedial Action (IRA) closure area Processing equipment associated with the pondcrete reduction and processing system will operate in accordance with applicable RFETS Health and Safety and Environmental Standards Section IV 3 6 provides a detailed discussion on pondcrete processing operations

The mobile sludge processing system will be assembled in Tent 12 on Pad 750 (RCRA Unit 25) Storage space to support the process will be used in and around the tent This pad currently is an interim status storage pad with tents that house the 66 10,000 gallon sludge storage tanks The friable product processing system will be established to prepare the sludge for placement under the OU-4 final engineered cover Processing equipment associated with the friable product processing system will operate in accordance with all applicable RFETS Health and Safety and Environmental Standards Section IV 3 5 provides a detailed discussion on sludge process operations

Both the pondcrete and the sludge processing systems will be designated as TUs Upon completion of the processing phases, it is envisioned that the TU processing equipment will be decontaminated, decommissioned, dismantled, and removed from their respective pads for reuse or disposal The components from the processing equipment will not be placed under the final engineered cover since the dismantling, decontamination, and closure sequence will probably not be completed until after the commencement of construction activities for the final engineered cover The actual closure of the 904 and 750 pads themselves, will be deferred to accommodate future RFETS waste storage requirements **[NOTE: Closure of the sludge interim storage tanks is beyond the scope of this project.]**

IV.11.5.2 Temporary Unit(s) Closure Sequence

The following discussion presents the engineering approach for closure of the TUs The scope of the closure is limited to the demolition and disposition of the TU equipment It is anticipated that the closure, demolition, and disposition of the components can be accomplished through commonly practiced engineering and dismantling techniques All equipment will be staged, and dispositioned per Section IV 4 (Waste Management) The closure sequence presented in this section is a preliminary planning sequence, subject to adjustment based on several factors such as available resources, technical feasibility, regulatory considerations, required control measures, and the coordination of planned OU-4 remediation activities

IV.11.5.2.1 Decontamination and Decommissioning of the Temporary Units

Upon completion of the pondcrete and sludge processing activities, the TU equipment will be decontaminated and decommissioned Prior to demolition efforts, all equipment will be inspected for the absence of residual sediments, sludges, and free liquids Waste minimization considerations will be factored into the demolition sequencing evaluations It is assumed that interim staging and laydown areas will be established in the immediate vicinity of the 904 and 750 Pads

Decontamination of the pondcrete processing system will consist of thoroughly flushing and rinsing with fresh water all equipment (pumps, tanks, hoppers, containers and associated piping, etc) which came into contact with the pondcrete, the processing additive(s), and the treated waste to completely remove these materials from the equipment As required, the decontamination process may involve the use of low-pressure steam or mechanical scrubbing with detergent-type products or other non-hazardous solvents Waste decontamination fluids will be containerized and transferred to Building 374 for treatment and disposal

Decommissioning of the pondcrete processing system will consist of dismantling the major components of the system to the extent that it will not be possible to re-activate this system on an instantaneous, or near-instantaneous basis To this effect, flexible connections between pieces of equipment will be removed, and hard connections will be severed Electrical supply to control panels and switches will be disconnected and strategic wiring removed The storage silos will be emptied and the non-contaminated additives will be stockpiled at remote locations (laydown area) or potentially used elsewhere at the RFETS

Decontamination of the sludge processing system will consist of thoroughly flushing and rinsing with fresh service water all equipment (vacuum units, pumps, mixers, tanks, hoppers, containers and piping, etc) which came into contact with the sludge, the contaminated soil, and the treated waste to completely remove these materials from the equipment As required, the decontamination process may also involve the use of low-pressure steam or mechanical scrubbing with detergent-type products or other solvents Waste decontamination fluids will be containerized and transferred to Building 374 for treatment and disposal

Decommissioning of the sludge processing system will consist of dismantling the system's major components to the extent that it will not be possible to re-activate this system on an instantaneous, or near-instantaneous basis To this effect, flexible piping and hoses will be removed, hard-piped connections will be broken, blind flanges will be installed and operating valves will be removed Electrical supply to control panels and switches will be disconnected and strategic wiring removed The storage silos will be emptied and the non-contaminated additives will be stockpiled at remote locations (laydown area) or potentially used elsewhere at the RFETS

The decontamination and decommission of both TUs will be strictly manual operations The effectiveness of the decontamination process will be verified by the collection and analysis of swipe samples or through other appropriate types of sampling This effort will determine equipment segregation and management requirements

The confirmation sampling of the decontaminated equipment will verify that all waste and additives have been adequately removed Upon verification that all equipment is visually free of sediments, sludges, and liquids, demolition of the TU will be conducted In addition to the verification activities, any equipment or debris with radiological contamination will be managed in accordance with Section IV 4 (Waste Management)

Demolition of the TUs will be performed in a systematic and controlled manner Non-destructive demolition techniques for decommissioning of the TUs shall be employed to the extent practicable This involves effectively disassembling the TU processing equipment in a similar manner as it was erected

Throughout the closure activities, both engineering and administrative control measures will be in place to minimize the potential spread of contamination These actions will protect the workers, the public, and the environment by minimizing the potential for airborne radiological and non-radiological contamination Typical engineered controls include physical barriers, containments, wetting agents, fixatives, filtration equipment, and sealants In addition to the engineering controls, administrative controls will also be implemented, including and not limited to, controlling work area access/egress, establishing radiological control zones, monitoring personnel within and prior to exit of work zones, and monitoring the success of the engineered and administrative controls

IV.11.5.2.2 Temporary Unit(s) Certification of Closure

The TUs, although subject to the OU4 IM/IRA implementation activities, must be closed and managed according to the RCRA closure requirements The TUs will be closed in accordance with applicable provisions of 6 CCR 1007-3 264, Subparts G, J and S respectively Since the TU equipment will be dismantled and removed as well as all the process related materials, post closure care requirements would not be applicable as a result of the clean closure

The 6 CCR 1007-3, 264 Subpart J standards apply to the treatment or storage of hazardous waste in tanks The standard and provisions under this subpart would also be applicable for closure of tanks and/or tank systems Table IV 11-4 identifies the applicable parts of Subpart J The 6 CCR 1007-3, 264 197 standard, is directly applicable to the closure of tank systems At closure of the TUs, the owner or operator must remove or decontaminate all waste residues, contaminated equipment system components, contaminated soils, and structures and equipment, contaminated with waste and manage them as hazardous waste, as required The 6 CCR 1007-3, 264 114 standard requires that all contaminated equipment, structures, and soils be properly disposed of or decontaminated during partial or final closure These materials shall be managed based on the results of characterization activities following the characterization evaluation

TABLE IV.11-4
6 CCR 1007-3, 264 SUBPART J APPLICABILITY/COMPLIANCE

Subpart J Requirements	Applicability/Compliance
§ 264 190 Applicability	Applicable The requirements of this subpart apply except as provided in (a), (b), or (c)
§ 264 191 Assessment of existing tank system's integrity	Non-applicable The processing will be conducted in a new tank installation
§ 264 192 Design and installation of new tank system or components	Applicable A new tank system will be design and temporarily installed
§ 264 193 Containment and detection of releases	Applicable Part IV 11 4 3(c)(5) identifies the monitoring program for both pads and discusses the controls that will be established for the processing equipment The tent like structures will provide additional containment as well as daily walk through inspections during processing operations to confirm piping and equipment integrity The existing Pad 750 and the Pad 904 tents where the units will be installed provide adequate protection of human health and the environment
§ 264 194 General operating requirements	Applicable The processing tank components will not deteriorate/fail as a result of contact with the processing materials Part IV 3 identifies the conceptual design and discusses process operations
§ 264 195 Inspections	Applicable The pads are subject to scheduled daily and weekly inspections The pads will be inspected daily and the tank processing systems will be inspected during periods of operation
§ 264 196 Response to leaks or spills and disposition of leaking or unfit-for-use tank systems	Applicable Response to leaks or spills will follow established plant practices, including implementing the RCRA Contingency Plan
§ 264 197 Closure and post-closure care	Applicable Part IV 5 2 addresses closure of the TU processing systems Closure will be done in accordance with 264 197 However, post-closure care would not be applicable since all the equipment will be removed thus resulting in a clean closure
§ 264 198 Special requirements for ignitable or reactive wastes	Not Applicable None of the remediation wastes have been classified as ignitable or reactive wastes
§ 264 199 Special requirements for incompatible wastes	Not Applicable None of the remediation wastes have been classified as incompatible wastes

Closure of the TUs will comply with the standards and provisions promulgated in 6 CCR 1007-3 264 Subpart S as well as the closure requirements applicable to the SEPs as identified in the ARAR/TBC Compliance Demonstration Table (Table IV 11-1) The requirements identified in 6 CCR 1007-3 265 1(b) are incorporated by reference, and addresses the interim status facilities and applicable closure requirements for the closure of the SEPs The closure criteria and activities for waste management will be implemented to verify that closure is completed according to applicable requirements All operations will be conducted in accordance with the DOE Radiation Control Manual and the RFETS radiation protection requirements

IV.11.6 Consistency With Final Remedies

The Comprehensive List of Technologies (CLT) data base, developed for EG&G as Task 3 of the CMS/FS (ES, 1994), was utilized to identify process options that could potentially be employed to remediate soils and ground water at OU4 The process options were selected based on chemical contaminants identified during the RFI/RI field work program (Part II of this IM/IRA) and historical research examined while preparing the Phase II RFI/RI The impacted media data were utilized in combination with the chemical contaminants information to generate a list of potential remedial options to ensure the selected IM/IRA would be consistent with all final remediation activities

It has not been determined if the chemical contaminants in ground water at OU4 exist at concentrations that pose a threat to human health and the environment These chemicals cannot be considered COCs at this time However, a list of potential chemical contaminant groups in the ground water was developed for the purpose of generating a list of potential remedial options The COCs for the soils at OU4 have been determined (Part III of this IM/IRA) Historical information concerning chemical contaminants present in the soils at OU4 has not been reconfirmed and its accuracy is questionable A conservative approach was taken in identifying chemical contaminant groups present in OU4 soils Several of the chemical contaminants identified in this scope of work may be eliminated in future projects

The chemical contaminant groups identified for each medium are summarized below

Ground Water -	Metals Radionuclides PCBs/pesticides Semivolatile Organic compounds Volatile Organic Compounds Other (Inorganics)
Soils and Sediments -	Metals Radionuclides PCBs/Pesticides Semivolatile Organic Compounds

A search of the CLT for the above-noted contaminant groups resulted in numerous process options for treatment of both ground water and soils Only process options which are capable of treating all of the chemical contaminants were considered for this discussion

Ex situ treatment of the contaminated soils north of the seepline should not have an impact on the final engineered covers *In-situ* treatment of these contaminated soils should also be possible without impacting the final engineered covers

The proposed IM/IRA would not impact potential future ground water remediation activities Downgradient interceptor trenches, french drains, or pumps could be installed outside the final engineered cover to facilitate *ex situ* treatment of ground water from beneath the cover *In situ* treatment options should also be possible from perimeters of the cover

Numerous process options were identified that had the ability to treat the ground water at OU4 *Ex situ* treatment options include incineration, sedimentation, centrifugation, and filtration/microfiltration/ultrafiltration techniques Oxidation/reduction processes, slurry walls, or grout curtains could be utilized for *in situ* treatment or containment of ground water

Containment options were also identified for the soils and sediments at OU4 These containment options included capping, diversion ditches, etc *Ex situ* treatment options include incineration, sedimentation/separation, and centrifugation It should be noted, however, that excavation of the soil in the vicinity of the final engineered cover may cause stabilization problems for the cover *In situ* chemical fixation, stabilization, or vitrification could be accomplished for the soils in the vicinity of the final engineered cover These processes would be more likely not to disturb the stability of the final engineered cover in comparison to excavation options

The proposed closure system will not impact the ground water flow system Therefore, the DOE considers that the proposed closure system does not limit or constrain the potential alternatives for ground water corrective action Process options were identified that could potentially be employed to remediate ground water and soils at OU4 Review of these options indicated that construction of the closure system should not limit future ground water remediation efforts as long as it's implementation does not require excavation or disturbance of soils in the immediate vicinity of the final engineered cover The potential extraction of ground water from beneath the final engineered cover will likely increase the stability of the final engineered covers' slopes if the upper hydrostratigraphic unit is largely dewatered causing the friction to increase at the alluvium-bedrock interface The shallow aquifer yields are very low which will not likely cause excessive subsidence

IV.12 REFERENCES FOR PART IV

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ROCKY FLATS, OU-4
SOLAR EVAPORATION PONDS
NUCLEAR FACILITY DESIGNATION

Per DOE Order 6430 1A, United States Department of Energy General Design Criteria, a nuclear facility (special facility) is defined as

> "A facility whose operations involve radioactive materials in such form and quantity that a significant nuclear hazard potentially exists to the employees or the general public Included are facilities that (1) produce, process, or store radioactive liquid or solid waste, fissionable materials, or tritium, (2) conduct separation operations, (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations, or, (4) conduct fuel enrichment operations "

The remediated Solar Evaporation Ponds (SEPs) will be classified as a nuclear facility as they will ultimately store solid radioactive waste materials As discussed within Division 13, 1300-1 2 of the General Design Criteria, twenty different types of special facilities have been designated The most appropriate designation for the SEPs is that of Radioactive Solid Waste Facility (RSWF)

Radioactive Solid Waste Facilities store, treat, and dispose of the range of solid waste generated by DOE nuclear facilities and reactor facilities These facilities contain high-level, low-level, and transuranic-contaminated solid waste including radioactive mixed waste These radioactive solid waste facilities may be separate facilities or they may be adjunct to another type of nuclear facility (e g , a high-level solid waste storage facilities associated with a reprocessing facility) The environmental, safety, and health concerns to be addressed to fulfill the design requirements for these facilities vary significantly according to the nature of the waste, the waste management techniques that are implemented, and the characteristics of the facility site

DOE Order 6450 1A, "General Design Criteria", specifically addresses the requirements associate with the design of a RSWF The SEPs are considered to fit into this category as some of the contaminated soils, liners and debris that exceed the calculated PRGs will be placed under the final engineered cover once the facility is remediated There is no intent to actually turn this site into an active (operational) disposal facility Because of this, some aspects of the regulations pertaining to the RSWFs are not applicable to the particular OU4 situation The requirements designated within 6430 1A as specifically pertaining to RSWFs and their applicability to the OU4 remediation activities are discussed within the sections

"For those DOE facilities regulated by the NRC, the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem (0 25 mSv) to the whole body, 75 mrem (0 75 mSv) to the thyroid, and 25 mrem (0 25 mSv) to any other organ [40 CFR 191 03(a)] Additional requirements specific to these facilities are provided in 10 CFR 60 and 10 CFR 61 "

RESPONSE

The combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem (0 25 mSv) to the whole body, 75 mrem (0 75 mSv) to the thyroid, and 25 mrem (0 25 mSv) to any other organ Additionally, airborne exposure to the public will be limited to 10 mrem/yr

1324-2.2.2 Waste Management and Storage Facilities (Not to Include Disposal)

"The references specified in Section 1300-1.4 3, Routine Releases, provide the appropriate dose limits for members of the public for these facilities "

RESPONSE

DOE is in concurrence with this statement

1324-3 NUCLEAR CRITICALITY SAFETY

"Nuclear criticality safety at RSWFs is applicable to those facilities that store or process enriched uranium, uranium-233, or transuranic contaminated solid waste For other radioactive solid waste facilities, nuclear criticality safety is not a design or operational consideration "

"Nuclear criticality control provisions for a RSWF shall consider the following

- Design of radioactive solid waste storage and/or process systems to prevent the carry-over of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas of the facility (e g , from a compaction area to a storage area)

- A system of positive control and backflow preventors, such as air gaps (siphon breakers), to prevent inadvertent transfer of fissile materials and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers

"Instrumentation and control systems shall be required at a RSWF to provide monitoring and control capabilities associated with confinement, nuclear criticality safety, and radiation protection."

RESPONSE

The normal operations for this facility will be simply to remediate the SEPs Due to the types, quantities and form of the materials that are involved with this remediation effort, these special design features are not applicable, and are therefore not required

1324-5.2 **High-Level Waste Disposal Facility Confinement**

"During the short-term period following emplacement when short-lived nuclides dominate the hazard associated with a disposal facility, the engineered system of barrier shall remain effective and shall contain the emplaced wastes This time period is considered to include at least 300 years, but not more than 1,000 years following permanent closure Technical criteria associated with the engineered system of barriers shall address the following

- Establishment of a high-integrity confinement system during establishment (limit the rate of release of radionuclides from the system)
- *In situ* stresses affecting the engineered system of barriers
- Corrosion affecting the engineered system of barriers
- Radiological effects on barrier integrity
- Contact with groundwater"

"During the long-term period, reliance shall not be placed on the engineered system of barriers to contain emplaced waste Confinement during the long-term period shall be accomplished by the geologic setting Technical criteria associated with the geologic setting shall address the following

- Leaching characteristics of waste and waste binders
- Site and soil characteristics, including fractures, porosity, hydraulic conductivity, sorption, hydraulic gradient, and thermal gradient
- Long-term geologic stability
- Groundwater travel time

ROCKY FLATS, OU-4
SOLAR EVAPORATION PONDS
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The remediated Solar Evaporation Ponds (SEPs) will be classified as a nuclear facility as they will ultimately store solid radioactive waste materials As discussed within Division 13, 1300-1 2 of the General Design Criteria, twenty different types of special facilities have been designated The most appropriate designation for the SEPs is that of Radioactive Solid Waste Facility (RSWF)

Radioactive Solid Waste Facilities store, treat, and dispose of the range of solid waste generated by DOE nuclear facilities and reactor facilities These facilities contain high-level, low-level, and transuranic-contaminated solid waste including radioactive mixed waste These radioactive solid waste facilities may be separate facilities or they may be adjunct to another type of nuclear facility (e g , a high-level solid waste storage facilities associated with a reprocessing facility) The environmental, safety, and health concerns to be addressed to fulfill the design requirements for these facilities vary significantly according to the nature of the waste, the waste management techniques that are implemented, and the characteristics of the facility site

DOE Order 6450 1A, "General Design Criteria", specifically addresses the requirements associate with the design of a RSWF The SEPs are considered to fit into this category as some of the contaminated soils, liners and debris that exceed the calculated PRGs will be placed under the final engineered cover once the facility is remediated There is no intent to actually turn this site into an active (operational) disposal facility Because of this, some aspects of the regulations pertaining to the RSWFs are not applicable to the particular OU4 situation The requirements designated within 6430 1A as specifically pertaining to RSWFs and their applicability to the OU4 remediation activities are discussed within the sections

1324 RADIOACTIVE SOLID WASTE FACILITIES

1324-1 COVERAGE

"Section 1300, General Requirements, shall apply These requirements are in addition to the requirements of the section and other applicable sections of these criteria, particularly those sections numbered -99 0, Nonreactor Nuclear Facilities-General "

RESPONSE

DOE is in concurrence with this statement

1324-2 OBJECTIVES

1324-2.1 General

"The design objective shall be to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4 Guidance on Limiting Exposure of the Public."

RESPONSE

The objective of the SEP remediation design is to ensure that conservatively estimated consequences of normal operations and credible accidents are limited in accordance with the guidelines contained in Section 1300-1.4, Guidance on Limiting Exposure of the Public. It should be noted however, that the normal operations for the SEPs is the remediation of the facility, not the operation of a Radioactive Solid Waste Facility Accident and exposure estimates are based upon those scenarios appropriate for the remediation of the SEPs

1324-2.2 Siting Design Dose Objectives for Normal Operations and Anticipated Operational Occurrences

1324-2.2.1 Disposal (Permanent Isolation) Facilities

"For those DOE facilities not regulated by the Nuclear Regulatory Commission (NRC), the combined annual dose equivalent to any member of the public in the general environment resulting from discharge of radioactive material and direct radiation shall not exceed 25 mrem (0 25 mSv) to the whole body and 75 mrem (0 75 mSv) to any organ [40 CFR 191 03(b)] Section 1300-1 4 3, Routine Releases, provides references for additional limits that are applicable to these facilities "

"For those DOE facilities regulated by the NRC, the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem (0 25 mSv) to the whole body, 75 mrem (0 75 mSv) to the thyroid, and 25 mrem (0 25 mSv) to any other organ [40 CFR 191 03(a)] Additional requirements specific to these facilities are provided in 10 CFR 60 and 10 CFR 61 "

RESPONSE

The combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem (0 25 mSv) to the whole body, 75 mrem (0 75 mSv) to the thyroid, and 25 mrem (0 25 mSv) to any other organ Additionally, airborne exposure to the public will be limited to 10 mrem/yr

1324-2 2 2 Waste Management and Storage Facilities (Not to Include Disposal)

"The references specified in Section 1300-1 4 3, Routine Releases, provide the appropriate dose limits for members of the public for these facilities "

RESPONSE

DOE is in concurrence with this statement

1324-3 NUCLEAR CRITICALITY SAFETY

"Nuclear criticality safety at RSWFs is applicable to those facilities that store or process enriched uranium, uranium-233, or transuranic contaminated solid waste For other radioactive solid waste facilities, nuclear criticality safety is not a design or operational consideration "

"Nuclear criticality control provisions for a RSWF shall consider the following

- Design of radioactive solid waste storage and/or process systems to prevent the carry-over of fissile material and other material capable of sustaining a chain reaction from geometrically favorable portions of the facility to other areas of the facility (e g , from a compaction area to a storage area)

- A system of positive control and backflow preventors, such as air gaps (siphon breakers), to prevent inadvertent transfer of fissile materials and other material capable of sustaining a chain reaction from geometrically favorable or poisoned containers to unsafe containers

- Inclusion of heating or cooling jackets in the favorable dimension of geometrically favorable vessels to preclude a leak in the jacket from causing an unacceptable reduction of the margin of subcriticality.

- The design of sumps for nuclear criticality safety if a credible mechanism exists for accumulating fissile material and other material capable of sustaining a chain reaction (e t , due to leakage from or failure of the primary confinement boundary and/or cooling water system)"

RESPONSE

Nuclear criticality safety is not a concern for the remediation of the SEPs. The major isotopes, and their 95% UCL values, that will be placed under the final engineered cover are those stipulated in Table III 2-3, OU4 Characterization, Background, and PRG Information for Potential Contaminants of Concern

1324-4 RADIATION PROTECTION

"For those DOE facilities regulated by the NRC, the occupational radiation protection requirements specified in 10 CFR 20 and 10 CFR 835, both apply (the most conservative limits taking precedent) "

RESPONSE

The Rocky Flats Plant is not regulated by the NRC. DOE does understand however, that the radiation protection criteria specified in DOE 5480.11 does apply to the remediation of the SEPs

1324-5 SPECIAL DESIGN FEATURES

1324-5.1 General

"Process equipment off-gas treatment systems shall be designed to ensure their integrity for normal operations, anticipated operational occurrences, and for the DBAs they are required to withstand "

"Cooling water systems or cooling air systems shall be provided, where required, for facilities and equipment associated with the interim storage or treatment of high-level radioactive solid waste, and to ensure the long-term integrity of the primary confinement boundary As a minimum, cooling water systems shall comply with Section 1540-99, Special Facilities To the extent practicable, passive cooling means shall be used for air cooling systems If a cooling air system is provided to ensure an acceptable temperature of the stored material, it shall be designed as a safety class system "

"Instrumentation and control systems shall be required at a RSWF to provide monitoring and control capabilities associated with confinement, nuclear criticality safety, and radiation protection "

RESPONSE

The normal operations for this facility will be simply to remediate the SEPs Due to the types, quantities and form of the materials that are involved with this remediation effort, these special design features are not applicable, and are therefore not required

1324-5 2 High-Level Waste Disposal Facility Confinement

"During the short-term period following emplacement when short-lived nuclides dominate the hazard associated with a disposal facility, the engineered system of barrier shall remain effective and shall contain the emplaced wastes This time period is considered to include at least 300 years, but not more than 1,000 years following permanent closure Technical criteria associated with the engineered system of barriers shall address the following

- Establishment of a high-integrity confinement system during establishment (limit the rate of release of radionuclides from the system)
- *In situ* stresses affecting the engineered system of barriers
- Corrosion affecting the engineered system of barriers
- Radiological effects on barrier integrity
- Contact with groundwater"

"During the long-term period, reliance shall not be placed on the engineered system of barriers to contain emplaced waste Confinement during the long-term period shall be accomplished by the geologic setting Technical criteria associated with the geologic setting shall address the following

- Leaching characteristics of waste and waste binders
- Site and soil characteristics, including fractures, porosity, hydraulic conductivity, sorption, hydraulic gradient, and thermal gradient
- Long-term geologic stability
- Groundwater travel time

- Absence of resources that would be an incentive for human intrusion

- Stability of rock mass"

"The facility shall be designed to allow retrieval of wastes during the 50-year period following emplacement and before permanent closure of the facility "

RESPONSE

No high level radioactive waste will be consolidated within the Solar Evaporation Ponds, and therefore, this requirement is not applicable

1324-5.3 **Low-Level Waste Disposal Facility Confinement**

"Low-level solid waste that is disposed to the ground shall be confined by a site-specific system of barriers that may include, but not necessarily be limited to, waste form, waste packaging, and the geologic setting "

"When site permeability characteristics do not provide the required confinement capabilities, the confinement system shall be augmented by the following·

- Constructing low permeability walls around the low-level waste

- Lining the walls and bottom of the excavated area with low permeability material

- Other suitable methods for reducing permeability"

"Means shall be provided to minimize contact of emplaced low-level waste with water Active water control measures shall not be required following permanent closure Typical requirements for water control are as follows

- Placing a layer of highly permeable material (e.g., sand, gravel) beneath the low-level waste to channel any percolating water to a sump

- Mounding the soil surface to facilitate surface water runoff

- Use of a suitable low-permeability cover material (e t , clay) over the disposal area to prevent contact of the waste by infiltrating rainwater This cover material shall be protected by a layer of overburden (e.g , sand, gravel, top soil)

- A site diversion system for surface water runoff during operation of the facility (This system shall not be required following site permanent closure)

- Temporary protective covers (e t , tarpaulin) before the completion of the natural in-place soil barrier over the low-level waste

- Revegatation of the overburden layer

- Other suitable and reliable means for minimizing water contact with low-level waste"

RESPONSE

The remediated site permeability characteristics and the design of the final engineered cover meet these requirements as they are related to both confinement and the minimization of contact with waste materials and water

1324-6 CONFINEMENT SYSTEMS

1324-6 1 General

"The following provisions are typical for a RSWF confinement system The actual confinement system requirements for a specific RSWF shall be determined on a case-by-case basis "

"The degree of confinement required in a radioactive solid waste facility is both storage-specific and process-specific, but in either case shall suit the most restrictive case anticipated "

"In general, the primary contamination confinement shall be the radioactive solid waste process systems equipment and associated off-gas or vent systems during the treatment stage of processing In special cases, such as radioactive solid waste facilities where the process or storage include corrosive or noxious materials, the radioactive solid waste process or storage system shall be totally enclosed and provided with its own ventilation system and off-gas cleanup system In such cases, the radioactive solid waste process or storage system shall be treated as the primary confinement system however, depending on the waste being processed and stored, the primary confinement and secondary confinement shall consists of a site-specific engineered system of barriers (e g , drums, liners, concrete casks) when the primary confinement described above is not required "

"Secondary confinement for radioactive solid waste during treatment shall be a process cell or building its ventilation system, while for such waste during interim storage, a storage building or structure shall be used "

"Tertiary confinements are not required in most cases for radioactive solid waste during the treatment or interim storage phase of the radioactive solid waste management process however, the final repository for all such solid wastes shall be tertiary confinement by the natural geologic setting that has been selected as a site and for the specific solid wastes processed at the facility "

"In addition to these principal confinement systems, features such as change rooms and special access ways shall be used to minimize the spread of radioactive contamination within the facility "

RESPONSE

The remediation of the SEPs will not include the treatment or processing of radioactive materials as discussed within this portion of DOE Order 6430 1A, 1324-6.1. The only materials to be consolidated within this facility are soils, liners and debris associated with the SEPs An exception is taken to this requirements as the concentrations and form of the contaminates do not necessitate this type of confinement system

1324-6.2 Primary Confinement System

"The primary confinement system consists of process systems equipment and its associated ventilation and off-gas system, storage containers, or other waste and site-specific engineered barriers "

"Systems components, and structures that compose the process system and/or storage containers shall be designed to ensure their integrity for normal operations, anticipated operational occurrences, and for the DBAs they are required to withstand "

"As a minimum, portions of the process system and/or storage containers whose failure would result in an unacceptable risk and whose functions are necessary to facilitate a safe shutdown conduction shall be designed to remain functional following a DBA High-level enriched uranium, uranium-233, and transuranic solid waste processes and/or storage containers shall meet these requirements The need to meet these requirements for other solid waste shall be determined on a case-by-case basis and shall be commensurate with the potential hazards associated with the waste "

RESPONSE

The remediation of the SEPs will not include the treatment or processing of radioactive materials as discussed within this portion of DOE Order 6430 1A, 1324-6 1 The only materials to be consolidated within this facility are soils, liners and debris associated with the SEPs An exception is taken to this requirements as the concentrations and form of the contaminants do not necessitate this type of confinement system

1324-6 3 **Secondary Confinement System**

"The secondary confinement system consists of the process cell barriers and the ventilation systems associated with the cells or building, or a storage building or structure In some cases, a drum, cask, or other waste and site-specific engineered barrier shall provide secondary confinement "

"The process cell and/or building confinement barriers and associated ventilation systems shall be capable of performing their necessary functions following a DBE Other secondary confinements shall be considered to determine the need to meet these requirements commensurate with the hazards associated with the radioactive solid waste to be confined "

"The secondary confinement shall be designed to ensure that it can withstand the effect of server natural phenomena and man-made events, include the DBAs and the DBF initiated by these events, and remain functional to the extent that the guidelines in Section 1300-1 4 2, Accidental Releases, are not violated

"All penetrations of the secondary confinement shall have positive seals to prevent the migration of contamination out of the secondary confinement area "

"Process cells shall be supplied with ventilation air from the building ventilation system, and shall be provided exhaust ventilation with sufficient capacity to ensure an adequate controlled ventilation flow as required in the event of a credible breach in the secondary confinement barrier Pressure in the compartments shall be negative with respect to the building ventilation system Special features (e t , air locks or enclosed vestibules) shall be considered for access through secondary and tertiary confinement barriers "

RESPONSE

The remediation of the SEPs will not include the treatment or processing of radioactive materials as discussed within this portion of DOE Order 6430 1A, 1324-6 1 The only materials to be consolidated within this facility are soils, liners and debris associated with the SEPs An exception is taken to this requirements as the concentrations and form of the contaminants do not necessitate this type of confinement system

1324-6.4 **Tertiary Confinement System**

"The natural geologic setting composes the tertiary confinement system."

"The tertiary confinement system shall function during normal operations, anticipated operational occurrences, and the DBAs it is required to withstand It shall be capable of performing its necessary functions following a DBE."

"The tertiary confinement system shall remain functional following DBAs, and the severe natural phenomena postulated for the facility site In addition, the tertiary confinement system shall meet the following performance objectives:

- Following permanent closure, ongoing site maintenance shall not be needed
- In the absence of unplanned natural processes or human contact with a low-level waste disposal facility, calculated contaminant levels in groundwater at the site boundary shall not exceed the maximum contaminant levels established in 40 CFR 141
- In the event of human-induced activities following permanent closure, or reasonably foreseeable but unplanned natural processes, the guidelines of Section 1300-1.42., Accidental Releases, shall not be violated Institutional controls may be relied on for a limited time following closure to preclude reclamation activities at a low-level waste disposal site. For the purposes of calculation, these controls shall not be relied on for more than 100 years following permanent closure "

RESPONSE

The remediation of the SEPs will not include the treatment or processing of radioactive materials as discussed within this portion of DOE Order 6430.1A, 1324-6 1 The only materials to be consolidated within this facility are soils, liners and debris associated with the SEPs An exception is taken to this requirements as the concentrations and form of the contaminants do not necessitate a tertiary confinement system It should be noted, however, that the design for the remediated SEPs does meet the objectives of the tertiary confinement system

1324-7 **EFFLUENT CONTROL AND MONITORING**

1324-1.1 **Radioactive Solid Waste**

"The fundamental radioactive solid waste treatment concepts include volume reduction, immobilization of, change of composition, and removal of radioactive material from the waste The waste treatment concept(s) for a particular application shall be selected on

an individual case basis To the extent practicable, however, features shall be included to allow volume reduction and/or immobilization "

"The solid radioactive wastes typically associated with RSWFs that shall be considered during the design include, but are not limited to, fuel cladding hulls, spent fuel elements intended for disposal, solidified high-level liquid waste, nontransuranic waste (e t , waste dryer solids, nonfuel tearing components), and general trash (e g , paper, rags, gloves) Nuclear criticality safety shall be considered in the design of the solid radioactive solid waste processing facility "

RESPONSE

The materials to be consolidated under the final engineered cover will be volume reduced as much as possible in order to provide a stable base for the cover Actual volume reduction techniques will be determined during the final design process of the IM/IRA remediation effort The only wastes that will be consolidated under the final engineered cover will be soils, liners and debris associated with the SEPs Nuclear criticality safety is not a concern for the remediation of the SEPs The major isotopes, that will be placed under the final engineered cover are those stipulated in Table III 2-3, OU4 Characterization, Background, and PRG Information for Potential Contaminants of Concern The mobility of these contaminants will be reduced in response to their placement under the engineered cap This placement under the cap constitutes the waste treatment of the solid materials

1324-7 2 Radioactive Liquid Waste

1324-7.2 1 Process Wastes

"The liquid radioactive wastes typically associated with RSWFs that are to be considered during the design include, but are not limited to, decontamination solutions, washdown solutions, water collection systems, and contaminated laundry waste Nuclear criticality safety shall be considered in the design of the radioactive liquid waste processing facility "

RESPONSE

No liquid wastes will be disposed within the remediated SEPs

1324-7 3 Effluents

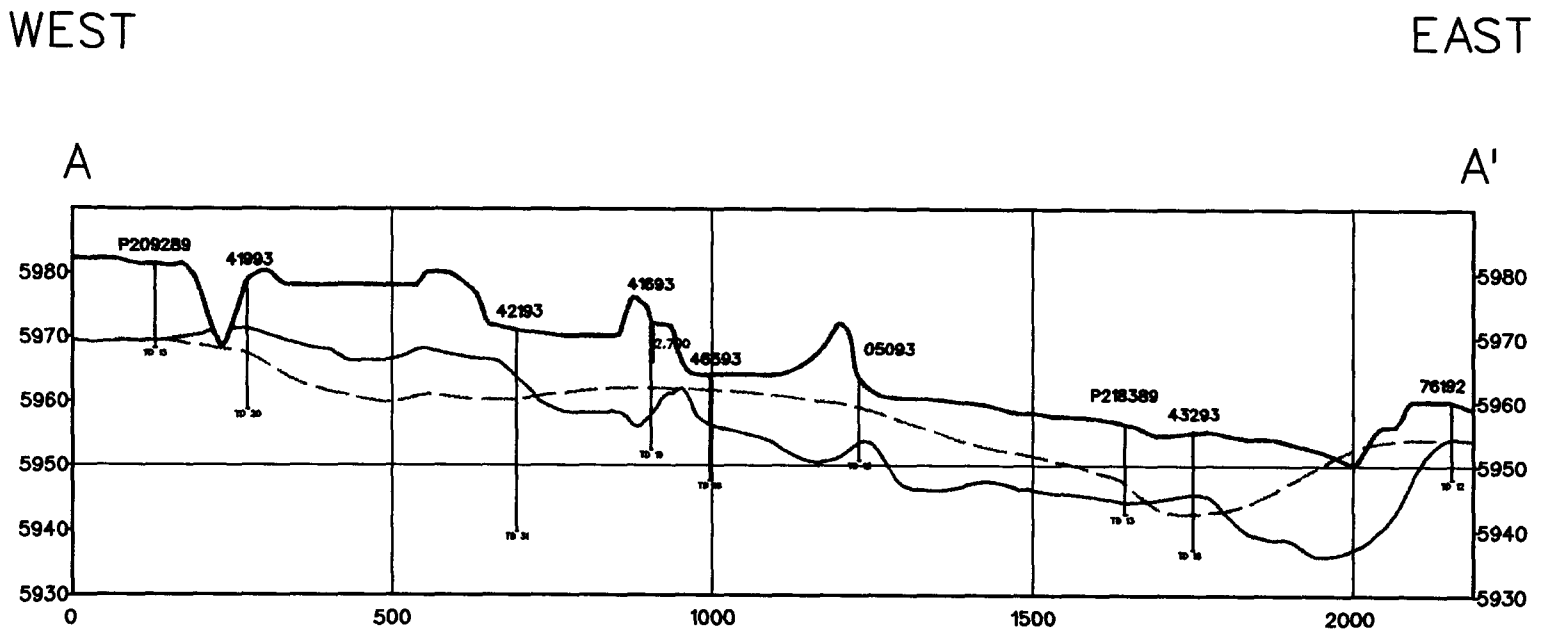
"The airborne radioactive wastes typically associated with radioactive solid waste facilities that shall be considered during the design include, but are not limited to, the airborne effluents from process system vents and fission product gases Effluent system designs shall preclude the holdup or collection of fissile material and other material

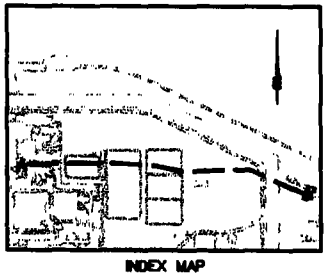
capable of sustaining a chain reaction in portions of the system not geometrically favorable Nuclear criticality safety shall be considered in the design of airborne effluent systems "

"Exhaust outlets that may contain transuranics or fission products shall be provided with tow monitoring systems These monitoring systems shall comply with Section 1589 99 0 1 , Radioactive Airborne Effluents "

RESPONSE

No effluent systems will be included in the design of the final engineered cover, however, effluent emission calculations have been performed to assess the airborne and surface water routes Groundwater effluents will be evaluated in the Phase II RFI/RI for the SEPs Nuclear criticality safety is not a concern for the remediation of the SEPs. The major isotopes, and their 95% UCL values, that will be consolidated under the final engineered cover are those stipulated in Table III.2-3, OU4 Characterization, Background, and PRG Information for Potential Contaminants of Concern





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Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note The maximum reported concentration is completely shaded, and other values are shaded as percentage f the maximum value.

Preliminary Remediation Goals (PRG)1

AMERICIUM-241 1.09 pCi/g

FEET

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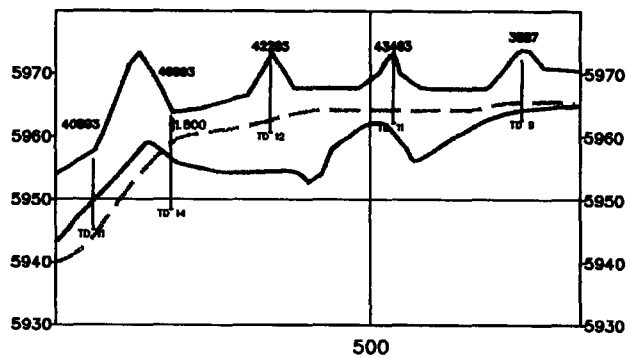
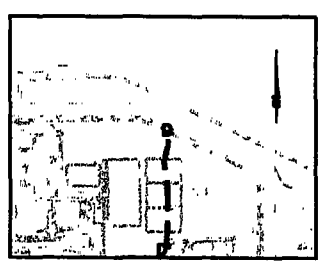
Appendix IV.C-6

Solar Evaporation Ponds, Operable Unit No. 4, IM/IRA EA DD, Cross Section Showing Americium-241 Vadose Zone Concentration Greater Than PRGs

NORTH SOUTH

D D'





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Surface Topography

Bedrock Surface

Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value

Preliminary Remediation Goals (PRG):

AMERICIUM 241 1.09 pCi/g

100 0 100 200 300 FEET

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Appendix IV.C-7

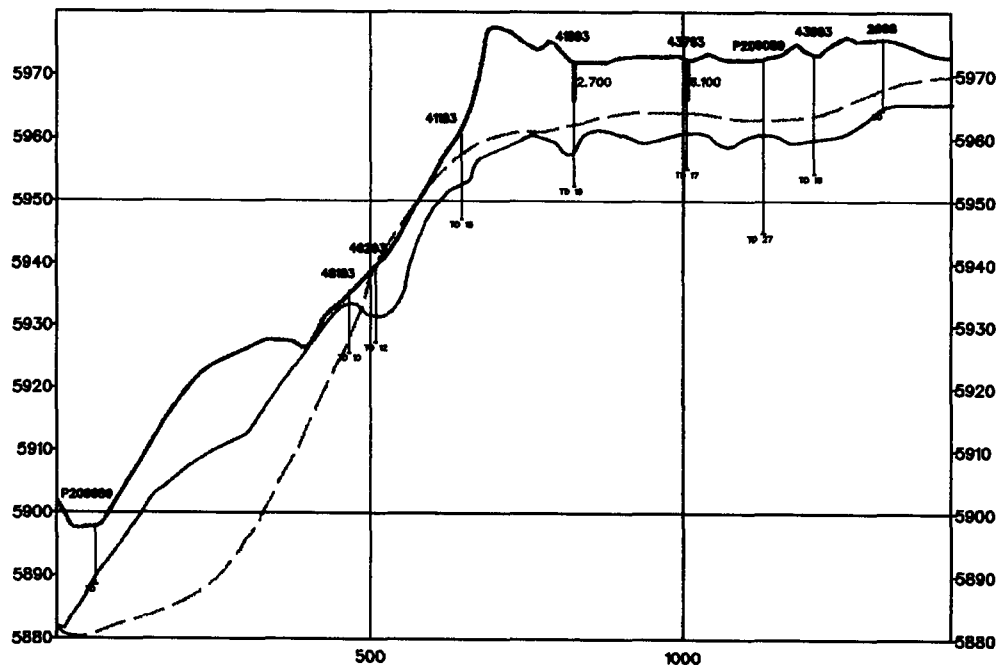
Solar Evaporation Ponds, Operable Unit No. 4, IM/IRA EA DD, Cross Section Showing Americium-241 Vadose Zone Concentration Greater Than PRGs

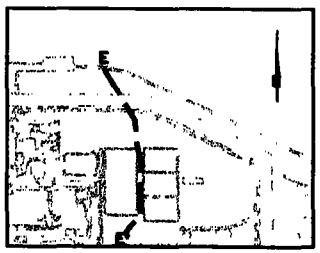
NORTH

SOUTH

E

E'





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LEGEND:

Surface Topography

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Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note: The maximum reported concentration is completely shaded, and other values are shaded as a percentage of the maximum value.

Preliminary Remediation Goals (PRG)

AMERICIUM-241 1.09 pCi/g

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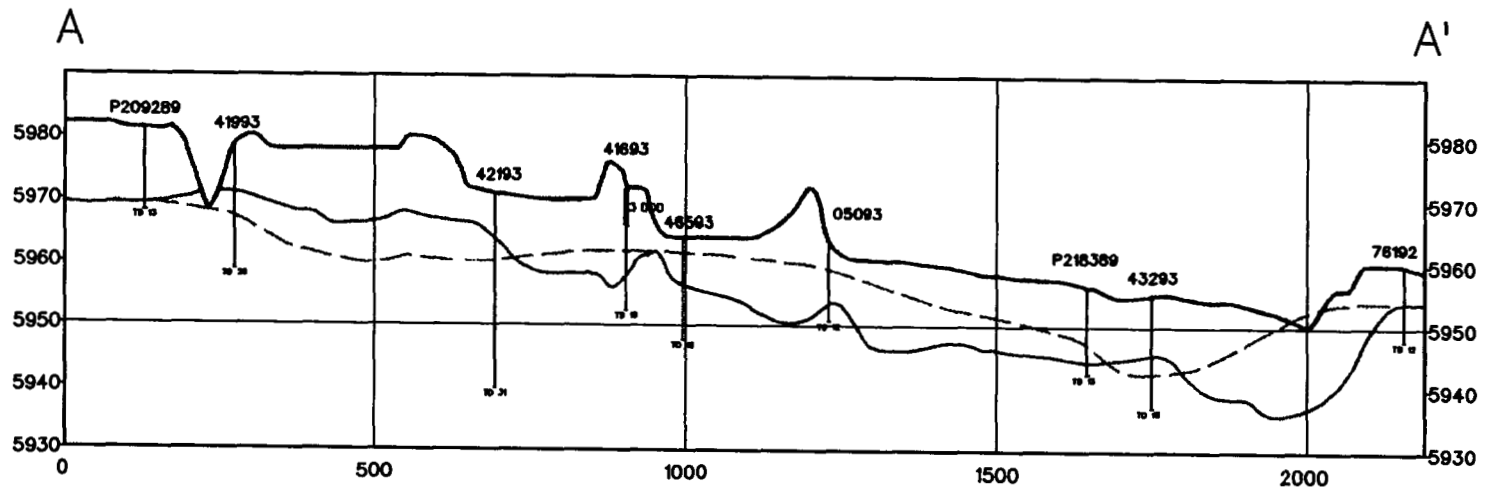
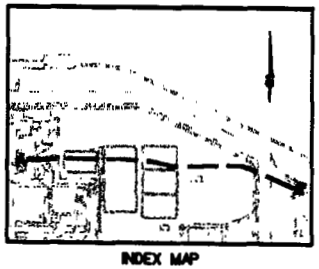
Appendix IV.C-6

Solar Evaporation Ponds, Operable Unit No. 4, IM/IRA EA DD, Cross Section Showing Americium-241 Vadose Zone Concentration Greater Than PRGs





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Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

N t The maximum reported concentration is completely shaded, and ther alues are shaded as percentage f the maximum value

Preliminary Remediation Goals (PRG):

PLUTONIUM-239/240 1.16 pCi/g

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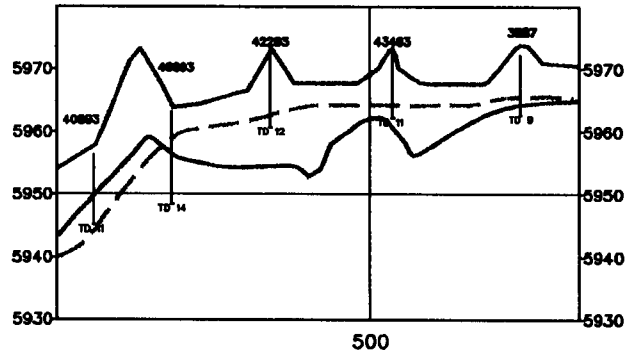
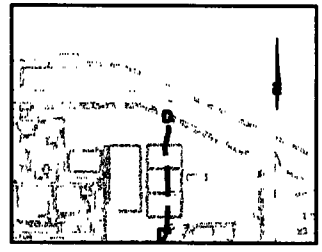
Appendix IV.C-9

Solar Evaporation Ponds, Operable Unit No. 4, M/RA EA DD, Cross Section Showing Plutonium Vadose Zone Concentration Greater Than PRGs

NORTH SOUTH

D D'





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2.700 Composite Sample Interval and Concentration

Note The maximum eported concentration is completely shaded, and other values are shaded as percentage f the maximum value

Preliminary Remediation Goals (PRG)

PLUTONIUM-239/240 1.16 pCi/g

FEET

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Appendix IV.C-10

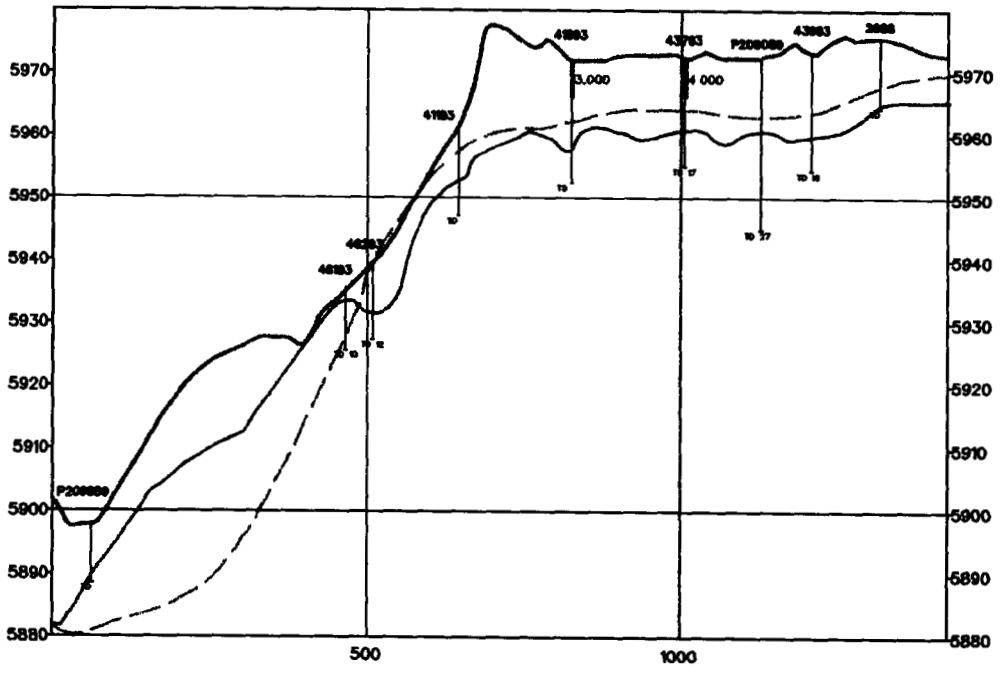
Solar Evaporation Ponds, Operable Unit No. 4, RI/FFA EA DD, Cross Section Showing Plutonium-239/240 Vadose Zone Concentration Greater Than PRGs

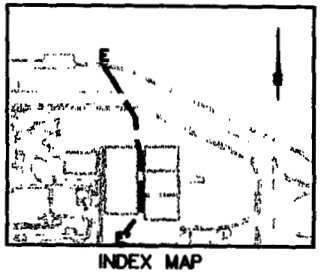
NORTH

SOUTH

E

E'





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2.700 Composite Sample Interval and Concentration

Note: The maximum reported concentration is completely shaded, and other values or shaded as percentage of the maximum value.

Preliminary Remediation Goals (PRG):

PLUTONIUM-239/240 1.16 pCi/g

100 0 100 200 300 FEET

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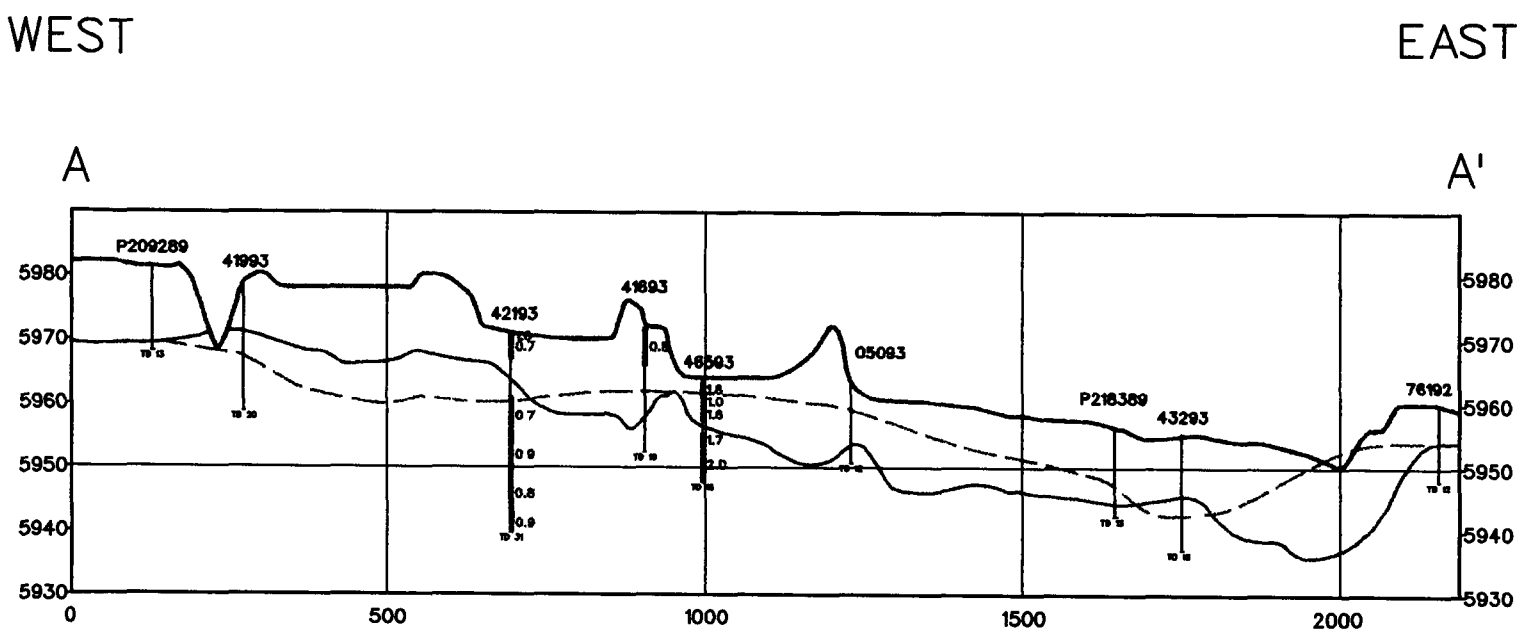
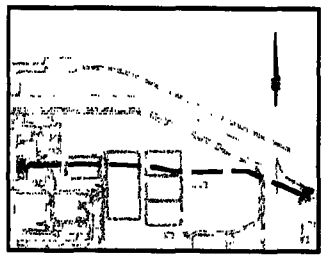
Appendix IV.C-11

Solar Evaporation Ponds, Operable Unit No. 4, RI/FEA EA DD, Cross Section Showing Plutonium-239/240 Vadose Zone Concentration Greater Than PRGs





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2.700 Composite Sample Interval and Concentration

Note: The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value

Preliminary Remediation Goals (PRG):

RADIUM-226 0.65 pCi/g

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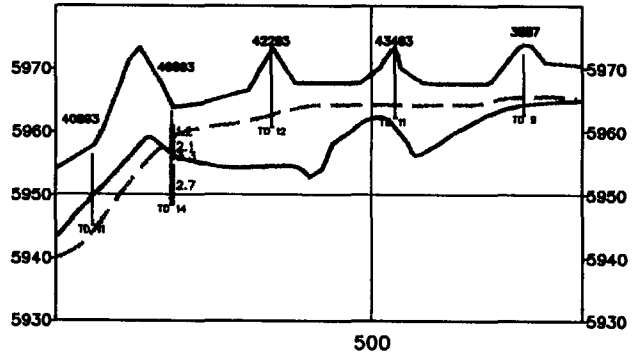
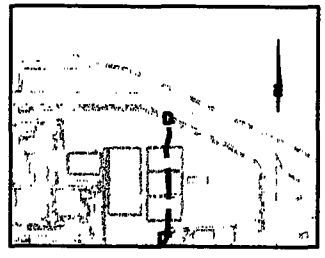
Appendix IV.C-12

Solar Evaporation Ponds, Operable Unit No. 4, IM/IRA EA DD
Cross Section Showing Radium-226 Vadose Zone Concentration Greater Than PRGs

NORTH SOUTH

D D'





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Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note The maximum eported concentration is completely shaded, and other values are shaded as percentage f the maximum value

Preliminary Remediation Goals (PRG)

RADIUM 226 0 65 pCi/g

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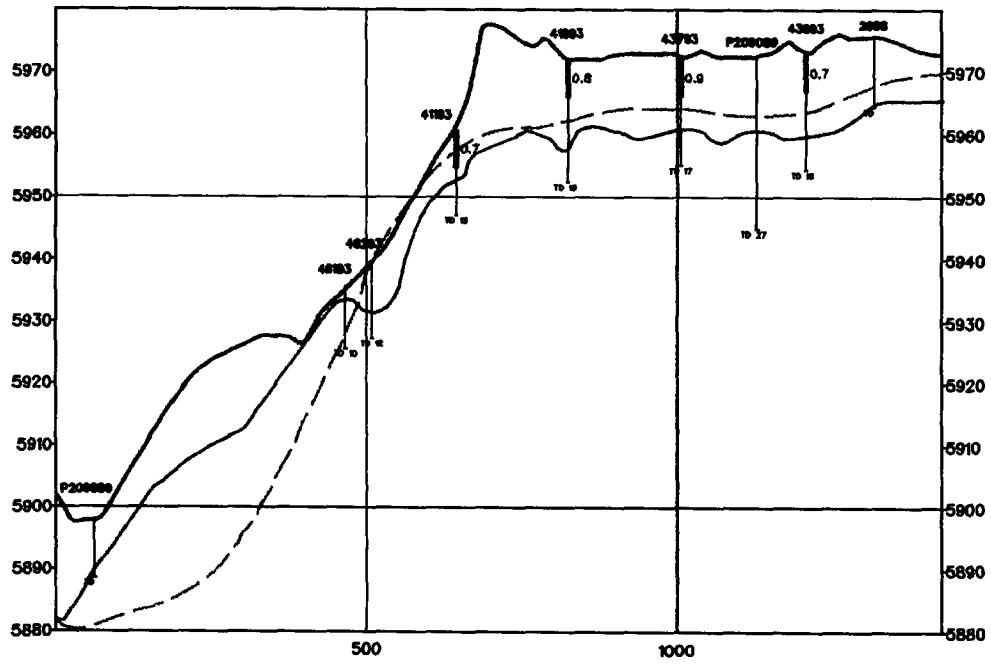
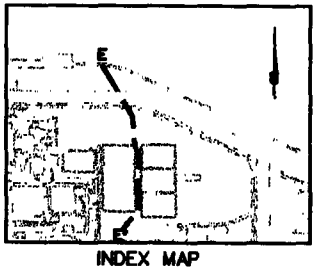
Appendix IV.C-13

Solar Evaporation Ponds, Operable Unit No. 4, IM/IRA EA DD, Cross Section Showing Radium-226 Vadose Zone Concentration Greater Than PRGs

NORTH SOUTH

E E'





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Note: The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value.

Preliminary Remediation Goals (PRG):

RADIUM 226 0.65 pCi/g

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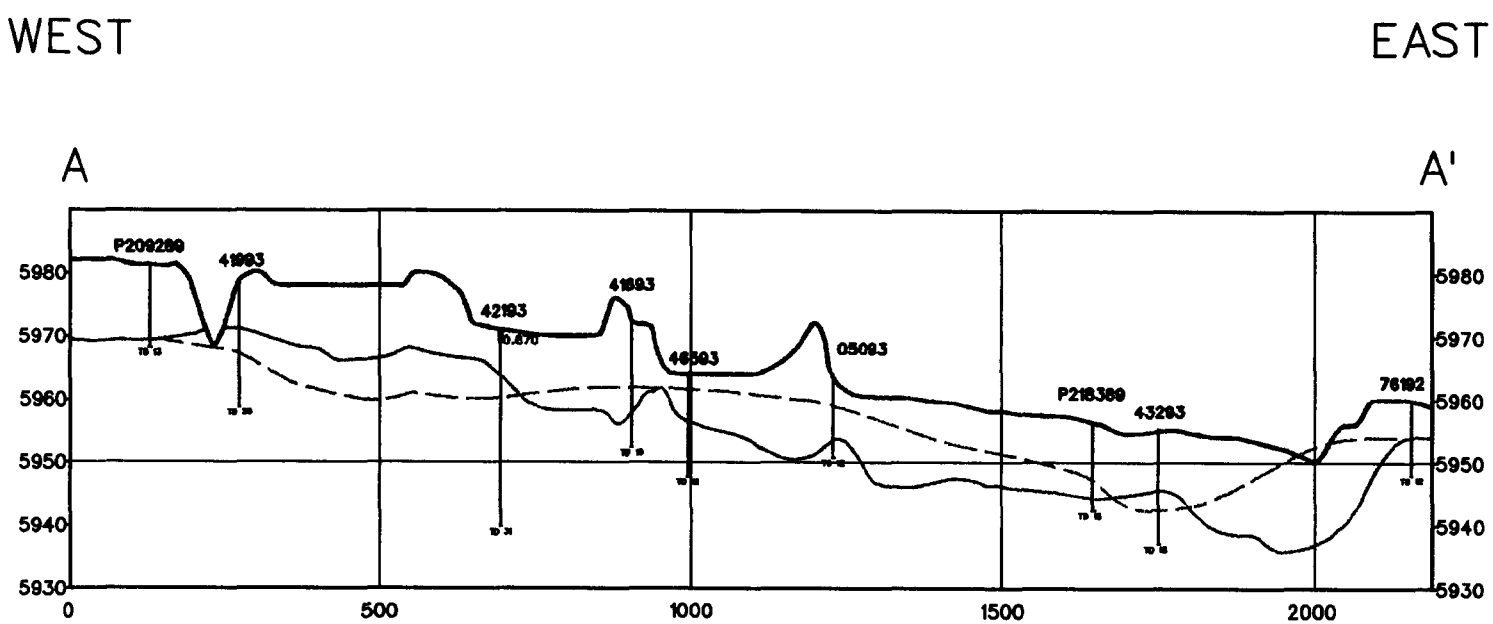
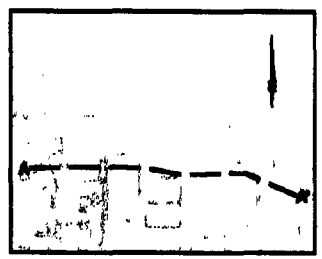
Appendix IV.C-14

Solar Evaporation Ponds, Operable Unit No. 4, IM/IRA EA DD, Cross Section Showing Radium-226 Vadose Zone Concentration Greater Than PRGs





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2.700 Composite Sample Interval and Concentration

Note The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value

Preliminary Remediation Goals (PRG):

URANIUM-235 0 80 pCi/g

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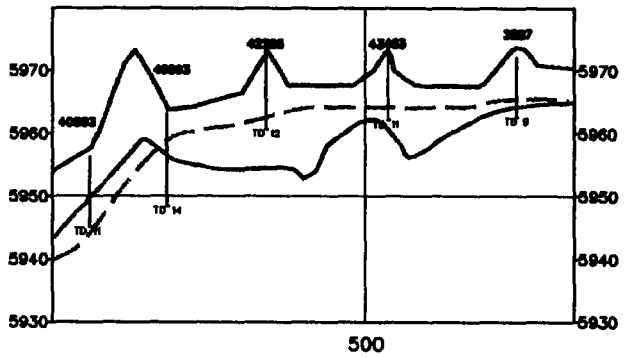
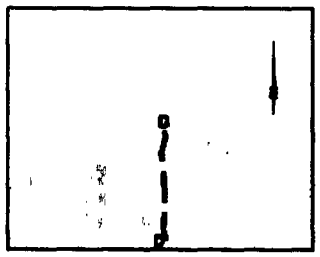
Appendix IV.C-15

Solar Evaporation Ponds, Operable Unit No. 4, RI/FFA EA DD, Cross Section Showing Uranium-235 Vadose Zone Concentration Greater Than PRGs

NORTH SOUTH

D D'





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LEGEND:

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Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value

Preliminary Remediation Goals (PRG):

URANIUM-235 0.60 pCi/g

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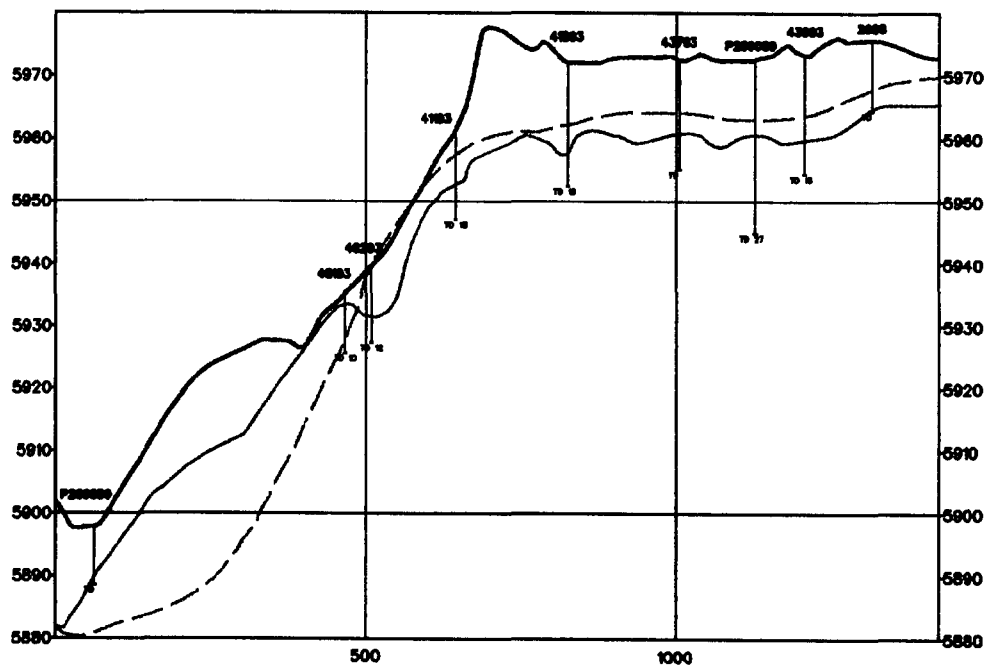
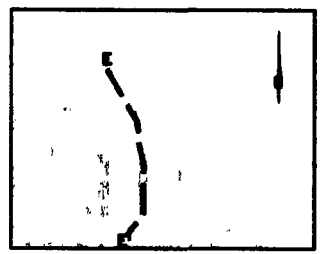
Appendix IV.D-18

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Cross Section Showing Uranium-235 Vadose Zone Concentration Greater Than PRGs

NORTH SOUTH

E E'





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2.700 Composite Sample Interval and Concentration

Note: The maximum reported concentration is completely shaded, and other above or shaded as percentage of the maximum value

Preliminary Remediation Goals (PRG)

URANIUM-235 0 80 pCi/g

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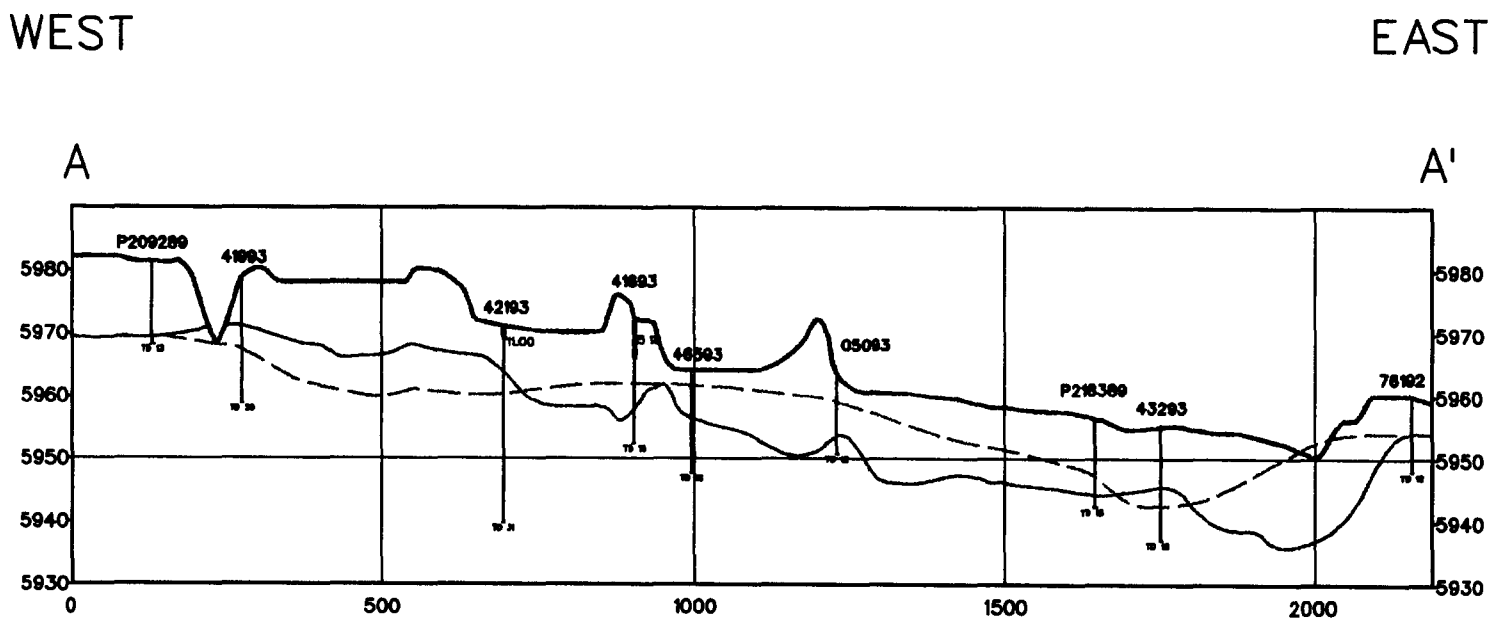
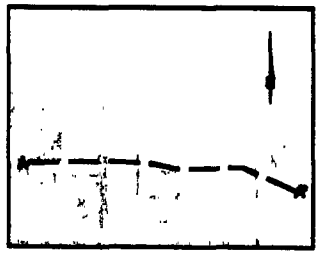
Appendix IV.C-17

Solar Evaporation Ponds, Operable Unit No. 4, RI/FS EA OD, Cross Section Showing Uranium-235 Vadose Zone Concentration Greater Than PRGs





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Bedrock Surface

Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note The maximum reported concentration is completely shaded, and other dues are shaded as a percentage f the maximum value

Preliminary Remediation Goals (PRG):

URANIUM 238 3.86 pCi/g

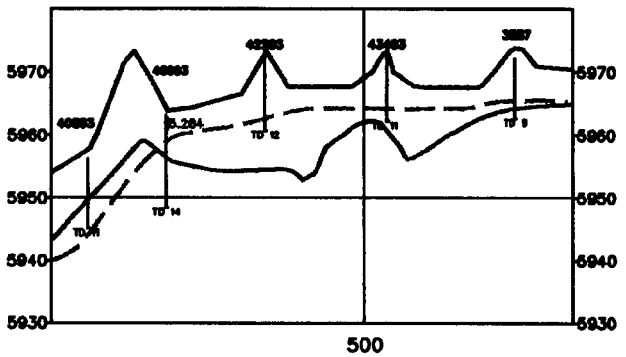
PREPARED FOR
U S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Appendix IV.C-18

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD,
Cross Section Showing Uranium-238
Vadose Zone Concentration Greater
Than PRGs

NORTH SOUTH

D D'



INDEX MAP

LEGEND:

Surface Topography

Bedrock Surface

Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value

Preliminary Remediation Goals (PRG):

URANIUM-238 3.86 pCi/g

PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Appendix IV.D-18

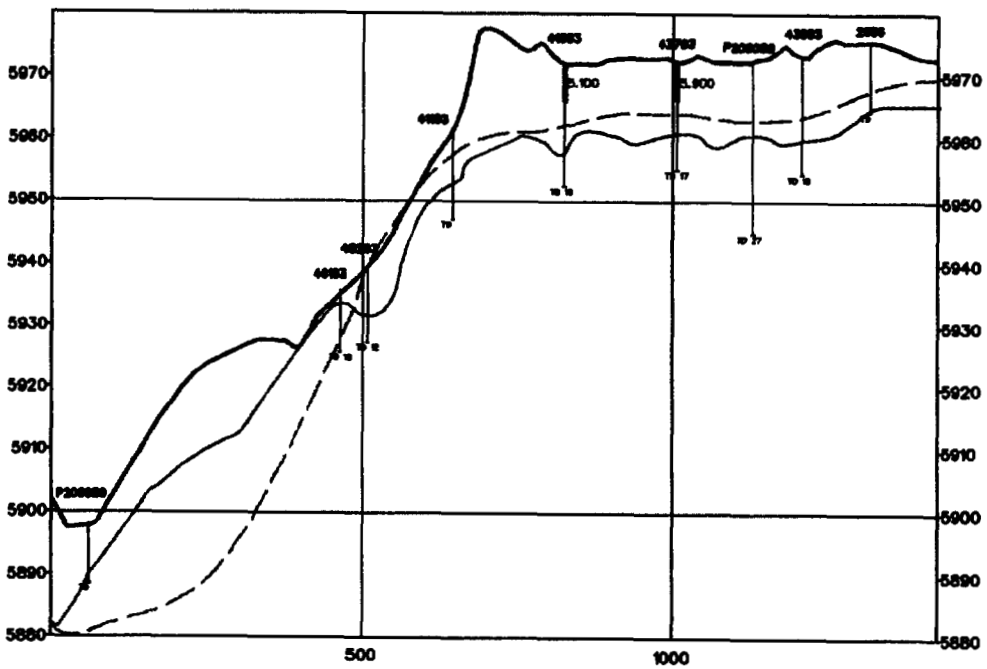
Solar Evaporation Ponds
Operable Unit No. 4, RI/FS EA DD,
Cross Section Showing Uranium-238
Vadose Zone Concentration Greater
Than PRGs

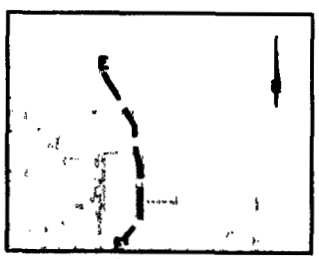
NORTH

SOUTH

E

E'





INDEX MAP

LEGEND:

Surface Topography

Bedrock Surface

Mean Historical Seasonal High Water Table Elevation

2.700 Composite Sample Interval and Concentration

Note: The maximum reported concentration is completely shaded, and other values are shaded as percentage of the maximum value.

Preliminary Remediation Goals (PRG):

URANIUM-238 3.86 pCi/g

PREPARED FOR
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Appendix IV.C-20

Solar Evaporation Ponds, Operable Unit No. 4, RI/FS EA DD, Cross Section Showing Uranium-238 Vadose Zone Concentration Greater Than PRGs

APPENDIX IV D

APPROACH FOR THE

SAMPLING AND ANALYSIS PLAN

FOR BUILDING 788 (RCRA UNITS 21 AND 48) AND

BUILDING 964 (RCRA UNIT 24)

REMOVAL (CLOSURE) AND WASTE MANAGEMENT

SECTION 1

BUILDING 788 INTRODUCTION

1 1 Purpose

The following sections discuss the proposed approach for the sampling and analysis plan (SAP) for Building 788 Issues such as the specific methodologies and quality assurance/quality control (QA/QC) will be addressed as the final SAP is developed Sampling methodologies for both the radiological and hazardous constituents are based on the select waste/material management plan for Building 788 (RCRA Units 21 and 48) (see Section IV 4 3) from plans submitted in the EG&E Radiological Engineering "Baseline Radiological Characterization Survey for RCRA #21 and #48, RWN-010-94" and EG&G RCRA Permitting and Compliance "Sampling and Analysis Plan for RCRA Closure of Units 21 and 48 "

The preferred waste/material management plan is to remove Building 788 and ancillary equipment, to perform segregation during demolition to allow retrieval of usable and recyclable equipment and material, and to stage non-recoverable waste for disposition under the final engineered cover Results of sampling and analysis will establish radiation and contamination levels which will in turn provide the basis for the selection of personal protection equipment (PPE), the selection of containment measures required during the demolition and size reduction of the building and equipment, the feasibility of applying the Best Demonstrated and Available Technology (BDAT) standards and/or radiological decontamination processes, equipment release for unrestricted use, and other regulated reuse or disposal options

[NOTE Currently, no sampling and analysis criteria has been developed for IHSS 176 Should it be determined that sampling and analysis protocol be developed for IHSS 176, issues such as the specific methodologies and quality assurance/quality control (QA/QC) will be addressed as the final SAP is developed]

SECTION 2

BUILDING 788 SAMPLING/CHARACTERIZATION SURVEY PRIOR TO DISASSEMBLY

2 1 Baseline Sampling Plan

The primary objective of the baseline sampling program is to determine the amount and location of both radiological and hazardous material contamination From this information, requirements will be developed for containment measures needed during the demolition and size reduction of the building and equipment The demolition, segregation, and management of these potentially contaminated materials will be conducted in a manner that is protective of human health and the environment

The results will also be used in conjunction with process knowledge and material makeup in determining the feasibility of applying the BDAT standards and/or radiological decontamination processes The demolition waste/material will be segregated based on process knowledge, visual inspection, and sample results as required Material segregated and classified as recoverable will be transferred to the decontamination pad for the application of BDAT and/or radiological decontamination processes

Radiological baseline sampling will be performed in accordance with "Baseline Radiological Characterization Survey for RCRA #21 and #48, RWN-01094 " This plan was developed by the EG&G Radiological Engineering from the source document "Environmental-Implementation Guide for Radiological Survey Procedures, Draft, November, 1992 "

Equipment and building material will be "smear sampled" (wipe test) and analyzed and direct radiation surveys will be performed by the Protected Area Radiochemistry (PARC) sampling team Sample collection and management will be performed in accordance with the requirements of the Waste Stream and Residue Identification and Characterization (WSRIC) Program description A proposed methodology for hazardous material sampling for Building 788 (including RCRA Units 21 and 48) is located in the draft "RCRA Closure Plan for Interim Status Units 21 and 48" provided by EG&G RCRA Compliance

2 2 Release/Disposition Sampling Program

Equipment that has been classified as recoverable, usable, or recyclable will be resampled after the BDAT and/or radiological decontamination process to determine the potential for conditional and unconditional release Hazardous debris/equipment subject to the "Debris Rule" will be considered non-regulated or low-level radioactive (depending on radiological contamination status) debris/equipment after the application of the BDAT

Low-level radioactive debris will be re-surveyed and re-sampled according to the approved "Baseline Radiological Characterization Survey for RCRA #21 and #48, RWN-010-94" methodology Debris/equipment that meets the free release criteria for low-level radiological waste will be released for reuse or recycle Debris/equipment that does not meet the free release criteria, and for which further decontamination would not be effective, will be considered for regulated reuse or disposal in a regulated landfill

SECTION 3

BUILDING 964 INTRODUCTION

3.1 Purpose

The following sections discuss the proposed approach for sampling and analysis of Building 964 (RCRA Unit 21) Issues such as specific methodologies and quality assurance/quality control (QA/QC) will be addressed as the final SAP is developed Sampling methodologies for both the radiological and hazardous constituents (if applicable) will be based on the selected waste/material management plan developed for Building 964

The preferred waste/material management plan is to remove Building 964, including and not limited to miscellaneous items from the facility, to perform segregation during demolition to allow retrieval of usable and recyclable material, and to stage non-recoverable waste for disposal under the engineered cover or at the RFETS solid waste landfill Results of sampling and analysis will establish radiation and contamination levels which will in turn provide the basis for the selection of personal protection equipment (PPE) and containment measures required during the demolition and size reduction of the building materials, the feasibility of applying the Best Demonstrated and Available technology (BDAT) standards and/or radiological decontamination, equipment release for unrestricted use, and other regulated reuse or disposal options

SECTION 4

BUILDING 964 SAMPLING/CHARACTERIZATION SURVEY PRIOR TO DISASSEMBLY

4.1 Baseline Sampling Program

The primary objective of the baseline sampling program is to determine the amount and location of both radiological and hazardous material contamination From this information, requirements for containment measures required during the demolition and size reduction of the building materials and miscellaneous items removed will be developed The containment measures required will be based on the severity of radiological and hazardous constituents identified The demolition, segregation, management of the building materials will be conducted in a manner that is protective of human health and the environment

The results of the sampling program will also be used in conjunction with process knowledge and material makeup in determining the feasibility of applying the BDAT standards and/or radiological decontamination processes The demolition waste/material will be segregated based on process knowledge, visual inspection, and sample results as required Material segregated and classified as recoverable will be transferred to the decontamination pad for application of BDAT and/or radiological decontamination processes along with the recoverable material from Building 788

Radiological baseline sampling will be performed in accordance with "Baseline Radiological Characterization Survey developed for RCRA Units #21 and #48, RWN-010-94 " This plan was developed by EG&G Radiological Engineering from the source document "Environmental Implementation Guide for Radiological Survey procedures, Draft, November, 1992 "

Building materials and miscellaneous items removed from Building 964 will be "smear sampled" by the PARC sampling team and analyzed in a manner similar to that conducted on Building 788 and its ancillary equipment Sample collection and management will be performed in accordance with the requirements of the WSRIC Program description

4.2 Release/Disposition Sampling Program

Building material that has been classified as recoverable, usable, or recyclable will be resampled after the BDAT and/or radiological decontamination process to determine the potential for conditional and unconditional release Building material which may be hazardous and subject to the "Debris Rule" will be considered non-regulated or low-level radioactive (depending on radiological contamination status) waste material after application of the BDAT

Low-level radioactive building materials and miscellaneous items will be re-surveyed and re-sampled according to the approved "Baseline radiological Characterization Survey developed for RCRA Units #21 and #48, RWN-010-94" methodology Building materials and miscellaneous items that meet the free release criteria for low-level radiological waste will be released for reuse or recycle Building materials and miscellaneous items that does not meet the free release criteria, and for which further decontamination would not be effective, will be considered for disposal in the RFETS solid waste landfill or dispositioned under the engineered cover

EG&G
OU4 IM/IRA PROJECT COST ESTIMATE
CONSTRUCTION SCHEDULE

Description	OU4 ROCKY FLATS PLANT GOLDEN CO 80401
Client	EG&G SAME (303)966-7000
Engineer	WALT EDMONSON (303)831-8100
Estimator	WALT EDMONSON
Rate table	HANFORD94
Audit	Dimensional
Report hours	Manhours
Document	ESTIMATE REPRESENTS BASE- LINE 60% CONC & 788 REMEDIATION
Bid date	4-11-94 1 56 PM
Type of estimate	Base bid
Report format	Detail report Combine items Round quantities Print extended descriptions

TAKEOFF QTY	LABOR UNIT PRICE	LABOR AMOUNT	MATRL UNIT PRICE	MATRL AMOUNT	SUB AMOUNT	SUB NAME	EQUIP UNIT PRICE	EQUIP AMOUNT	TOTAL AMOUNT
910 000 SPEC CONDITIONS									
0100 000 BASELINE RAD/HAZ SURVEY									
0002 SET-UP STAGING AREA									
80 00 MH	65 00 /MH	5 200				-			5 200
0003 SET-UP EXCLUSION ZONE									
160 00 MH	65 00 /MH	10 400				-			10 400
0004 SET-UP STEP-OFF/SURVEY AREA									
80 00 MH	65 00 /MH	5 200				-			5 200
0005 DEVELOP RAD WORKER PERMIT									
80 00 MH	65 00 /MH	5 200				-			5 200
0006 BASELINE SURVEY BY HPT									
80 00 MH	65 00 /MH	5 200							5 200
0007 OBTAIN EXCAVATION PERMIT									
40 00 MH	65 00 /MH	2 600				-			2 600
0008 CONDUCT TRAINING ON SAMPLING									
60 00 MH	65 00 /MH	3 900				-			3 900
0009 PHASE II ACTIVITIES									
00 LS									0
0010 MODIFY RAD WORKER PERMIT									
40 00 MH	65 00 /MH	2 600				-			2 600
0011 WRITE H & S PLAN									
640 00 MH	65 00 /MH	41 600				-			41 600
0012 PHASE III ACTIVITIES									
00 LS						-			0
0012 ZONE B WELL ABANDONMENT									
1 00 LS			66 000 00 /LS	**66 000**					66 000
0013 DAILY SURVEYS									
4 000 00 MH	65 00 /MH	260 000							260 000
0014 COVER SURF CONTAMINATION									
2 800 00 MH	65 00 /MH	182 000							182 000
BASELINE RAD/HAZ SUR		523 900*		66 000*					589 900*
			Labor hrs	8 060 00		Equip hrs	8 060 00		
0200 000 MONITOR JOB SITE REM									
0002 ENTER EXIT JOBSITE									
20 180 00 MH	40 00 /MH	807 200				-			807 200
0015 RAD TECHNICIANS 4-9 MONTHS									
4 536 00 MH	34 53 /MH	156 628							156 628
MONITOR JOB SITE REM		963 828*							963 828*
			Labor hrs	24 716 00		Equip hrs	24 716 00		
5000 000 INDIRECT FIELD COSTS									
0011 OBTAIN BUILDING PERMITS									
80 00 MH	40 00 /MH	3 200							3 200
0012 COST OF PERMIT									
1 00 LS			500 00 /LS	500		-			500
0013 MOBILIZATION									
1 000 00 MH	40 00 /MH	40 000							40 000
0014 SANITARY (PORTABLE TOILETS) 8									
26 00 MO							584 00 /MO	15 184	15 184
0015 HANDWASH UNIT 4									
26 00 MO						-	340 00 /MO	8 840	8 840
0016 EYEWASH UNIT 4									
26 00 MO							116 62 /MO	3 032	3 032
0017 TEMPORARY UTILS (PHONE WATER)									

TAKEOFF QTY	LABOR UNIT PRICE	LABOR AMOUNT	MATRL UNIT PRICE	MATRL AMOUNT	SUB AMOUNT	SUB NAME	EQUIP UNIT PRICE	EQUIP AMOUNT	TOTAL AMOUNT
26 00 MO			500 00 /MO	13 000					13 000
0022 LIGHTS NORTH OF SEEPLINE									
26 00 MO							4 100 00 /MO	106 600	106 600
0023 LIGHTS SOUTH OF SEEPLINE									
26 00 MO							4 100 00 /MO	106 600	106 600
0025 WATER TANKER (631WW) & OPER									
572 00 DY	320 00 /DY	183 040				-	1 235 00 /DY	706 420	889 460
0026 OFF HIGHWAY TRUCK (77C) & OPER									
572 00 DY	320 00 /DY	183 040				-	1 910 00 /DY	1 092 520	1 275 560
0027 WHEEL LOADER (992C) & OPER									
572 00 DY	320 00 /DY	183 040				-	2 995 00 /DY	1 713 140	1 896 180
0028 MOBILE LAB FOR GEO SOIL TEST									
26 00 MO							700 00 /MO	18 200	18 200
0029 GEOTECHNICAL TECH									
1 500 00 MH	80 00 /MH	120 000				-			120 000
0030 FIELD TECH									
3 000 00 MH	80 00 /MH	240 000				-			240 000
0032 STAFFED LAB									
120 00 DY	3 000 00 /DY	360 000				-			360 000
0033 STAND BY LAB									
120 00 DY	800 00 /DY	96 000				-			96 000
0035 ROAD BASE (6) AND GRADING									
2 180 00 SY	06 /SY	131	7 54 /SY	16 437		-	04 /SY	87	16 655
0036 OFFICE TRAILER									
26 00 MO						-	375 00 /MO	9 750	9 750
0037 BREAK TRAILER									
26 00 MO						-	260 00 /MO	6 760	6 760
0038 TRAILER WITH LOCKERS									
26 00 MO						-	375 00 /MO	9 750	9 750
0039 PERSONNEL DECON TRAILER W/SHOW									
26 00 MO						-	550 00 /MO	14 300	14 300
0040 LAB/TRAILER SET-UP/REMOVE									
6 00 LS						-	505 00 /LS	3 030	3 030
0041 PREPARE STOCKPILE AREA									
200 000 00 SY	10 /SY	20 000				-	07 /SY	14 000	34 000
0043 H & S EQUIPMENT									
1 00 LS						-	605 700 00 /LS	605 700	605 700
0044 DEMOBILIZATION/SITE CLEAN-UP									
1 00 LS	120 000 00 /LS	120 000				-			120 000
0045 DECON OF EQUIPMENT INSIDE PA									
800 00 MH	17 84 /MH	14 272				-			14 272
0046 DECON OF EQUIPMENT BUFFER ZONE									
400 00 MH	17 84 /MH	7 136				-			7 136
0048 PURCHASE WASTE CRATES									
100 00 EA			260 00 /EA	26 000		-			26 000
0049 INSTALL LIDS ON WASTE CRATES									
100 00 EA	12 00 /EA	1 200				-			1 200
0050 OFFLOAD WASTE CRATES									
100 00 EA	7 00 /EA	700							700
0051 ASSAY WASTE CRATES									
200 00 MH	80 00 /MH	16 000							16 000
INDIRECT FIELD COSTS		1 587 759*		55 937*				4 433 913*	6 077 609*
			Labor hrs	22 628 00		Equip hrs	22 628 00		

7000 000 SURFICIAL SOILS REMOVAL
1 NORTH HILLSIDE

TAKEOFF QTY	LABOR UNIT PRICE	LABOR AMOUNT	MATRL UNIT PRICE	MATRL AMOUNT	SUB AMOUNT	SUB NAME	EQUIP UNIT PRICE	EQUIP AMOUNT	TOTAL AMOUNT
3 100 00 CY	1 26 /CY	3 906					84 /CY	2 604	6 510
2 NORTH OF PERIMETER FENCE									
5 400 00 CY	1 26 /CY	6 804				-	84 /CY	4 536	11 340
3 WASTE PLACEMENT									
8 500 00 CY	1 51 /CY	12 835					1 01 /CY	8 585	21 420
4 EXCESSIVE HANDLING									
17 000 00 CY	1 51 /CY	25 670				-	1 01 /CY	17 170	42 840
SURFICIAL SOILS REMO		49 215*						32 895*	82 110*
8000 000 POND PREP FOR COVER									
0001 POND PREPARATION									
00 CY						-			0
0002 GRIND POND LINERS 8000									
131 160 00 SY	24 /SY	31 478				-	08 /SY	10 493	41 971
0003 MOVE & STOCKPILE LINERS									
11 800 00 CY	1 51 /CY	17 818				-	1 01 /CY	11 918	29 736
0005 HAND CLEARING @ MONITOR WELLS									
1 000 00 MH	17 62 /MH	17 620				-			17 620
0015 SUBSURFACE DRAIN									
00 CY						-			0
0016 EXCAVATE A B & C SEPs									
129 200 00 CY	1 26 /CY	162 792				-	84 /CY	108 528	271 320
0017 EXCESSIVE MATERIAL HANDLING									
387 600 00 CY	1 51 /CY	585 276				-	1 01 /CY	391 476	976 752
0018 EXCAVATE SUBSURFACE TRENCH									
1 778 00 CY	1 26 /CY	2 240				-	84 /CY	1 494	3 734
0019 EXCAVATE TOE DRAIN									
769 00 CY	1 26 /CY	969				-	84 /CY	646	1 615
0020 EXCAVATE CMP TRENCHES									
378 00 CY	1 26 /CY	476				-	84 /CY	318	794
0021 EXCAVATE BERM & N HILLSIDE									
19 823 00 CY	1 26 /CY	24 977				-	84 /CY	16 651	41 628
0023 DELIVER FILTER 1 SAND									
14 800 00 CY			8 28 /CY	122 544		-			122 544
0024 DELIVER FILTER 2 SAND									
14 800 00 CY			8 28 /CY	122 544		-			122 544
0025 DELIVER DRAIN GRAVEL									
14 800 00 CY			15 27 /CY	225 996		-			225 996
0026 PLACE FILTER & DRAIN MATERIAL									
44 400 00 CY	1 51 /CY	67 044				-	1 01 /CY	44 844	111 888
0027 GRADE FILTER & DRAIN MATERIAL									
278 258 00 SY	1 51 /SY	420 170				-	1 01 /SY	281 041	701 210
0029 FILTER FABRIC									
231 882 00 SY	75 /SY	173 912				-	45 /SY	104 347	278 258
POND PREP FOR COVER		1 504 772*		471 084*				971 755*	2 947 611*
1 000 LS	2 947 610 560/LS	Labor hrs	1 000 00	Equip hrs	1 000 00				
9000 000 MIX/PLACE WASTE									
1 PROCESS SLUDGE/PONDCRETE									
100 00 LS						-	412 000 00 /LS	41 200 000	41 200 000
2 MIXER ALLOWANCE									
100 00 LS						-	12 000 00 /LS	1 200 000	1 200 000
3 MIX SOIL SLUDGE & PONDCRETE									
133 230 00 CY	1 20 /CY	159 876				-	2 02 /CY	269 125	429 001
4 PLACE MIXED WASTE									
133 230 00 CY	1 51 /CY	201 177				-	1 01 /CY	134 562	335 740

TAKEOFF QTY	UNIT PRICE	LABOR AMOUNT	UNIT PRICE	MATRL AMOUNT	SUB AMOUNT	NAME	UNIT PRICE	EQUIP AMOUNT	TOTAL AMOUNT
5 GRADE MIXED WASTE									
1 180 440 00 SY	06 /SY	70 826				-	04 /SY	47 218	118 044
6 COMPACT MIXED WASTE									
1 180 440 00 SY	04 /SY	47 218				-	03 /SY	35 413	82 631
7 PLACE C POND SOILS									
37 000 00 CY	1 51 /CY	55 870				-	1 01 /CY	37 370	93 240
8 GRADE C POND SOILS									
437 200 00 SY	06 /SY	26 232				-	04 /SY	17 488	43 720
9 COMPACT C POND SOILS									
437 200 00 SY	04 /SY	17 488					03 /SY	13 116	30 604
10 PLACE ORGANICS									
8 500 00 CY	1 51 /CY	12 835				-	1 01 /CY	8 585	21 420
MIX/PLACE WASTE		591 522*						42 962 877*	43 554 399*
9500 000 CONCRETE ENTOMBMENT									
1 EXCAVATION									
700 00 CY			1 26 /CY	882		-	84 /CY	588	1 470
2 CONCRETE GROUT/PUMP									
100 00 CY	1 00 /CY	100	88 92 /CY	8 892					8 992
CONCRETE ENTOMBMENT		100*		9 774*				588*	10 462*
10000 000 UTILITIES									
010 DESIGN/REVIEW SHORING ACT									
200 00 LS	90 00 /LS	18 000				-			18 000
011 SHORING (EXCAVATION/REMOVAL									
5 580 00 LS	40 40 /LS	225 432				-			225 432
012 SHORING (excavation/grouting)									
1 150 00 LF	8 08 /LF	9 292							9 292
013 REMOVE 3" LD-STL									
60 00 LF	27 24 /LF	1 634				-	1 33 /LF	80	1 714
014 REMOVE 3" LD-STL									
60 00 LF	27 24 /LF	1 634				-	1 33 /LF	80	1 714
015 REMOVE 3"PW-STL									
60 00 LF	27 24 /LF	1 634				-	1 33 /LF	80	1 714
016 REMOVE & GROUT 3 PW-SST									
570 00 LF	27 24 /LF	15 527				-	1 33 /LF	758	16 285
018 REMOVE & RELOCATE 6" RW-CI									
550 00 LF	27 24 /LF	14 982				-	1 33 /LF	732	15 714
019 REMOVE 3 SROB-CAP									
310 00 LF	27 24 /LF	8 444				-	1 33 /LF	412	8 857
020 REMOVE 8 PWF-CI									
40 00 LF	27 24 /LF	1 090				-	1 33 /LF	53	1 143
021 REMOVE 8' PW-CI									
30 00 LF	27 24 /LF	817				-	1 33 /LF	40	857
022 REMOVE 440V-E									
180 00 LF	27 24 /LF	4 903				-	1 33 /LF	239	5 143
023 REMOVE 440 V E									
620 00 LF	27 24 /LF	16 889				-	1 33 /LF	825	17 713
024 REMOVE & RELOCATE 15 -SD-CMP									
520 00 LF	27 24 /LF	14 165					41 33 /LF	21 492	35 656
025 REMOVE/RELOCAT 440V-E									
320 00 LF	27 24 /LF	8 717				-	1 33 /LF	426	9 142
026 REMOVE/RELOCATE TELEPHONE									
350 00 LF	27 24 /LF	9 534					1 33 /LF	466	10 000
027 REMOVE @ 10' PW-PVC/6 PW-VCP									
290 00 LF	27 24 /LF	7 900					1 33 /LF	386	8 285

TAKEOFF QTY	<---- - - -LABOR- - - -> UNIT PRICE	AMOUNT	< - -----MATRL---------> UNIT PRICE	AMOUNT	<------SUB-----> AMOUNT	NAME	<----------EQUIP---------> UNIT PRICE	AMOUNT	TOTAL AMOUNT
028 REMOVE 3'SROB-CAP									
90 00 LF	27 24 /LF	2 452				-	1 33 /LF	120	2 571
029 REMOVE 3/4 E-PVC									
90 00 LF	27 24 /LF	2 452				-	1 33 /LF	120	2 571
031 GROUT 8" RW-CAP									
390 00 LF	46 98 /LF	18 322				-	11 08 /LF	4 321	22 643
032 REMOVE 12" OS-CMP									
50 00 LF	27 24 /LF	1 362				-	1 33 /LF	67	1 429
033 REMOVE 1-1/2" DCW-STL									
320 00 LF	27 24 /LF	8 717				-	1 33 /LF	426	9 142
034 REMOVE 3" SROP/3"ROPW-CAP									
140 00 LF	27 24 /LF	3 814				-	1 33 /LF	186	4 000
035 REMOVE 8 PW-CI									
20 00 LF	27 24 /LF	545				-	1 33 /LF	27	571
0030 GROUT 8 RW-CAP									
760 00 LF	46 98 /LF	35 705				-	11 08 /LF	8 421	44 126
0036 REMOVE 8'PW-CI									
50 00 LF	27 24 /LF	1 362					1 33 /LF	67	1 429
0037 DISPOSE OF UTILITIES									
6 730 00 LF	1 51 /LF	10 162				-	1 01 /LF	6 797	16 960
0038 CUT TRANSPORT & STORE PIPING									
6 730 00 LF	3 00 /LF	20 190							20 190
UTILITIES		465 676*						46 617*	512 293*
11000 000 INSTALL FINAL ENG COVER									
2 DELIVERY OF GRAVEL BASE									
7 367 00 CY			15 07 /CY	111 021					111 021
3 MOVE GRAVEL TO POND 207A									
7 367 00 CY	1 51 /CY	11 124				-	1 01 /CY	7 441	18 565
4 GRADE GRAVEL IN POND 207A									
43 720 00 SY	06 /SY	2 623					04 /SY	1 749	4 372
5 COMPACT LOWER BASE COURSE									
43 720 00 SY	04 /SY	1 749					03 /SY	1 312	3 060
6 DELIVERY OF ASPHALT CONCRETE									
44 400 00 SY			12 02 /SY	533 688					533 688
7 UNLOAD & DIST ASPHALT CONCRETE									
44 400 00 SY	1 51 /SY	67 044					1 01 /SY	44 844	111 888
8 DELIVERY OF SAND (DRAINAGE)									
15 192 00 CY			8 28 /CY	125 790					125 790
9 MOVE SAND FOR LOWER SAND LAYER									
15 192 00 CY	1 51 /CY	22 940				-	1 01 /CY	15 344	38 284
10 GRADE LOWER SAND LAYER									
90 160 00 SY	06 /SY	5 410				-	04 /SY	3 606	9 016
11 COMPACT LOWER SAND LAYER									
90 160 00 SY	04 /SY	3 606					06 /SY	5 410	9 016
12 DELIVERY OF ANGULAR RIPRAP									
23 485 00 CY			18 28 /CY	429 306					429 306
13 MOVE ANGULAR RIPRAP									
23 485 00 CY	1 51 /CY	35 462					1 01 /CY	23 720	59 182
14 GRADE ANGULAR RIPRAP									
92 916 00 SY	06 /SY	5 575					04 /SY	3 717	9 292
15 COMPACT ANGULAR RIPRAP									
92 916 00 SY	04 /SY	3 717					03 /SY	2 787	6 504
16 DELIVERY OF RIP RAP (2-4)									
16 365 00 CY			15 07 /CY	246 621					246 621
17 MOVE RIP RAP									

TAKEOFF QTY	LABOR UNIT PRICE	LABOR AMOUNT	MATRL UNIT PRICE	MATRL AMOUNT	SUB AMOUNT	SUB NAME	EQUIP UNIT PRICE	EQUIP AMOUNT	TOTAL AMOUNT
16 365 00 CY	1 51 /CY	24 711				-	1 01 /CY	16 529	41 240
18 GRADE RIP RAP (3 PASSES)									
145 678 00 SY	06 /SY	8 741				-	04 /SY	5 827	14 568
19 COMPACT RIP RAP									
145 678 00 SY	04 /SY	5 827				-	03 /SY	4 370	10 197
20 DELIVERY OF GRAVEL (FILTER)									
16 844 00 CY			18 28 /CY	307 908		-			307 908
21 MOVE GRAVEL									
16 844 00 CY	1 51 /CY	25 434				-	1 01 /CY	17 012	42 447
22 GRADE GRAVEL LAYER									
99 966 00 SY	06 /SY	5 998				-	04 /SY	3 999	9 997
23 COMPACT GRAVEL LAYER (2 PASS)									
99 966 00 SY	04 /SY	3 999				-	03 /SY	2 999	6 998
24 DELIVERY OF SAND (FILTER)									
17 331 00 CY			8 28 /CY	143 501		-			143 501
25 MOVE SAND FOR UPPER LAYER									
17 331 00 CY	1 51 /CY	26 170				-	1 01 /CY	17 504	43 674
26 GRADE UPPER SAND LAYER									
102 850 00 SY	06 /SY	6 171				-	04 /SY	4 114	10 285
27 COMPACT UPPER SAND LAYER									
102 850 00 SY	04 /SY	4 114				-	03 /SY	3 086	7 200
28 DELIVERY OF GENERAL BACKFILL									
46 429 00 CY			6 27 /CY	291 110		-			291 110
29 MOVE GENERAL BACKFILL									
46 429 00 CY	1 51 /CY	70 108				-	1 01 /CY	46 893	117 001
30 COMPACT BACKFILL (3 PASSES)									
165 327 00 SY	04 /SY	6 613				-	03 /SY	4 960	11 573
31 GRADE GENERAL BACKFILL									
165 327 00 SY	06 /SY	9 920				-	04 /SY	6 613	16 533
32 DEL OF TOPSOIL/GRAVEL ADMIX									
29 002 00 CY			19 03 /CY	551 908		-			551 908
33 MOVE TOPSOIL/GRAVEL ADMIX									
29 002 00 CY	1 51 /CY	43 793				-	1 01 /CY	29 292	73 085
34 GRADE TOPSOIL/GRAVEL ADMIX									
172 122 00 SY	06 /SY	10 327				-	04 /SY	6 885	17 212
35 DELIVERY OF PEA GRAVEL									
9 680 00 CY			15 50 /CY	150 040		-			150 040
36 MOVE PEA GRAVEL									
9 680 00 CY	1 51 /CY	14 617				-	1 01 /CY	9 777	24 394
37 GRADE PEA GRAVEL									
57 374 00 SY	06 /SY	3 442				-	04 /SY	2 295	5 737
INSTALL FINAL ENG C		429 235*		2 890 892*				292 084*	3 612 210*
12000 000 FINAL FILLS & SUBGRADES									
1 PLACE & GRADE HILLSIDE									
35 00 CY	9 42 /CY	330				-	6 30 /CY	221	550
2 PLACE & GRADE C POND									
6 700 00 CY	9 42 /CY	63 114				-	6 30 /CY	42 210	105 324
3 PLACE & GRADE BERMS/ROADS									
2 116 00 CY	9 42 /CY	19 933					6 30 /CY	13 331	33 264
4 PLACE & GRADE GRAVEL ROAD									
1 320 00 CY	9 42 /CY	12 434	15 07 /CY	19 892		-	6 30 /CY	8 316	40 643
5 PLACE & GRADE CMP-SLUDGE									
280 00 CY	9 42 /CY	2 638	15 07 /CY	4 220			6 30 /CY	1 764	8 621
6 PLACE & GRADE CMP-SOIL									
100 00 CY	9 42 /CY	942				-	6 30 /CY	630	1 572

TAKEOFF QTY	LABOR UNIT PRICE	LABOR AMOUNT	MATRL UNIT PRICE	MATRL AMOUNT	SUB AMOUNT	SUB NAME	EQUIP UNIT PRICE	EQUIP AMOUNT	TOTAL AMOUNT
7 PLACE & GRADE TOE DRAIN-SAND									
769 00 CY	9 42 /CY	7 244	8 28 /CY	6 367			6 30 /CY	4 845	18 456
8 PLACE & GRADE TOP SOIL									
9 277 00 CY	1 87 /CY	17 348	19 03 /CY	176 541		-	1 05 /CY	9 741	203 630
FINAL FILLS & SUBGRA		123 982*		207 021*				81 057*	412 060*
12500 000 EROSION PROTECTION									
1 2 COVER-RECLAIMED AREAS									
55 660 00 SY	1 57 /SY	87 386	46 /SY	25 604		-	1 05 /SY	58 443	171 433
2 LG RIP RAP @ CULVERTS									
410 00 CY	10 68 /CY	4 379	18 28 /CY	7 495		-	6 30 /CY	2 583	14 457
3 SM RIP RAP @ TOE DRAIN									
15 00 CY	10 68 /CY	160	18 28 /CY	274		-	6 30 /CY	95	529
4 CONCRETE INLETS									
6 00 EA	166 67 /EA	1 000	2 500 00 /EA	15 000		-			16 000
EROSION PROTECTION		92 925*		48 373*				61 121*	202 418*
12700 000 SEEDING									
1 ALL AREAS									
23 50 AC						-	2 500 00 /AC	58 750	58 750
2 BARB WIRE PERIMETER FENCE									
1 700 00 LF	8 51 /LF	14 467	5 67 /LF	9 639		-			24 106
SEEDING		14 467*		9 639*				58 750*	82 856*
13000 000 REMOVE EQUIPMENT DECON									
0111 REMOVE EQUIPMENT DECON WASH									
1 00 LS	15 000 00 /LS	15 000				-			15 000
REMOVE EQUIPMENT DEC		15 000*							15 000*
14000 000 OFF-SITE DISPOSAL									
0057 OFF -SITE DISPOSAL									
1 00 LS						-	183 620 00 /LS	183 620	183 620
OFF SITE DISPOSAL								183 620*	183 620*
15000 000 FINAL SITE SURVEY BY HPT									
0112 FINAL SITE SURVEY									
160 00 MH	80 00 /MH	12 800				-			12 800
FINAL SITE SURVEY BY		12 800*							12 800*
			Labor hrs		160 00		Equip hrs	160 00	
16000 000 BLDG 788 DEMO/REM									
0002 788 MANAGEMENT									
1 320 00 MH	77 27 /MH	101 996				-			101 996
0003 788 CHARACTERIZATION									
368 00 MH	85 00 /MH	31 280				-			31 280
0004 788 CHARACTERIZATION									
1 00 LS			796 000 00 /LS	796 000		-	10 000 00 /LS	10 000	806 000
0005 INDIRECT FIELD COST									
2 200 00 MH	18 18 /MH	39 996				-			39 996
0006 INDIRECT FIELD COST									
1 00 LS			15 000 00 /LS	15 000					15 000
0007 BUILDING 788									
2 180 00 MH	81 65 /MH	177 997				-			177 997
0008 BUILDING 788									
1 00 LS			183 272 00 /LS	183 272		-			183 272
0009 UNIT 48									

```
                 <-- -  ----LABOR------- -> < ---------MATRL---------> <------SUB- - -> <----- ----EQUIP----- ---->        TOTAL
  TAKEOFF QTY      UNIT PRICE          AMOUNT   UNIT PRICE          AMOUNT   AMOUNT    NAME   UNIT PRICE          AMOUNT        AMOUNT

     3 000 00  MH       24 67 /MH      74 010                                        -                                          74 010
  0010 UNIT 48
         1 00  LS                                25 000 00 /LS      25 000          -         10 000 00 /LS      10 000       35 000
        BLDG  788 DEMO/REM             425 279*                  1 019 272*                                      20 000*  1 464 551*
                                                          Labor hrs       9 068 00      Equip hrs        9 068 00

17000 000  PARTIAL DECON UNDER CAP
     1 BUILDING 964 DEMO/REMOVAL
           00  LS                                                                      -                                            0
     2 964 MANAGEMENT
      1 440 00  MH       77 27 /MH     111 269                                                                                 111 269
     3 964 CHARACTERIZATION
        240 00  MH       85 00 /MH      20 400                                                                                  20 400
     4 964 CHARACTERIZATION (LAB SAM)
         1 00  LS                               702 000 00 /LS     702 000          -         10 000 00 /LS      10 000      712 000
     5 964 INDIRECT FIELD COSTS
      1 520 00  MH       18 18 /MH      27 634                                        -                                          27 634
     6 964 INDIRECT FIELD COSTS
         1 00  LS                                15 000 00 /LS      15 000                                                      15 000
     7 BLDG 964 DEMO
      2 250 00  MH       81 65 /MH     183 713                                        -                                         183 713
       PARTIAL DECON UNDER             343 015*                   717 000*                                      10 000*  1 070 015*
                                                          Labor hrs       5 450 00      Equip hrs        5 450 00

18000 000  TRAINING
  0001 TRAINING
      2 400 00  MH       25 00 /MH      60 000                                        -                                          60 000
                  TRAINING              60 000*                                                                                  60 000*
                                                          Labor hrs       2 400 00      Equip hrs        2 400 00

19000 000  POSTCLOSURE (MONITORING)
  0001 POSTCLOSURE MONITORING SYSTEM
         1 00  LS                                                                      -       1257 805 00 /LS  1 257 805   1 257 805
       POSTCLOSURE (MONITOR                                                                                    1 257 805*  1 257 805*
                    1 000 LS     1 257 805 000/LS

      - - ------  --- ------ ---------- - ------------------ ------------ ----- -- ---- ------------------------------- --- -
      SPEC  CONDITIONS              7 203 476                  5 494 991                                      50 413 081  63 111 548
                                                          Labor hrs      73 482 00      Equip hrs       73 482 00
      -  --  - -  -------- --- ------      - --- - --- - - ------------------- -- ----------  ------------------- ------ -
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ESTIMATE TOTALS

	7 203 476	Labor	73 482 00	hrs	
	5 494 991	Material			
	50 413 081	Equipment	73 482 00	hrs	
63 111 548					
	3 529 703	BLDG FACTOR (49%)		C	49 00000%
	2 500 000	ENGINEERING COSTS		L	
	164 850	SMALL TOOLS & CONSUMABLES		C	3 00000%
	1 314 693	PROJECT MANAGEMENT (6%)		L	
	5 039 656	CONTRACTOR CONSTRUCTION MGMT		L	
	3 724 963	CONSTRUCTION MNGMT (17%)		L	
	2 629 386	CONTRACTOR G&A		L	
	18 903 251				
82 014 799					
	1 095 577	ESCALATION		L	
	1 095 577				
83 110 376					
	340 000	A/E EG&G SUPPORT		L	
	1 314 693	EG&G FACILITY INSPECTIONS		L	
	657 346	EG&G PROCUREMENT RECOVERY 3%		L	
	2 355 491	EG&G G&A 10 75%		L	
	761 908	EG&G PROJ MNGMT 6% OF CONST		L	
	3 286 732	EG&G CONST MNGMT 15% CNST MNGM		L	
	432 209	EG&G PROJ MNGMT - RAD MONITOR		L	
	441 242	EG&G CONST MARK-UPS MATL TAX		L	
	9 589 621				
92 699 997					
	15 089 000	CONTINGENCY		L	
107 788 997	TOTAL ESTIMATE				

QUALITY CONTROL PROCEDURES

Department of Energy (DOE)

The DOE will be responsible for implementation of construction activities and control of the project The DOE will conduct audits of the QA/QC testing activities and has the ultimate authority to approve QA/QC tests

Construction Manager (CM)

The CM will be responsible for overseeing and supervising construction activities The CM will also provide verification and acceptance to the contractor regarding QA/QC tests and procedures The QA/QC tests will be submitted to the DOE by the CM The CM is also responsible for responding to the concerns of the contractor, QA/QC manager, and the design engineer, if retained The CM will also be responsible for documentation of all inspections, identification of required corrective actions, and documentation of completed corrective actions

Contractor

The contractor will be responsible for performing the construction activities in accordance with engineering specifications The construction contractors are directly responsible for performance of QC activities, as required in their contracts, and report to the CM A third party contractor will perform the QC activities Therefore, the QC testing will not be performed by either the construction manager's organization or the construction contractor's organization The QC contractor will provide reports to the construction contractor The construction contractors will forward copies of inspection reports to the CM for each category of work performed (earthwork, drilling, sampling, etc) and a summary of all corrective actions and deviations to ensure the adequacy of the QC effort

Quality Control Inspection Methods and Testing Procedures

QC inspection methods and testing procedures associated with the OU4 remediation activities are described in the following paragraphs by construction activity The construction activities are as follows

- Site preparation,
  Excavation of contaminated soil media,
  Backfilling of excavations,
  Crushing of liners from SEPs,
  Placement of engineered cover components,
  Closure of existing underground utilities,
- Rerouting of existing underground utilities,
  Borehole advancement,

- Recordkeeping during well development, and
- Closure certification

Site Preparation

The site shall initially be cleared of vegetation, rocks, rubbish, and all other perishable and detrimental matter Adequacy of the site preparation procedures will be determined by visual inspection by the contractor After the SEPS are closed and areas with surface elevations higher than the grade shown on the construction drawings as determined by surveying are identified, the areas shall be graded and excavated as necessary to the required grade

The Contractor shall have full responsibility for the direction of the work and arranging for inspection of the work in progress and coordination of any inspection agency or surveillance to ensure conformance with standards and specifications

Excavation of Contaminated Soil Media

Excavation activities will be performed to consolidate the OU4 liners and contaminated media within the engineered cover

Excavation shall meet alignments, grades, dimensions, and shapes shown on the construction drawings

A sufficient number of monuments and benchmarks will be established for overall horizontal and vertical control The surveyors shall provide initial layout, concurrent inspection, and final checkout to ensure that all work performed conforms to lines, grades, cross sections and details indicated on construction drawings.

Approval of the contaminated soil media from the excavation areas and from the SEPs is the responsibility of the contractor and will be documented in a written report.

The contractor shall have full responsibility for the direction of the work, for arranging for inspection of the work in progress, and for coordination with any inspection agency or surveillance to ensure conformance with standards and specifications

Backfilling Excavations

Excavated areas that will not be beneath an engineered cover will be backfilled with clean native soils The backfilled areas will be regraded and seeded

Prior to field activities, all soils to be used as backfill will be tested to determine maximum dry density and optimum moisture content Testing services shall be provided by an

independent testing laboratory Backfill testing methods and QC verification checks for density and moisture content shall be conducted according to the following table

Field Placement Testing Methods and Frequencies

Material Type	Test Method	Frequency[1]
A Topsoil/Gravel Admix		
Topsoil	pH (SW 846 Method 9045) Gradation (ASTM D422) TOC (9060 modified) Atterberg Limits (ASTM D4318) Number of Passes[2]	1 Test per 5000 CY^3 1 Test per 5000 CY^3 1 Test per 5000 CY^3 1 Test per 5000 CY^3 1/acre/lift
Gravel	Gradation (ASTM D422) LA Abrasion (ASTM C131) Classification (ASTM D2487) Number of Passes	1 Test per 5000 CY^3 1 Test per 10000 CY^3 1 Test per 5000 CY^3 1/acre/lift
B General Backfill	Gradation (ASTM D422) Atterberg Limits (ASTM D4318) Classification (ASTM D2487) Total Density (ASTM D2922) Water Content (ASTM D3017)	1 Test per 5000 CY^3 1 Test per 5000 CY^3 1 Test per 5000 CY^3 5/acre/lift 5/acre/lift
C Filter Sand	Gradation (ASTM D422) Number of Passes	1 Test per 5000 CY^3 1/acre/lift
D Filter Sand/Gravel	Gradation (ASTM D422) Number of Passes	1 Test per 5000 CY^3 1/acre/lift
E Upper Riprap Layer	Gradation (ASTM C136) Aggregate Soundness (ASTM C88)	1 Test per 5000 CY^3 1/acre/lift
F Lower Riprap Layer	Gradation (ASTM C136) Aggregate Soundness ASTM C88)	1 Test per 5000 CY^3 1 Test per 10000 CY^3
G Cushion Sand	Gradation (ASTM D422) Classification (ASTM D2487)	1 Test per 5000 CY^3 1 Test per 5000 CY^3
H Gravel Base Course	Gradation (ASTM D422) Atterberg Limits (ASTM D4318) L A Abrasion (ASTM C131) Aggregate Soundness (ASTM C88) Total Density (ASTM D2922) Water Content (ASTM D3017)	1 Test per 5000 CY^3 1 Test per 5000 CY^3 1 Test per 10000 CY^3 1 test per 10000 CY^3 5/acre/lift[5] 5/acre/lift[6]
I Buried Contaminated Media	Gradation (ASTM D422) Total Density (ASTM D2922) Water Content (ASTM D3017)	1 Test per 5000 CY^3 5/acre/lift[5] 5/acre/lift[6]

J Subsurface Filter Sands	Gradation (ASTM D422) Classification (ASTM D2487)	1 Test per 5000 CY^3 1 Test per 5000 CY^3
K Subsurface Drain Gravel	Gradation (ASTM D422) Classification (ASTM D2487) Aggregate Soundness (ASTM C88) Hydr Conductivity (ASTM D2434)	1 Test per 2500 CY^3 1 Test per 2500 CY^3 1 Test per 5000 CY^3 1 Test per 2500 CY^3

1 Initial tests will begin prior to construction operations
2 Number of Passes Test Method refers to the required documented passes performed by the Subcontractor
3 Frequency refers to the minimum number of tests required for the Test Method
4 Grab samples will be taken from the lift materials for each test
5 Quality Control checks for density will be conducted for 1 of every 20 nuclear methods by the sand Cone Method (ASTM D1556)
6 Quality Control checks for moisture content will be conducted for 1 of every 10 Nuclear Methods (shallow depth) by Direct Water Content Measurements (ASTM D2216)

The Subcontractor shall be responsible for documenting all test results and the number of passes completed per lift Placed materials not in accordance with the requirements of specifications shall be repaired and/or replaced by the Subcontractor. The Subcontractor shall submit a description of repair and/or replacement methods to the Contractor for approval before implementation Acceptance criteria for repaired and/or replaced materials shall be in accordance with the original requirements of the specification

Areas that do not conform with the specifications will first be investigated for the extent of the non-conformance Areas that are a different material type or have failed the specifications more than once shall be tested regardless of the testing frequency guidelines. The contractor retains the right to determine when additional testing will be required A One-Point Proctor, Atterberg Limit, and Gradation test shall be performed by the Subcontractor and the results shall be submitted to the Contractor Following review of the testing results, the Contractor will determine whether a new moisture-density relationship curve will be developed or if the Subcontractor will rework the non-conforming areas to meet specifications. If a new Compaction Curve is produced for a change in soil type, all tests outlines in the previous table shall be conducted for the new material type

Final acceptance shall be explicitly detailed by survey location, layer description, material type, and lift number

The laboratory proctor tests, in-place nuclear gauge testing, and sand-cone testing, shall be documented by a third party laboratory with certified independent laboratory test reports and submitted to the contractor, who will in turn submit them to the CM for verification and acceptance

The Contractor shall have full responsibility for the direction of the work, for arranging for inspection of the work in progress, and for coordination of any inspection agency or surveillance to ensure conformance with standards and specifications

Crushing and Excavation of Liners from SEPs

The liners from SEPs 207-A, 207-C, and the 207-B series SEPs will be crushed and excavated prior to placement beneath the engineered cover

Visual observations shall be made to ensure the material that is placed in the engineered cover as backfill has passed the crushing criteria in accordance with engineering specifications

Approval of activities to crush the liners from the SEPs is the responsibility of the Contractor and will be documented in a written report

The Contractor shall have full responsibility for the direction of the work, for arranging for inspection of the work in progress, and for coordination of any surveying services, inspection agency, or surveillance to ensure conformance with standards and specifications

Placement of Sludge and Pondcrete

SEP sludge and pondcrete will be treated for placement beneath the final engineered cones Testing and observations shall be performed to ensure the sludge and pondcrete are in accordance with the waste acceptance criteria

Placement of Materials for the Engineered Cover

Offsite materials will be procured for the construction of the engineered cover

The following in-process tests may be required

A sufficient number of monuments and benchmarks will be established for overall horizontal and vertical control The surveyors shall provide initial layout, concurrent inspection, and final checkout to ensure that all work performed conforms to lines, grades, cross sections and details indicated on construction drawings

The in-process tests shall be documented with certified independent third-party laboratory test reports and submitted to the Contractor, who in turn shall submit them to the CM for verification and acceptance All tests shall be dated and signed by the person performing the tests Daily reports, including a record of all in-process inspections and tests performed, should be maintained

The contractor shall have full responsibility for direction of the work, for arranging for surveying and other services, including inspection of work in progress and coordination of any inspection agency to ensure conformance to project requirements

Closure of Existing Underground Utilities

Some of the underground utilities in and around the OU4 SEPs that are not necessary for future activities at the RFP will be closed in-place These utilities may be excavated and removed or filled with a Portland cement-type grout for permanent closure Another alternative for permanent closure includes capping the ends of the pipe with a material consistent with the pipe material

The capping requirements include visual observation of capping activities to ensure that specifications are met The valve boxes should be visually inspected to ensure that the control handles have been removed and that the shafts have been welded in the closed position The valve boxes should be filled with grout according to specifications.

The underground utilities requiring grouting should also be visually inspected The volume of grout required to fill the piping system should be closely monitored The volume should not exceed 20 percent of the expected volume required to fill the pipe. Any exceedence may indicate that the pipe is broken or cracked

QC testing for grout will be performed according to design specifications The in-process tests shall be documented with certified independent third-party laboratory test reports and submitted to the contractor, who in turn shall submit them to the CM for verification and acceptance. All tests shall be dated and signed by the person performing the tests. Daily reports of all in-process inspections and tests performed should be maintained Tests and inspections will be documented

The contractor shall have full responsibility for direction of the work, for arranging for surveying and other services, including inspection of work in progress and coordination of any inspection agency to ensure conformance with project requirements.

Rerouting of Existing Underground Utilities

Some of the underground utilities in and around the OU4 SEPs are necessary for future activities at the RFP These utilities include domestic cold-water, raw-water, storm drains, telephone service, and electrical power The utilities will be rerouted around the perimeter of the engineered covers Utility piping requiring rerouting will be excavated in sections or cut for easier removal

All new piping shall be inspected by the Contractor for obvious defects by the Contractor upon delivery to the site Piping shall then be assembled by the Contractor in accordance with the design specifications All installed domestic cold-water and raw-water piping shall be

hydrostatically and/or pneumatically pressure-tested by the contractor according to design specifications

Borehole Advancement

A log of each boring shall be prepared by the Contractor's onsite geologist which notes lithologies encountered and other pertinent information The geologic boring log completed by the geologist shall include the following information, at a minimum

- Depth,
- Profile,
- Unified Soil Classification Systems (USCS) soil classification,
- Geologic description (including color, grain size, moisture, plasticity, fractures, joints, and local formation name, if known),
- Drill pressure/blow counts,
- Remarks (includes photoionization detector measures, water table information, weather, and any pertinent comments regarding drilling),
- Drilling machinery, and
  Equipment decontamination procedures

After a day of drilling is completed, the contractor's geologist will review his/her logs for completeness and consistency, and will revise them as necessary Changes will be made by crossing out the error with one line and writing in the correction along with the author's initials and the date Field logs shall be typed for readability in reports, and shall accompany the typed geologic log, without exception A Contractor oversight-geologist will ensure that these procedures are followed

Monitoring well/piezometer construction will be observed by the contractor's geologist to ensure adherence to the QA/QC plan and the project design specifications In addition to the data recorded on the geologic boring log for completion of soil borings, the following information will be recorded on the boring log

- Well material decontamination procedures,
- Total depth of completed well, and
  Depth to water table after sufficient time has elapsed to allow for water table stabilization

Recordkeeping During Well Development

The following information shall be recorded by the Contractor in a bound, sequentially paginated field book during development of each monitoring well

  Date,
- Time,

- Well number and location;
- Depth of well,
- Depth to water table before development begins,
- Depth to top of screen,
- Development method, rate of water removal, and total volume removed,
- Temperature, pH, and specific conductance measured for the initial ground water sample and for subsequent sampling,
- Documentation of field instrument calibrations;
- Physical appearance of the water removed during development and photograph identification, and
- Signatures of those performing this work

Proper recordkeeping shall document the effectiveness of the well construction and the adequacy of development. The contractor will check the contractor's logs for completeness The recorded information will be turned over to the CM upon completion

Closure Certification

Within 60 days after the completion of closure, the owner of operator must submit a certification that the SEPs have been closed in accordance with the specifications in the approved closure plan

A professional engineer (P E.) will be responsible for overseeing the closure activities to ensure that they comply with the approved decision document. The P E shall have full responsibility for maintaining a field log documenting observations. These field observations will be summarized in a closure report

Quality Assurance

Attachment 1 provides a quality assurance outline which specifies the 18 required aspects of the RFP quality assurance program

ATTACHMENT 1 TO APPENDIX F

QUALITY ASSURANCE PROCEDURES

1 0 Organization and Responsibilities

- Purpose

  This procedure will define the functional and administrative organizations, associated responsibilities, and lines of communication required for the control of activities affecting quality

- Scope

  This procedure will apply to all programs, project activities, and operations

- Requirements

  The quality assurance (QA) organizational structure, functional responsibilities, levels of authority, and lines of control will be documented and controlled

2 0 Quality Assurance Program

- Purpose

  This procedure will define the actions and responsibilities necessary for implementation and maintenance of the QA program

- Scope

  This procedure will apply to all activities affecting quality, and to all participants in programs or projects

- Requirements

  A documented QA program will be planned, implemented, and maintained in accordance with RFP procedures

3.0 Construction Control

- Purpose

This procedure will establish the responsibilities and actions required to assure the implementation of QA requirements and controls on construction activities

- Scope

This procedure will apply to all construction activities conducted in support of operations

- Requirements

The responsible design organization shall ensure that construction activities are defined, controlled, and verified, and that:

(a) Applicable design inputs are appropriately specified on a timely basis and correctly translated into design documents;
(b) Design interfaces are identified and controlled,
(c) Design adequacy is verified by persons other than those who designed the item, and
(d) Design changes, including field changes, are governed by control measures equal to those applied to the original design

4.0 Control of Procurement Documentation

- Purpose

This procedure will define the actions and responsibilities for preparing and controlling documents implemented for the procurement of items and services purchased for activities.

- Scope

This procedure will apply to the procurement of all items and services used in the performance of activities

- Requirements

Requirements necessary to ensure the required quality shall be included or invoked on documents (purchase requisitions, Statement of Work, purchase orders, and specifications) developed for the purchase of items or services In addition,

measures shall be established to ensure that purchased items or services conform to procurement document requirements

5 0 Instructions, Procedures, and Drawings

- Purpose

  This procedure will define the actions necessary for ensuring that design, procurement, environment investigation, construction, maintenance, operation, and other activities are performed in accordance with approved instructions, procedures, and drawings

- Scope

  This procedure will apply to activities requiring a high degree of confidence that the item or service meets requirements and is satisfactory to the customer, and where thoroughness, accuracy, and precision are essential for performance

- Requirements

  Instructions, procedures, and drawings shall be prepared, approved, and controlled to ensure that all operations and services are performed and controlled within specific guidelines and in accordance with appropriate regulatory requirements

6.0 Document Control

- Purpose

  This procedure will define the actions and responsibilities required to control documents that specify quality requirements, document the achievement of quality, or prescribe activities affecting quality, and to ensure that applicable documents are available at locations where they are to be used

- Scope

  This procedure will apply to organizations responsible for the control of the identification, classification, preparation, review and approval, revision, maintenance, and distribution of documents and records that furnish evidence of quality Document control includes the actions necessary to ensure that accurate and current documents are available at the worksite and used by those performing activities affecting quality

- Requirements

  Documents that specify quality requirements or prescribe activities affecting quality shall be controlled to ensure that correct documents are being employed Control includes identification, preparation, issue, change, maintenance, review, approval by authorized personnel, and release for use.

7 0 Control of Purchased Items and Services

- Purpose

  This procedure will define the QA actions and responsibilities necessary for procuring items and services through the procurement system, and also will define interfacing technical activities.

- Scope

  This procedure will apply to the procurement of standard and special items and services used in the performance of activities

- Requirements

  Requirements necessary to control the procurement of items or services shall be invoked to ensure conformance to specified requirements At a minimum, procurement of items and services affecting quality shall be controlled Control shall provide for source evaluation and selection, evaluation of objective evidence of quality furnished by the supplier, and examination of items or services upon delivery or completion

8.0 Identification and Control of Items

- Purpose

  This procedure will define the actions and responsibilities required to ensure that only correct and accepted items are used, analyzed, installed, transferred, stored, or placed into service

- Scope

  This procedure will apply to all items acquired, provided, or generated in support of operations and activities

- Requirements

  Controls shall be established and implemented to ensure that only correct and accepted items are analyzed, used, or installed at any stage from initial collection or receipt through final stage

9 0 Special Process Control

- Purpose

  This procedure will define the actions and responsibilities required to ensure that special processes are identified and that they are performed by qualified personnel in accordance with specified requirements

- Scope

  This procedure will apply to all special processes (e g , welding, environmental sampling, well drilling, and construction, laboratory analysis, and nondestructive examination)

- Requirements

  Processes that affect quality shall be controlled The level of control shall be commensurate with the nature of the process and its relationship to the whole of the activity Performance shall be by qualified personnel using controlled procedures, and control shall be in accordance with specified requirements

10 0 Inspections

- Purpose

  This procedure will define the requirements and actions necessary for planning, executing, and reporting inspections conducted to verify that items, services, or activities conform to specified requirements

  Scope

  This procedure will apply to all activities where a high degree of confidence is required to ensure that the item, activity, or service will meet specified requirements

- Requirements

  Inspection activities required to verify conformance of an item or activity to specified requirements shall be planned, executed, and documented

11.0 Test Control

- Purpose

  This procedure will define the actions and responsibilities required to plan, accomplish, and evaluate tests that verify conformance of items, services, and operations to specified requirements

- Scope

  This procedure will apply to all test activities performed on items, services, materials, and analyses used in the conduct of design, construction, environmental investigation, environmental remediation, and waste management activities

- Requirements

  Tests required to verify conformance of an item or service to specified requirements and to demonstrate that items will perform satisfactorily in service shall be planned and executed. Characteristics to be tested and test methods to be employed shall be specified Test results shall be documented and their conformance with acceptance criteria shall be evaluated. Tests required to collect data shall be planned, executed, documented, and evaluated

12.0 Control of Measuring and Testing Equipment

- Purpose

  This procedure will define the requirements for control and calibration of Measuring and Testing Equipment (M&TE)

- Scope

  This procedure will apply to M&TE used in activities where quality must be assured (e g , field sampling, laboratory analysis, fabrication, construction, installation, testing, inspection, and operation and maintenance of activities and facilities) M&TE includes working (installed and portable) devices or systems and standards used for calibration of devices or systems

Calibration and control measures are not required for rulers, tape measures, levels, and other such devices if normal commercial equipment provides adequate accuracy

- Requirements

M&TE used to measure controlled characteristics of items affecting quality, safety, or processes shall be of the proper type, range, accuracy, and tolerance M&TE shall be identified or maintained in a documented usage/calibration program

13 0 Handling, Storage, and Shipping

- Purpose

This procedure will describe the actions and responsibilities necessary for controlling the handling, storage, and shipping of items or materials to prevent damage or loss and to prevent the release of hazardous materials to the environment

- Scope

This procedure applies to all activities that require assurance that an item or material being handled, stored, or shipped is protected from damage or loss and from accidental release of contaminants into the environment

- Requirements

Measures shall be established for the control of samples, waste, materials, and equipment to ensure protection from loss, deterioration, and physical damage and to ensure containment integrity during handling, storage, and shipping Activities associated with handling, storage, and shipping shall be conducted in accordance with approved instructions, procedures, and drawings

14 0 Inspection, Test, and Operating Status

- Purpose

This procedure will define the actions and responsibilities for determining and identifying the operational status of items or systems and for ensuring that they are not inadvertently installed, used, or operated

- Scope

  This procedure will apply to all activities where knowledge of the operating status of equipment or systems is required to prevent the inadvertent use of those items or systems

- Requirements

  The status or results of inspection and test activities shall be identified either on items or in documents traceable to the items to ensure that required inspections and tests are performed and that items that have not passed the necessary inspections or tests are not inadvertently installed, used, or operated.

15.0 Nonconformance Control

- Purpose

  This procedure will define the actions and responsibilities necessary to identify and control (i e , segregate, dispose, and report) nonconforming items, activities, or services performed, fabricated, or purchased

- Scope

  This procedure will apply to all items, services, or activities performed, used, fabricated, or purchased that do not conform to specifications.

- Requirements

  Procedures shall be developed and implemented to control items, services, or activities that do not conform to requirements and specifications to prevent their inadvertent installation and use These measures shall include appropriate requirements and controls for the identification, documentation, segregation, and disposition of nonconforming items and notification to affected organizations.

16.0 Corrective Action

- Purpose

  This procedure will define the actions necessary to initiate, evaluate, track, and verify completion of corrective actions implemented to prevent recurrence of conditions adverse to quality

- Scope

  This procedure will apply to all corrective actions initiated for nonconformance which occur during the conduct of activities and projects

- Requirements

  Corrective actions shall be taken to prevent recurrence of conditions adverse to quality The corrective action shall be documented and reported to appropriate levels of management and follow-up action shall be taken to verify implementation of the corrective action(s) When necessary, investigations will be undertaken to determine the root cause(s), to evaluate QA measures taken to mitigate causes, and to define appropriate technical and corrective actions and follow-up

17 0 Quality Assurance and Project Records

- Purpose

  The purpose of the procedure will be to describe the actions and responsibilities necessary for the identification, control, storage, disposition, and retrieval of quality-related records and documents

- Scope

  This procedure will apply to the management of quality-related records generated, acquired, or used by personnel, subsidiaries, or subcontractors in the performance of their job activities For the purpose of this procedure, the term "Record" refers to documents, instructions, procedures, drawings, and project record files

- Requirements

  Records furnishing documentary evidence of quality shall be maintained and the requirements for record transmittal, distribution, storage, retention, maintenance, and disposition shall be established and documented

18 0 Conduct of Audits

- Purpose

  This procedure will define the requirements and actions necessary for planning, conducting, and reporting QA Audits

- Scope

This procedure will apply to internal and external audit activities conducted to verify and evaluate the adequacy of the application of QA requirements and controls to projects, operations, or other activities performed

- Requirements

Planned and scheduled audits shall be performed to verify compliance with all aspects of the QA program and to determine its effectiveness. These audits shall be performed in accordance with written procedures or checklists by qualified personnel who do not have direct responsibility for performing the activities being audited Audit results shall be documented to responsible management. Follow-up action shall be taken when indicated to provide the necessary corrective action required to eliminate the cause of the problem area and to verify the corrective action adequacy

APPENDIX IV.G

SAMPLING AND ANALYSIS PLAN FOR VERIFICATION OF RECLAIMED AREAS

SECTION 1

INTRODUCTION

1.1 INTRODUCTION

The preferred remedial alternative for OU4 is the consolidation of contaminated soils, liners, sludge, pondcrete, and debris within the proposed OU4 CAMU This consolidation will provide an efficient means of managing the remediation wastes while minimizing the areal extent of the final engineered cover The purpose of this sampling and analysis plan (SAP) is to obtain the analytical information to

1) Direct soil excavation activities,
2) Verify soil outside of the engineering cover has been remediated to acceptable PRGs, and
3) Characterize collected storm water for discharge

The SAP is divided into the following subsections

- Section 2 Soil Sampling and Analysis

  This subsection describes the sampling approach, sampling locations, sampling parameters, sample collection procedures, analysis, and investigative derived waste

- Section 3 Storm Water Sampling and Analysis

  This subsection discusses the storm water management approach, sample location, parameters, collection requirements, analysis procedures, and investigative derived waste

- Section 4 Quality Assurance and Quality Control

  This section identifies the QA/QC requirements

- Section 5 References

SECTION 2

SOIL SAMPLING AND ANALYSIS

2.1 EXCAVATION/CONSOLIDATION APPROACH

There are four areas of excavation associated with remediation activities at OU4 These areas, as identified in Figure IV G-1, are divided into three remediation zones and IHSS 176 The following paragraphs summarize the excavation activities for each area

The soils under the Solar Evaporation Ponds (SEP), **Zone A**, will be excavated down to the mean seasonal high ground water elevation This excavation activity will generate approximately 129,200 cubic yards of soil No soil samples will be collected from Zone A since all the excavated soils will be consolidated beneath the engineered cover Furthermore, the removal of all soils down to the mean seasonal high GW elevation from the 207-C pond area will constitute the clean closure of this SEP

The hillside, **Zone B**, just north of the SEPs will under go remediation activities through initially excavating 6 inches of surface soil The removal of the surface soil contamination is expected to generate approximately 3,100 cubic yards of soil for consolidation beneath the engineered cover Additional excavation activity within the Zone B area will be based on analytical results Excavation will continue to remove soil areas exceeding vadose zone PRGs Once confirmation sampling activities are complete, final backfilling, grading, and vegetating shall commence

The Buffer Zone, **Zone C**, will have 6 inches of soil removed generating approximately 5,400 cubic yards of soil for consolidation beneath the engineered cover Upon completion of the initial excavation activities, wide spread soil samples will be collected throughout Zone C However, excavation will not extend deeper than six inches to prevent damage to the ITS even if vadose zone PRGs are exceeded Upon completion of sampling activities, final backfilling, grading, and vegetating shall commence The sampling data will be compiled and utilized by the Phase II RFI/RI team during the assessment of the area as well as determining the effectiveness of the ITS system The sampling data will aid in determining what impacts any soil contamination will have on the ground water, directing any additional Phase II RFI/RI sampling requirements, and identifying any potential future remediation activities

The contractor storage yard, **IHSS 176**, located east of the SEPs will be partially covered by the engineered cover as depicted in Figure IV G-1 The soils beneath the engineered cover will be excavated down to the mean seasonal high ground water elevation to install the subsurface drainage system The remaining area will initially have 6 inches of soil removed This will equate to approximately 1,000 cubic yards of soil for consolidation beneath the engineered cover Excavation will continue to remove soil areas exceeding vadose zone PRGs Once confirmation sampling activities are complete, final backfilling, grading, and vegetating shall commence

2.2 SAMPLING APPROACH

Sampling will be accomplished through the collection of composite samples which will represent the actual exposure risks associated with the OU4 vadose zone Contaminants of Concern (COCs) Once the initial layer of soil has been excavated (approximately 6"), a composite sample will be collected from six contiguous grid points The sample will be screened with a portable G-M detector count rate meter The meter will be utilized in determining sample package handling requirements as well as identifying samples with radiological contamination above background levels The verification composite samples will be collected and analyzed for the zadose zone COCs identified in Section 2 5, Sampling Parameters If the G-M reading indicates that the vadose zone PRGs are likely to be exceeded, verification analysis will not be conducted until further excavation is conducted to remove and consolidate the suspected contamination

2.3 SAMPLING LOCATIONS

A grid for the four primary areas for excavation, as identified on Figure IV G-1, will be establishing in accordance with RFETS OPS GT 17, Land Surveying The grid will facilitate the systematic selection of sampling locations, provide a reference for coordinating excavation activities, and allow the relocation of the composite sampling group in the event that the analytical results indicate COC concentrations that are in excess of the PRGs A systematic 10-meter by 10-meter grid has been selected as the basis for determining sample locations The 10 -meter interval was used to be consistent with the remediation requirements identified in 40 CFR 192 12 for uranium mill tailing sites Although the standards specified in this regulation are for radium contamination, this grid spacing has been adopted by the NRC as the standard for site decommissioning projects (NRC 1992a) This grid spacing is being incorporated for OU4

The grid will be set up on an x-y axis with the x-axis of the grid representing the east-west orientation and the y-axis representing north-south The 10-meter intervals are lettered along the x-axis and numbered along the y-axis The combination of letters and numbers will eliminate the potential for transposing the x and y coordinates The grid will be referenced to the Rocky Flats Environmental Technology Site (RFETS) coordinate system at the origin (AA,50)

2.4 SAMPLING PARAMETERS

The vadose zone soil PRGs are being utilized as the cleanup targets for OU4 based on the initial excavation of approximately 6 inches of soil Based on the sampling information contained in the Phase I RFI/RI, the surficial soil contains the majority of the contaminants With the removal and replacement of contaminated surface soils with clean backfill, the remediation of OU4 will be accomplished when the vadose zone PRGs are attained The Phase I RFI/RI results were also evaluated with respect to remediation area to determine whether or not remediation are specific-COC subsets could be identified The COC subsets are presented in Table IV G-1 These subsets were derived from identifying the zone specific COCs from Part

IV Figures IV C-1 through IV C-5 This subset was then compared against the vadose zone COCs identified in Part III Table III 2-3, Summary of COCs Based on Risk Analysis, to establish the final subsets The "X's" indicate the COCs that will be analyzed for the verification samples collected within the respective remediation areas

Table IV.G-1

Remediation Area Specific COCs

Contaminant of Concern	Zone A[a]	Zone B	Zone C	IHSS 176
Cadmium	N/A	X	X	N/A
Americium-241	N/A	X	N/A	N/A
Plutonium-239/240	N/A	X	N/A	N/A
Uranium-233/234	N/A	X	N/A	N/A
Uranium-235	N/A	X	X	N/A
Uranium-238	N/A	X	X	N/A
Radium-226	N/A	X	N/A	N/A
Lead	N/A	N/A	N/A	X

[a] As a result of all the soils in Zone A being excavated down to the mean seasonal high water elevation, all the COCs will be removed thus resulting in the clean closure SEP 207-C

In order to verify that the analytical results are less than the PRGs, the detection limit shall be a minimum of 25 percent of the PRG For the purpose of this plan, the minimum detection limits are based on the PRGs Lower detection limits will be used to the extent practicable since lower detection limits provide more flexibility to average and statistically evaluate the results to verify that the PRGs have been obtained Table IV G-1 identifies the vadose zone COCs which exceed the PRGs, the associated PRGs, detection limits, and the analytical method This COC list will be utilized for identifying potential field screening techniques, focusing laboratory analytical sampling procedures, and expediting remediation activities Analytical methodologies and their corresponding detection limits were selected, as applicable, in accordance with the GRRASP (EG&G 1991)

Since all the verification analytical results will need to be defensible, a high quality assurance level shall be required throughout program As such, all verification samples are considered critical and the analyses will be conducted at either QA level 4 or QA level 5 The verification sampling results will be utilized in demonstrating compliance with PRGs If the results indicate that the remediation is complete, final backfilling, grading, and vegetating activities shall commence However, if the results indicate the presence of contaminants,

additional samples may be collected in Zone B and IHSS 176 areas to determine if further soil excavation is warranted

Table IV.G-2
Sampling Parameters

Contaminant of Concern	Vadose Zone PRGs	Detection Limit[a]	Analytical Methodology
Cadmium	18 80 (mg/kg)	4 7 (mg/kg)	SW-846, Method 6010
Americium-241	1 09 (pCi/g)	0 27 (pCi/g)	GRASSP[b]
Plutonium-239/240	1 16 (pCi/g)	0 29 (pCi/g)	GRASSP[b]
Uranium-233/234	16 70 (pCi/g)	4 18 (pCi/g)	GRASSP[b]
Uranium-235	0 80 (pCi/g)	0 2 (pCi/g)	GRASSP[b]
Uranium-238	3 86 (pCi/g)	0 96 (pCi/g)	GRASSP[b]
Radium-226	0 65 (pCi/g)	0 16 (pCi/g)	GRASSP[b]
Lead	Not Established	Not Established	SW-846, Method 6010

[a] The detection limit is based on 25% of the PRG
[b] GRRASP *(General Radiochemistry and Routine Analytical Services Protocol)* (EG&G 1991)

2.5 SAMPLE COLLECTION

The sample teams shall meet daily prior to initiating field work to review the work plan and address health and safety requirements The required supplies, including portable radios, will be provided by the subcontractor

All sampling equipment, whether existing or newly purchased, shall be decontaminated prior to use in accordance with RFETS OPS FO 03, "General Equipment Decontamination " This decontamination requirement is designed to prevent cross contamination, prevent false positives, and ensure worker protection The decontamination water and wash water will be managed in accordance with RFETS OPS FO 07, "Handling of Decontamination Water and Wash Water " Rinsate samples shall be collected according to RFETS OPS FO 03 to confirm the effectiveness of the decontamination procedures If sample results indicate the presence of contamination, the sampling equipment shall not be used until it is re-decontaminated or replaced A sample identification tag will be prepared to track the source of the rinsate to the sample equipment If contamination is detected in the rinsate samples, the decontamination frequency shall be increased

Disposal latex gloves shall be worn while collecting and handling the soil samples Samplers shall wear a new pair of gloves for each sample location as well as decontaminating the sampling tool (stainless trowel, scoop, coring device, shovel, etc) prior to collecting the sample The soil samples will be collected in accordance with RFETS OPS GT 08, Surface Soil Sampling To minimize down-time due to the decontamination process, multiple sets of sampling equipment will be used The used sampling equipment will be wrapped in plastic for transport to the decontamination area

Sample numbers will be established in accordance with RFETS OPS FO 14, "Field Data Management " In accordance with RFETS OPS FO 14, the RFETS sample number consists of a sample prefix that relates to the type of sample that was collected, a 5 digit location code, a two character code indicating the company that collected the sample, and a sample suffix relating to the operable unit A nomenclature system for soil sample location codes has not yet been developed in OPS FO 14 If a system has been developed prior to field implementation the procedure in OPS FO 14 will be followed, otherwise, the procedure below will be followed

1) The first two places of the five digit location code will identify the x-axis (east-west) coordinate,

2) The next two places will identify the y-axis (north-south) coordinate, and

3) The final place will be a letter to identify the depth of the sample, "A" represents the 0- to 6-inch interval, "B" represents the 6- to 12-inch interval, "C" represents the 12- to 18-inch interval, etc

Sample Containers will be labeled, decontaminated, packaged, and shipped according to RFETS OPS FO 13, "Containerization, Preserving, Handling and Shipping of Soil and Water Samples " Only sample containers certified as clean by the manufacturer will be used for sample collection The sampler shall in accordance with RFETS OPS FO 13 include any preservatives prior to closing the sample containers and sealing them with custody tape The exterior of the sample containers shall be decontaminated in accordance with RFETS OPS FO 13 Chain of Custody forms will be completed according to RFETS OPS FO 13 Field descriptions, measurements, and observations will be recorded on appropriate field data forms in accordance with RFETS OPS FO 13 The original data forms will be collected, bound, and submitted to EG&G

2 6 ANALYSIS PROCEDURES

At this time, it perceived that SW-846 procedures will be utilized in completing the analytical results for cadmium and lead The GRRASP will be utilized for the radiological analysis Equivalent analytical procedures may be utilized with prior notification and approval

2.7 INVESTIGATIVE DERIVED WASTE HANDLING AND DISPOSITION

Excess soils collected during sampling activities will be consolidated within the CAMU as remediation waste PPE generated during field operations will be handled according to the results of field screening activities in accordance with RFETS OPS FO 6 PPE will be bagged, sealed, labeled, and placed into appropriate cargo containers depending on whether they are potentially contaminated or not Decontamination water and wash water will be handled in accordance with RFETS OPS FO 7, "Handling of Decontamination Water and Wash Water " Section IV 4 of the IM/IRA identifies requirements for the management of other waste streams which may be generated as part of the implementing the IM/IRA

SECTION 3

STORM WATER SAMPLING AND ANALYSIS

3.1 STORM WATER MANAGEMENT APPROACH

During excavation activities, the potential exits for the accumulation of storm water During the conceptual design phase, alternatives for the control and management of the storm water will be investigated It is anticipated that the storm water will be channeled into drainage basins This action will allow for the continuation of construction activities while maintaining a mechanism for capturing the storm water runoff Surface water samples shall be collected from the retention basin on an as needed basis to maintain adequate capacity The sample results will be used to determine how the storm water is to be managed The management options include disposition via either evaporation in Building 374 or the RFETS sewage treatment plant in Building 995

3.2 SAMPLE PARAMETERS

Analytical sampling parameters for the storm water will be dictated by the limits established in the NPDES discharge permit The analytical methods utilized, to establish if contamination exists, shall be in accordance with the RFETS treatment facility's currently accepted analytical methods

3 3 SAMPLE COLLECTION REQUIREMENTS

All sampling equipment, whether existing or newly purchased, shall be decontaminated prior to use in accordance with RFETS OPS FO 03, "General Equipment Decontamination " This decontamination requirement is designed to prevent cross contamination, prevent false positives, and ensure worker protection The decontamination water and wash water will be managed in accordance with RFETS OPS FO 07, "Handling of Decontamination Water and Wash Water " Rinsate samples shall be collected according to RFETS OPS FO 03 to confirm the effectiveness of the decontamination procedures If sample results indicate the presence of contamination, the sampling equipment shall not be used until it is re-decontaminated or replaced The sampler shall attach the sample identification tag with the sampling equipment to track the source of the rinsate If contamination is detected in the rinsate samples, the decontamination frequency shall be increased Disposal latex gloves shall be worn while collecting and handling the samples Samplers shall wear a new pair of gloves for each sample location as well as decontaminating the sampling equipment

Water samples will be collected in the appropriate containers in accordance with RFETS OPS SW 03, Surface Water Sampling The sample Containers will be labeled, decontaminated, packaged, and shipped according to RFETS OPS FO 13, "Containerization, Preserving, Handling and Shipping of Soil and Water Samples " Only sample containers certified as clean by the manufacturer will be used for sample collection The sampler shall in accordance with

RFETS OPS FO 13 include any preservatives prior to closing the sample containers and sealing them with custody tape The exterior of the sample containers shall be decontaminated in accordance with RFETS OPS FO 13 Chain of Custody forms will be completed according to RFETS OPS FO 13 Field descriptions, measurements, and observations will be recorded on appropriate field data forms in accordance with RFETS OPS FO 13 The original data forms will be collected, bound, and submitted to EG&G

3.4 ANALYSIS PROCEDURES

The analytical methods utilized, to establish if contamination exists, shall be in accordance with the RFETS treatment facility's currently accepted analytical methods

3 5 INVESTIGATIVE DERIVED WASTE HANDLING AND DISPOSITION

PPE generated during storm water sampling will be handled according to the results of screening activities in accordance with RFETS OPS FO 6 PPE will be bagged, sealed, labeled, and placed into appropriate containers based on whether they are potentially contaminated or not Decontamination water and wash water will be handled in accordance with RFETS OPS FO 7, "Handling of Decontamination Water and Wash Water " Section IV 4 of the IM/IRA identifies requirements for the management of other waste streams which may be generated as part of the IM/IRA implementation

SECTION 4

QUALITY ASSURANCE AND QUALITY CONTROL

4.0 QUALITY ASSURANCE AND QUALITY CONTROL

All QA/QC activities should be implemented in accordance with the *General Radiochemistry and Routine Analytical Services Protocol (GRRASP)* (EG&G 1991) and the *Rocky Flats Plant Environmental Restoration Management Quality Assurance Program Description (QAPD)* (EG&G 1994) Prior to initiation of field work, a readiness review will be conducted by experienced QA specialists Should any corrective actions be discovered, they will be corrected prior to commencing field work In addition to the readiness review, the QA specialists will conduct periodic audits and inspections of both field and laboratory operations to ensure that all the procedures and requirements are properly being followed

Four types of QC samples will be collected decontamination rinsates, duplicate samples, container blanks, and reagent blanks Rinsate samples will be collected in accordance with RFETS OPS FO 09 to verify that the sampling tools are free from contamination The duplicate soil samples are an independent method of verifying the precision of the laboratory analysis To ensure unbiased results, the duplicate soil sample will be submitted to the laboratory for analysis without it being identified as a split sample To ensure that the sample container is not a source of contamination, one sample container per container lot will be filled with deionized water and analyzed Finally, all reagents used for sample preservation and equipment cleaning will be tested at least once to ensure that the reagents are not a source of contaminants

SECTION 5

REFERENCES

EG&G Rocky Flats, July 2, 1991, *General Radiochemistry and Routine Analytical Services Protocol (GRRASP)*, Golden, Colorado

EG&G Rocky Flats, March, 1994, *Rocky Flats Plant Environmental Management Quality Assurance Program Description (QAPD)*, Golden, Colorado

U S Environmental Protection Agency, 1986 *Test Methods for Evaluating Solid Waste Volume II Field Manual Physical/Chemical Methods,* SW-846

U S Environmental Protection Agency, 1989 *Methods for Evaluating the Attainment of Cleanup Standards, Volume I Soils and Soil Media,* EPA 230/02-89-042

U S Nuclear Regulatory Commission, June 1992a, *Manual for Conducting Radiological Surveys in Support of License Termination,* Washington, D C , US NRC, NUREG/CR-5849, ORAU-92/C57 Draft

U S Nuclear Regulatory Commission, July 1992b, *Branch Technical Position on Site Characterization for Decommissioning Sites,* Washington, D C , US NRC, Draft

GEOTECHNICAL ANALYSIS REPORT

1.0 INTRODUCTION

This report presents results of slope stability modeling for the hillside north of the Solar Evaporation Ponds (SEPs) at the Rocky Flats Environmental Technology Site (RFETS) There are areas in the vicinity of the SEPs where past slope movements are evident, causing uncertainty with respect to the stability of the north hillside Because of potential impacts to the design of the proposed engineered cover, slope stability analyses were required prior to final determination of the engineered cover configuration An additional stage of slope stability modeling will be performed as a function of the Title II design following determination of the ultimate cover configuration

In addition to a discussion of the slope stability modeling, this report briefly summarizes the field activities performed for the geotechnical investigation and the laboratory testing performed on soil and bedrock samples taken from the vicinity of the SEPs

2.0 FIELD ACTIVITIES

Field sampling activities were performed during August 1994 following procedures described in the Geotechnical Investigation Workplan (Engineering-Science, July 1994) Figure 1 shows locations of the four boreholes (GB-1, GB-2, GB-3, and GB-4) drilled for the slope stability investigation The fifth borehole, GB-5, also shown on Figure 1, was drilled to obtain data relevant to settlement

The field investigation focused on obtaining representative samples of each of the soil and bedrock types encountered in the vicinity of the SEPs Samples were collected of colluvium (sandy, gravelly clay), shallow bedrock (weathered claystone and siltstone/sandstone), and deep bedrock (claystone) In addition, fractured samples were collected of colluvial claystone from a known slump block in the buffer zone (GB-1) An attempt was made to collect and test samples that appeared to have natural fractures, though difficulties were encountered collecting fractured samples that were relatively

undisturbed The samples of fractured colluvial claystone were deemed to be appropriate for testing residual strengths of weak zones in the claystone

3.0 LABORATORY TESTING AND DATA REDUCTION

Samples collected during the field investigation were tested for shear strength and other properties relevant to the slope stability analyses Advanced Terra Testing, Inc (ATT), of Lakewood, CO, performed all geotechnical testing Tests performed included Consolidated Undrained (CU) triaxial tests, Direct Shear tests, and determinations of particle size distributions, Atterberg Limits, natural moisture content and field density

From the results of the shear strength testing, Mohr-Coulomb failure envelopes were developed for each distinct material type In order to be conservative with respect to determination of strength parameters to be used in the modeling, three different failure criteria were considered for each triaxial test The most conservative strength parameters were chosen after developing Mohr-Coulomb envelopes for the following failure criteria maximum deviator stress, maximum principal stress ratio, and maximum pore pressure For the majority of the tests, the most conservative strength parameters resulted from considering failure to coincide with maximum pore pressure

Table 1 presents a summary of the material properties determined by the laboratory testing The unit weights presented are average values determined from results of laboratory testing for the Geotechnical Investigation and the Phase I investigation The strength parameters were determined from results of the shear strength testing for the Geotechnical Investigation, considering the failure criteria described in the preceding paragraph

4.0 SLOPE STABILITY MODELING

This section summarizes the methods used for the slope stability analyses Specifics regarding the computer software and the rationale behind parameters used in the modeling are discussed

TABLE 1
SUMMARY OF MATERIAL PROPERTIES FOR SLOPE STABILITY MODELING
ROCKY FLATS OU-4 IM/IRA

Material Description	Average Unit Weight (pcf)		Shear Strength Parameters			
			Total		Effective[d]	
	Field	Saturated	Friction Angle	Cohesion (psf)	Friction Angle	Cohesion (psf)
CLAY, very sandy (CL) colluvium from hillside	118 7	127 8	30[a]	0[a]	29[c] (23 9)	200[c] (160)
CLAYSTONE, colluvial shallow slump material highly weathered	124 0	129 8	13[c]	500[c]	16[c] (12 9)	600[c] (480)
CLAYSTONE shallow bedrock highly weathered	123 3	132 4	17[a]	450[a]	23[b] (18 8)	350[b] (280)
CLAYSTONE deep bedrock weathered	124 0	140 1	24[c]	0[c]	31 5[b] (26 1)	500[b] (400)
SANDSTONE/SILTSTONE shallow bedrock weathered	124 4	134 6	30[b]	100[b]	32 5[b] (27)	200[b] (160)

Notes
(a) assumed failure at maximum deviator stress
(b) assumed failure at maximum principal stress ratio
(c) assumed failure at maximum pore pressure
(d) values in parentheses are laboratory-determined values multiplied by 0 8, as assumed for seismic loading conditions (ref "Rationalizing the Seismic Coefficient Method", U S Dept of the Army, July 1984)

4.1 Computer Software

The computer modeling for the slope stability analysis was performed using Version 5 of the XSTABL program developed by I S Designs, Inc , of Moscow, Idaho XSTABL performs two-dimensional limit equilibrium analyses and incorporates a random surface generator for searching out the critical failure surface for a given slope This model is considered "state of the art" for slope stability modeling and has been validated and verified by DOE's design team Further information regarding the computer model can be found in the XSTABL Reference Manual

4.2 Stratigraphy of Critical Section

Slope stability analysis requires stratigraphic cross-sections, soil and bedrock properties, and groundwater levels for the area of concern Numerous borings in the vicinity of the SEPs have allowed for development of soil and bedrock cross-sections for the slope north of the proposed cover For this stage of modeling, the critical section was chosen as the vertical plane running through the high point of the cover and down the hillside north of the SEPs to North Walnut Creek

In general, the north hillside is characterized by a layer of colluvium (typically sandy, gravelly clay) overlying a zone of weathered claystone bedrock In the vicinity of SEP 207-C and the western side of SEP 207-A is a subcropping of sandstone/siltstone Below the shallow bedrock units (i e , the weathered claystone and the sandstone/siltstone) is relatively unweathered claystone For modeling purposes, the upper bedrock units were assumed to be 40 feet thick, as estimated from historical boring logs

The groundwater surface used in the modeling was assumed to be at the mean seasonal high plus 2 2 feet, as presented in Appendix 3 D of the Proposed IM/IRA-EA Decision Document entitled "Evaluation of Potential Groundwater Fluctuations" This is the estimated maximum level that groundwater is expected to reach during the 1000-year design life of the proposed engineered cover

4.3 Material Properties

Shear strengths and field densities of the north hillside materials were determined from the laboratory testing performed by ATT for the Geotechnical Investigation and by D B Stephens and Associates for the Phase I Investigation The values summarized in Table 1 are consistent with those found during a literature review for properties of similar material types

The unit weights presented in Table 1 are average values for the distinct material types, as determined in the two laboratories The XSTABL model requires both field and saturated unit weights

As described in the section on Laboratory Testing, the shear strength parameters were determined by triaxial and direct shear testing For the modeling, drained and undrained shear strength parameters were required for the long-term loading and the short-term, post-construction conditions

The results of the shear strength testing on the colluvium (clay) are presented in Table 1 These strength parameters are considered the "best estimate" values and were used in the modeling for each set of bedrock conditions analyzed

For the shallow claystone, it was assumed that the "best estimate" shear strength parameters were equal to those determined for samples of the colluvial claystone, which were taken from an identified slump block in the buffer zone These parameters are more conservative than those determined for the shallow claystone, which was visibly less fractured than the colluvial claystone This assumption allows for the possibility that a failure zone in the shallow bedrock (just north of the ponds) exists but was not identified during the field investigation

The "best estimate" strength parameters for the sandstone/siltstone and the deep claystone, as determined using the most conservative failure criteria for the triaxial data, are presented in Table 1 In order to investigate the possibility that an existing failure zone reaches into the deep claystone, modeling runs were performed assuming that the deep claystone has strength parameters equal to those measured for the colluvial

claystone

4.4 Loading Due to the Engineered Cover

The proposed compacted waste and cover system was modeled with discrete pressure strips vertically loading the surface excavated for the subsurface drain Average vertical pressures on the excavated surface were calculated using the expected waste heights and assumed compacted waste density values With this method, the compacted waste above the excavated surface was assumed to have no shear strength The average waste heights and their respective distances from the crest of the hillside (i e , the pressure strips) were determined using a conservative cover configuration The cover configuration for the final design is expected to have relatively lower compacted waste heights and also is expected to be pulled back farther from the crest of the slope

4.5 Seismic Loading

Due to the 1000-year design life of the proposed cover system, an investigation of the effects of seismic loading on the slope stability was needed XSTABL was used to simulate psuedo-static conditions and calculate the resulting factors of safety using drained shear strength parameters and Spencer's Method Following general engineering practice, only the critical failure surfaces, as determined in the static analyses using undrained shear strength parameters, were analyzed for seismic loading A horizontal acceleration of 0 15g was chosen as the design basis earthquake per Rocky Flats Plant Standard No SC-106 In "Rationalizing The Seismic Coefficient Method", by the U S Dept of the Army (July 1984), the conclusion is made to use one-half of the peak ground acceleration for the magnitude of the seismic coefficient and 0 8 times the assumed strength parameters for seismic modeling For this analysis, the drained shear strength parameters were multiplied by 0 8, the vertical seismic coefficient was set to zero, and the horizontal seismic coefficient was assumed to be equal to 0 1, which is conservative with respect to the design basis earthquake (i e , 0 15g)

5.0 RESULTS

The XSTABL computer model was used to calculate factors of safety against slope failure for conditions likely to occur during the design life of the proposed engineered cover The critical cross-section was chosen with respect to surface geometry and was used for stability analyses that incorporated either the colluvial claystone strength parameters or the sandstone/siltstone strength parameters For the actual conditions on-site, the chosen cross-section does not pass through the sandstone/siltstone unit The critical cross-sections through each of the separate bedrock units will be analyzed for the slope stability modeling performed for the Title II design

Four different shallow and deep bedrock scenarios were modeled in which strength parameters of the materials were varied The colluvium was modeled using the "best estimate" parameters for all of the scenarios For each of the four scenarios, both static and dynamic loading conditions were analyzed The following describes the bedrock conditions and the results of the modeling for each of the scenarios

Scenario A:

For this scenario, the "best estimate" parameters were used for the shallow and deep bedrock units The static case for this scenario, which models post-construction loading conditions, resulted in a calculated Factor of Safety (FS) equal to 1 71 The long-term, drained conditions that undergo seismic loading resulted in a calculated FS equal to 1 52

Scenario B:

For this scenario, the deep bedrock was assumed to have strength parameters equal to the "best estimate" values for the shallow claystone This assumption allows for the possibility that an existing failure zone extends into the deep bedrock This scenario is considered conservative because no deep-seated failure zones in the north hillside have been identified during previous investigations The "best estimate" strength parameters were used for the shallow claystone

The static case for this scenario resulted in a calculated FS equal to 1 51 The long-term, drained conditions that undergo seismic loading resulted in a calculated FS equal to 1 07

Scenario C:

This scenario models a potential failure through the sandstone/siltstone unit The "best estimate" values for the sandstone/siltstone and the deep claystone were used for these analyses The static case for this scenario resulted in a calculated FS equal to 2 03 The long-term, drained conditions that undergo seismic loading resulted in a calculated FS equal to 1 82

Scenario D:

In this scenario, which models failure through the sandstone/siltstone unit, the deep bedrock was assumed to have strength parameters equal to the "best estimate" values for the shallow claystone This assumption allows for the possibility that an existing failure zone extends into the deep bedrock This scenario is considered conservative because no deep-seated failure zones in the north hillside have been identified during previous investigations The "best estimate" strength parameters were used for the sandstone/siltstone

The static case for this scenario resulted in a calculated FS equal to 1 60 The long-term, drained conditions that undergo seismic loading resulted in a calculated FS equal to 1 19

6.0 CONCLUSIONS

The slope stability modeling shows that using "best estimate" shear strength values for the soil and bedrock of the hillside north of the SEPs results in factors of safety against slope failure that are adequate in comparison to published values for earthen embankments In "Soil Mechanics, Design Manual 7 01" (ref Naval Facilities Engineering Command, September, 1986), the recommended minimum factor of safety for earthen embankments is 1 5 for static conditions and 1 15 for dynamic loading

conditions As shown on Table 2 of this report, these factor of safety requirements are exceeded using "best estimate" strength parameters for the shallow and deep claystone and the sandstone/siltstone (Scenarios A and C)

When the shear strength parameters of the deep claystone are reduced from the "best estimate" values to the values determined for samples taken from a known failure zone (Scenario B), the factor of safety is acceptable under static conditions but below the required value of 1 15 for the dynamic loading conditions Though this may raise concern about the ultimate stability of the north hillside, samples of the deep claystone taken during previous field investigations appeared to be intact with few fractures Therefore, use of the "best estimate" strength values for the deep claystone is more appropriate than use of the colluvial claystone strengths

The modeling performed for this report incorporated numerous conservative assumptions The cross-section used for the model was taken as the worst-case section determined for the north hillside, though this cross-section does not pass through the sandstone/siltstone unit or through a known failure surface in the shallow claystone The "best estimate" strength parameters were determined using the most conservative failure criteria for analyzing triaxial data, as described in Section 3 0 The loading due to the engineered cover was modeled as a vertical load applied directly to the excavated surface This assumption implies that the compacted waste and cover system will supply no added resistance to the sliding of failure surfaces that cut through the waste and cover However, due to the shear strengths of the waste and cover materials, additional resistance to sliding will occur

In addition, the surface loading is based on a cover configuration that is closer to the crest of the north hillside in comparison to the likely final cover configuration The seismic loading conditions modeled are also considered to be conservative Per Rocky Flats Plant Standard No SC-106, the design earthquake has a horizontal acceleration of 0 15g The seismic loading conditions modeled for this project assumed a horizontal acceleration of 0 2g, or a seismic coefficient of 0 1 (i e , one-half of the expected peak ground acceleration) It is believed that these modeling assumptions result in conservative factors of safety against slope failure in comparison to the actual field conditions

TABLE 2
RESULTS OF SLOPE STABILITY MODELING
ROCKY FLATS OU-4 IM/IRA

Drainage Conditions	Shallow Bedrock Type	Shallow Bedrock Shear Strengths Friction Angle	Shallow Bedrock Shear Strengths Cohesion (psf)	Deep Claystone Shear Strengths Friction Angle	Deep Claystone Shear Strengths Cohesion (psf)	Seismic Coefficient*	Analysis Method	Calculated Factor of Safety
SCENARIO A								
undrained	claystone	13	500	24	0	0	Simplified Bishop	1 71
drained	claystone	12 9	480	26 1	400	0 1	Spencer's	1 52
SCENARIO B								
undrained	claystone	13	500	13	500	0	Simplified Bishop	1 51
drained	claystone	12 9	480	12 9	480	0 1	Spencer's	1 07
SCENARIO C								
undrained	sandstone/ siltstone	30	100	24	0	0	Simplified Bishop	2 03
drained	sandstone/ siltstone	27	160	26 1	400	0 1	Spencer's	1 82
SCENARIO D								
undrained	sandstone/ siltstone	30	100	13	500	0	Simplified Bishop	1 60
drained	sandstone/ siltstone	27	160	12 9	480	0 1	Spencer's	1 19

* Design earthquake, per Rocky Flats Plant Standard No SG-106, is equal to 0 15g horizontal acceleration
The seismic coefficient is estimated to be 1/2 of the expected peak ground acceleration, per "Rationalizing the Seismic Coefficient Method", U S.Dept of the Army, July 1984 For these analyses, the seismic coefficient was assumed to be equal to 0 1, which is conservative with regards to the design earthquake

In summary, based on data from the geotechnical investigation and the XSTABL modeling, the slope of the north hillside is adequate with respect to short- and long-term stability However, because of the critical nature of the IM/IRA project, the results of the slope stability analyses presented here will be confirmed when the final engineered cover configuration is complete

The results of this report are based on data collected during the Geotechnical Investigation and the Phase I Investigation Variations in subsurface conditions not indicated by the investigations are normal and expected The assumptions and conclusions contained in this report are based on the degree of conservatism deemed proper for the OU-4 IM/IRA project

TABLE IV I-1
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT FOR THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor $(mg/(kg*day))^{-1}$	Incremental Cancer Risk
Barium	6 60E-03	1 43E-03	3 60E-04	NA	0 00e+00
Beryllium	4 40E-04	NA	0 00E+00	8 4	2 90e-09
Cadmium	2 90E-02	NA	0 00E+00	6 3	1 40e-07
Calcium	7 30E+00	NA	0 00E+00	NA	0 00e+00
Cyanide	9.70E-04	2.00E-02	3.80E-06	NA	0 00e+00
Lithium	8 60E-04	6 0	1 10E-08	NA	0 00e+00
Managanese	1 40E-02	1 14E-04	9 90E-03	NA	0 00e+00
Mercury	1 90E-05	8 57E-05	1 70E-05	NA	0 00e+00
Nitrate	1 80E-01	1 00E+00	1 40E-05	NA	0 00e+00
Nitrite	1 80E-01	1 00E+00	1 40E-05	NA	0 00e+00
Potassium	1 70E-01	5 10E+02	2 70E-08	NA	0 00e+00
Silicon	4 20E-01	0 7	0 00E+00	NA	0 00e+00

TABLE IV I-1
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT FOR THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Silver	2 40E-04	3 00E-03	6 40E-06	NA	0 00e+00
Sodium	2 50E-01	3 00E+02	6 70E-08	NA	0 00e+00
Sulfide	2 50E-03	NA	0 00E+00	NA	0 00e+00
Zinc	2 90E-04	3 50E-02	6 50E-07	NA	0 00e+00
2-butanone	1 80E-06	5 00E-02	2 80E-09	NA	0 00e+00
Acetone	4 20E-06	3	1 1E-10	NA	0 0e+00
Benzo(a)anthracene	9 2E-05	NA	0 0E+00	6 1	4 4e-10
Benzo(a)pyrene	9 8E-05	NA	0 0E+00	6 1	4 7e-10
Benzo(b)fluoranthene	4 1E-05	NA	0 0E+00	6 1	2 0e-10
Benzo(g h i)perylene	7 3E-05	NA	0 0E+00	6 1	3 5e-10
Benzo(k)flouranthene	4 7E-05	NA	0 0E+00	6 10e+00	2 2e 10
Bis(2-ethylhexyl)phthalate	9 2E-04	2 00E-02	3 6E-06	6 80e-04	4 9e-13

TABLE IV I-1
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT FOR THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor $(mg/(kg*day))^{-1}$	Incremental Cancer Risk
Chloroform	7 6E-07	NA	0 0E+00	0 081	4 8e-14
Chrysene	1.1E-04	2 00E-05	4 1E-04	6 10e+00	5 0e-10
Di-n-butyl phthlate	9 3E-05	1 00E-01	7 3E-08	NA	0 0e+00
Fluoranthene	4 2E-05	6 10E-04	5 4E-06	0 35	1 1e-11
Indeno(1,2,3-cd)pyrene	7 9E-05	NA	0 0E+00	6 1	3 8e-10
Methylene Chloride	1 9E-06	8 57E-01	1 7E-10	1 65e-03	2 4e-15
Phenanthrene	4 2E-05	NA	0 0E+00	6 1	2 0e-10
Pyrene	4 3E-05	NA	0 0E+00	2 00e-03	6 7e-14
Toluene	1 3E-05	1 50E+00	6 7E-10	NA	0 0e+00
Arochlor-1254	3 6E-01	NA	0 0E+00	4 3	1 2e-06

TABLE IV I-2
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Barium	6 60e-03	1 43e-03	3 60e-04	NA	0 0e+00
Beryllium	4 4e-04	NA	0 0e+00	8 4	2 9e-09
Cadmium	2 9e-02	NA	0 0e+00	6 3	1 4e-07
Calcium	7 3e+00	NA	0 0e+00	NA	0 0e+00
Cyanide	9 7e-04	2 00e-02	3 8e-06	NA	0 0e+00
Lithium	8 7e-04	6 0	1 1e-08	NA	0 0e+00
Managanese	1 5e-02	1 14e-04	1 0e-02	NA	0 0e+00
Mercury	1 9e-05	8 57e-05	1 7e-05	NA	0 0e+00
Nitrate	1 8e-01	1 00e+00	1 4e-05	NA	0 0e+00
Nitrite	1 8e-01	1 00e+00	1 4e-05	NA	0 0e+00
Potassium	1 8e-01	5 10e+02	2 7e-08	NA	0 0e+00
Silicon	4 3e-01	0 7	0 0e+00	NA	0 0e+00

TABLE IV I-2
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Silver	2.4e-04	3 00e-03	6 4e-06	NA	0 0e+00
Sodium	2 6e-01	3 00e+02	6 7e-08	NA	0 0e+00
Sulfide	2 5e-03	NA	0 0e+00	NA	0 0e+00
Zinc	2 9e-04	3 50e-02	6 5e-07	NA	0 0e+00
2-butanone	1.8e-06	5 00e-02	2.8e-09	NA	0 0e+00
Acetone	4.3e-06	3	1 1e-10	NA	0 0e+00
Benzo(a)anthracene	9 3e-05	NA	0.0e+00	6 1	4 4e-10
Benzo(a)pyrene	9 9e-05	NA	0 0e+00	6 1	4 7e-10
Benzo(b)fluoranthene	4 2e-05	NA	0 0e+00	6 1	2 0e-10
Benzo(g,h,i)perylene	7 3e-05	NA	0 0e+00	6 1	3 5e-10
Benzo(k)flouranthene	4 7e-05	NA	0 0e+00	6 10e+00	2 3e-10
Bis(2-ethylhexyl)phthalate	9 2e-04	2 00e-02	3 6e-06	6 80e-04	4 9e-13

TABLE IV I-2
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Chloroform	7 6e-07	NA	0 0e+00	0 081	4 8e-14
Chrysene	1 1e-04	2 00e-05	4 2e-04	6 10e+00	5 1e-10
Di-n-butyl phthlate	9 3e-05	1 00e-01	7 3e-08	NA	0 0e+00
Fluoranthene	4 2e-05	6 10e-04	5 4e-06	0 35	1 1e-11
Indeno(1,2,3-cd)pyrene	8 0e-05	NA	0 0e+00	6 1	3 8e-10
Methylene Chloride	1 9e-06	8 57e-01	1 7e-10	1 65e-03	2 4e-15
Phenanthrene	4 3e-05	NA	0 0e+00	6 1	2 0e-10
Pyrene	4 3e-05	NA	0 0e+00	2 00e-03	6 8e-14
Toluene	1 3e-05	1 50e+00	6 8e-10	NA	0 0e+00
Arochlor 1254	3 6e-01	NA	0 0e+00	4 3	1 2e-06

TABLE IV I-3
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Barium	1 50e-04	1 43e-03	8 00e-06	NA	0 0e+00
Beryllium	9 9e-06	NA	0 0e+00	8 4	6 5e-11
Cadmium	6 5e-04	NA	0 0e+00	6 3	3 2e-09
Calcium	1 6e-01	NA	0 0e+00	NA	0 0e+00
Cyanide	2 1e-05	2 00e-02	8 4e-08	NA	0 0e+00
Lithium	1 9e-05	6 0	2 5e-10	NA	0 0e+00
Managanese	3.2e-04	1 14e-04	2.2e-04	NA	0.0e+00
Mercury	4 2e-07	8 57e-05	3 9e-07	NA	0.0e+00
Nitrate	4 0e-03	1 00e+00	3 1e-07	NA	0 0e+00
Nitrite	4 0e-03	1 00e+00	3 1e-07	NA	0 0e+00
Potassium	3 9e-03	5 10e+02	6 0e-10	NA	0 0e+00

TABLE IV I-3
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Silicon	9 4e-03	0 7	0 0e+00	NA	0 0e+00
Silver	5 4e-06	3 00e-03	1 4e-07	NA	0 0e+00
Sodium	5 7e-03	3 00e+02	1 5e-09	NA	0 0e+00
Sulfide	5 6e-05	NA	0 0e+00	NA	0 0e+00
Zinc	6 4e-06	3 50e-02	1 4e-08	NA	0 0e+00
2-butanone	3 9e-08	5 00e-02	6 1e-11	NA	0 0e+00
Acetone	9 4e-08	3	2 5e-12	NA	0 0e+00
Benzo(a)anthracene	2 1e-06	NA	0 0e+00	6 1	9 8e 12
Benzo(a)pyrene	2 2e-06	NA	0 0e+00	6 1	1 0e-11
Benzo(b)fluoranthene	9 2e-07	NA	0 0e+00	6 1	4 4e-12
Benzo(g,h,i)perylene	1 6e-06	NA	0 0e+00	6 1	7 8e-12
Benzo(k)flouranthene	1 0e-06	NA	0 0e+00	6 10e+00	5 0e-12

TABLE IV I-3
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Bis(2-ethylhexyl)phthalate	2 0e-05	2 00e-02	8 0e-08	6 80e-04	1 1e-14
Chloroform	1 7e-08	NA	0 0e+00	0 081	1 1e-15
Chrysene	2 3e-06	2 00e-05	9 2e-06	6 10e+00	1 1e-11
Di-n-butyl phthlate	2 1e-06	1 00e-01	1 6e-09	NA	0 0e+00
Fluoranthene	9 3e-07	6 10e-04	1 2e-07	0 35	2 5e-13
Indeno(1,2,3-cd)pyrene	1 8e-06	NA	0 0e+00	6 1	8 4e-12
Methylene Chloride	4 1e-08	8.57e-01	3.8e-12	1 65e-03	5 3e-17
Phenanthrene	9 4e-07	NA	0 0e+00	6 1	4 5e-12
Pyrene	9 6e-07	NA	0 0e+00	2 00e-03	1 5e-15
Toluene	2 9e-07	1 50e+00	1 5e-11	NA	0 0e+00
Arochlor-1254	8 0e-03	NA	0 0e+00	4 3	2 7e-08

TABLE IV I-4
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Barium	1 00e-04	1 43e-03	2 00e-05	NA	0 0e+00
Beryllium	6 8e-06	NA	0 0e+00	8 4	1 1e-10
Cadmium	4 5e-04	NA	0 0e+00	6 3	5 6e-09
Calcium	1 1e-01	NA	0 0e+00	NA	0 0e+00
Cyanide	1 5e-05	2 00e-02	2 1e-07	NA	0 0e+00
Lithium	1 3e-05	6 0	6 2e-10	NA	0 0e+00
Managanese	2.2e-04	1 14e-04	5.4e-04	NA	0 0e+00
Mercury	2 9e-07	8 57e-05	9 5e-07	NA	0 0e+00
Nitrate	2 8e-03	1 00e+00	7 7e-07	NA	0 0e+00
Nitrite	2 8e-03	1 00e+00	7 7e-07	NA	0 0e+00
Potassium	2 7e-03	5 10e+02	1 5e-09	NA	0 0e+00

TABLE IV I-4
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Silicon	6 5e-03	0 7	0 0e+00	NA	0 0e+00
Silver	3 8e-06	3 00e-03	3 5e-07	NA	0 0e+00
Sodium	3 9e-03	3 00e+02	3 6e-09	NA	0 0e+00
Sulfide	3 8e-05	NA	0 0e+00	NA	0 0e+00
Zinc	4 4e-06	3 50e-02	3 5e-08	NA	0 0e+00
2-butanone	2 7e-08	5 00e-02	1 5e-10	NA	0 0e+00
Acetone	6 5e-08	3	6 1e-12	NA	0 0e+00
Benzo(a)anthracene	1 4e-06	NA	0 0e+00	6 1	1 7e-11
Benzo(a)pyrene	1 5e-06	NA	0 0e+00	6 1	1 8e-11
Benzo(b)fluoranthene	6 4e-07	NA	0 0e+00	6 1	7 7e-12
Benzo(g,h i)perylene	1 1e-06	NA	0 0e+00	6 1	1 4e-11
Benzo(k)flouranthene	7 2e-07	NA	0 0e+00	6 10e+00	8 8e-12

TABLE IV.I-4
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE SEPS

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Bis(2-ethylhexyl)phthalate	1 4e-05	2 00e-02	2 0e-07	6 80e-04	1 9e-14
Chloroform	1 2e-08	NA	0 0e+00	0 081	1 9e-15
Chrysene	1 6e-06	2.00e-05	2 3e-05	6 10e+00	2 0e-11
Di-n-butyl phthlate	1.4e-06	1 00e-01	4 0e-09	NA	0 0e+00
Fluoranthene	6.4e-07	6 10e-04	2.9e-07	0 35	4.5e-13
Indeno(1,2,3-cd)pyrene	1.2e-06	NA	0 0e+00	6 1	1 5e-11
Methylene Chloride	2 9e-08	8 57e-01	9 3e-12	1 65e-03	9 3e-17
Phenanthrene	6 5e-07	NA	0 0e+00	6 1	7 9e-12
Pyrene	6 6e-07	NA	0 0e+00	2.00e-03	2 6e-15
Toluene	2 0e-07	1 50e+00	3 7e-11	NA	0 0e+00
Arochlor-1254	5 6e-03	NA	0 0e+00	4 3	4 8e-08

TABLE IV I-5
WORKER RESULTS FOR EACH RADIONUCLIDE IN THE SEPS

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americum 241	3 10	3 20e-08	1 0e-07	0 51	1 60
Cesium 134	5 0e-03	2 80e-11	1 4e-13	7 30e-05	3 7e-07
Cesium 137	3 0e-03	1 90e-11	5 8e-14	5 00e-05	1 5e-07
Plutonium 239/240	2 0e+00	3 80e-08	7 6e-08	0 49	9 8e-01
Radium 226	8 7e-02	3 00e-09	2 6e-10	9 28e-03	8 1e-04
Strontium 89/90	2 9e-02	6 20e-11	1 8e-12	1 32e-03	3 8e-05
Tritium	3 7e-01	7 80e-14	2 9e-14	6 40e-08	2.3e-08
Uranium 233	1 8e+00	2 70e-08	4 8e-08	0 14	2 5e-01
Uranium 234	1 8e+00	2 60e-08	4 6e-08	0 14	2 5e-01
Uranium 235	2 7e-02	2 50e-08	6 7e-10	0 13	3 5e-03
Uranium 238	1 5e+00	2 40e-08	3 5e-08	0 12	1 8e-01

TABLE IV I-6
ON-SITE ADULT RESULTS FOR EACH RADIONUCLIDE IN THE SEPS

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americum 241	3 10	3 20E-08	1 0E-07	0 51	1 60
Cesium 134	5 1E-03	2 80E-11	1 4E-13	7 30E-05	3 7E-07
Cesium 137	3 0E-03	1 90E-11	5 8E-14	5 00E-05	1 5E-07
Plutonium 239/240	2 0E+00	3 80E-08	7 6E-08	0 49	9 8E-01
Radium 226	8.8E-02	3 00E-09	2 6E-10	9 28E-03	8 1E-04
Strontium 89/90	2 9E-02	6 20E-11	1 8E-12	1 32E-03	3 8E-05
Tritium	3 7E-01	7 80E-14	2 9E-14	6.40E-08	2 4E-08
Uranium 233	1.8E+00	2.70E-08	4 8E-08	0 14	2 5E-01
Uranium 234	1 8E+00	2.60E-08	4 7E-08	0 14	2 5E-01
Uranium 235	2 7E-02	2 50E-08	6 7E-10	0 13	3 5E-03
Uranium 238	1 5E+00	2 40E-08	3 6e-08	0 12	1 8e-01

TABLE IV I-7
OFF-SITE ADULT RESULTS FOR EACH RADIONUCLIDE IN THE SEPS

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americum 241	0 07	3 20e-08	2 2e-09	0 51	0 04
Cesium 134	1 1e-04	2 80e-11	3 1e-15	7 30e-05	8 2e-09
Cesium 137	6 7e-05	1 90e-11	1 3e-15	5 00e-05	3 4e-09
Plutonium 239/240	4 4e-02	3 80e-08	1 7e-09	0 49	2 2e-02
Radium 226	1 9e-03	3 00e-09	5 8e-12	9 28e-03	1 8e-05
Strontium 89/90	6 4e-04	6 20e-11	4 0e-14	1 32e-03	8 5e-07
Tritium	8 2e-03	7 80e-14	6 4e-16	6 40e-08	5 2e-10
Uranium 233	4 0e-02	2 70e-08	1 1e-09	0 14	5 6e-03
Uranium 234	4 0e-02	2 60e-08	1 0e-09	0 14	5 6e-03
Uranium 235	5 9e-04	2 50e-08	1 5e-11	0 13	7 7e-05
Uranium 238	3 3e-02	2 40e-08	7 9e-10	0 12	3 9e-03

TABLE IV.I-8
OFF-SITE CHILD RESULTS FOR EACH RADIONUCLIDE IN THE SEPS

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americum 241	0 05	3 20e-08	1 5e-09	0 51	0 02
Cesium 134	7 8e-05	2 80e-11	2 2e-15	7 30e-05	5 7e-09
Cesium 137	4 7e-05	1 90e-11	8 9e-16	5 00e-05	2 3e-09
Plutonium 239/240	3 1e-02	3 80e-08	1 2e-09	0 49	1 5e-02
Radium 226	1 3e-03	3 00e-09	4 0e-12	9 28e-03	1 2e-05
Strontium 89/90	4 4e-04	6.20e-11	2 7e-14	1 32e-03	5 8e-07
Tritium	5 6e-03	7 80e-14	4.4e-16	6 40e-08	3 6e-10
Uranium 233	2 7e-02	2 70e-08	7 4e-10	0 14	3 8e-03
Uranium 234	2 7e-02	2 60e-08	7 1e-10	0 14	3 8e-03
Uranium 235	4 1e-04	2 50e-08	1 0e-11	0 13	5 3e-05
Uranium 238	2 3e-02	2 40e-08	5 5e-10	0 12	2 7e-03

TABLE IV I-9
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Barium	1 10e-02	1 40e-03	1 20e-03	NA	NA
Beryllium	3 90e-04	NA	0 00e+00	8 40e+00	2 50e-09
Cadmium	6 80e-04	NA	0 00e+00	6 30e+00	8 20e-08
Calcium	2 33e-01	NA	0 00e+00	NA	NA
Cyanide	4 00e-05	2.00e-02	1 20e-05	NA	NA
Lithium	4 00e-05	6 00e+00	3 70e-08	NA	NA
Manganese	7 00e-04	1 10e-04	4.80e-04	NA	NA
Mercury	1 70e-05	8 00e-05	3 10e-05	NA	NA
Nitrate	6 24e-03	1 00e+00	2 90e-05	NA	NA
Nitrite	6 24e-03	1 00e+00	2 90e-05	NA	NA
Potassium	8 51e-03	5 10e+02	8.70e-08	NA	NA
Silicon	4 55e-03	7 00e-01	8 40e-05	NA	NA
Silver	2 10e-04	3 00e-03	1 10e-05	NA	NA
Sodium	7 02e-03	3 00e+02	9 60e-08	NA	NA
Sulfide	1 20e-04	NA	0 00e+00	NA	NA
Zinc	1 00e-05	3 50e-02	2 10e-06	NA	NA

TABLE IV I-9
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
2-butanone	2 80e-06	5 00e-02	8 80e-09	NA	NA
Acetone	6 80e-06	3 00e+00	3 60e-10	NA	NA
Benzo(a) anthracene	8 10e-05	NA	0 00e+00	6 10e+00	3 90e-10
Benzo(a) pyrene	8 60e-05	NA	0 00e+00	6 10e+00	4 10e 10
Benzo(b)fluoranthene	3 60e-05	NA	0 00e+00	6 10e+00	1 70e-10
Benzo(g,h,i)perylene	6 40e-05	NA	0 00e+00	6 10e+00	3 10e-10
Benzo(k)flouranthene	4 10e-05	NA	0 00e+00	6 10e+00	2 00e-10
Bis(2-ethylhexyl)phthalate	1 00e-05	2 00e-02	6 30e-06	6 80e-04	4 20e-13
Chloroform	0 00e+00	NA	0 00e+00	8 05e-02	NA
Chrysene	9 20e-05	2 00e-05	7 30e-04	6 10e+00	4 40e-10
Di-n-butyl phthalate	6 90e-05	1 00e-01	1 10e-07	NA	NA
Fluoranthene	3 60e-05	6 10e-04	9 50e-06	3 50e-01	1 00e-11
Indeno(1,2,3-cd)pyrene	6 90e-05	NA	0 00e+00	6 10e+00	3 30e-10
Methylene Chloride	3 00e-06	8 57e-01	5 50e-10	1 64e-03	3 80e-15
Phenanthrene	3 70e-05	NA	0 00e+00	6 10e+00	1 80e-10

TABLE IV I-9
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Pyrene	3 80e-05	NA	0 00e+00	2 00e-03	5 90e-14
Toluene	2 10e-05	1 50e+00	2 20e-09	NA	NA
Arochlor-1254	3 88e-03	NA	0 00e+00	4 30e+00	1 10e-09

TABLE IV I-10
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Barium	8 00e-07	1 40e-03	8 90e-08	NA	NA
Beryllium	2 90e-08	NA	0 00e+00	8 40e+00	1 90e-13
Cadmium	6 80e-04	NA	0 00e+00	6 30e+00	6 30e-12
Calcium	2 33e-01	NA	0 00e+00	NA	NA
Cyanide	4 00e-05	2 00e-02	9 30e-10	NA	NA
Lithium	4 00e-05	6 00e+00	2 80e-12	NA	NA
Manganese	7 00e-04	1 10e-04	4 80e-04	NA	NA
Mercury	1 30e-09	8 00e-05	2 30e-09	NA	NA
Nitrate	6 24e-03	1 00e+00	2 20e-09	NA	NA
Nitrite	6 24e-03	1 00e+00	2 20e-09	NA	NA
Potassium	8 51e-03	5 10e+02	6 60e-12	NA	NA
Silicon	4 55e-03	7 00e-01	6 40e-09	NA	NA
Silver	1 60e-08	3 00e-03	8 60e-10	NA	NA
Sodium	7 02e-03	3 00e+02	7 30e-12	NA	NA
Sulfide	1 20e-04	NA	0 00e+00	NA	NA

TABLE IV I-10
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Zinc	1 00e-05	3 50e-02	1 60e-10	NA	NA
2-butanone	2 10e-10	5 00e-02	6 80e-13	NA	NA
Acetone	5 20e-10	3 00e+00	2 70e-14	NA	NA
Benzo(a)anthracene	6 10e-09	NA	0 00e+00	6 10e+00	2 90e-14
Benzo(a)pyrene	6.50e-09	NA	0 00e+00	6 10e+00	3.10e-14
Benzo(b)fluoranthene	2 70e-09	NA	0 00e+00	6 10e+00	1 30e-14
Benzo(g,h,i)perylene	4 90e-09	NA	0 00e+00	6 10e+00	2 30e-14
Benzo(k)flouranthene	3 10e-09	NA	0 00e+00	6 10e+00	1 50e-14
Bis(2-ethylhexyl)phthalate	1 00e-05	2 00e-02	4 80e-10	6 80e-04	3 20e-17
Chloroform	0 00e+00	NA	0 00e+00	8 05e-02	NA
Chrysene	7 00e-09	2 00e-05	5 60e-08	6 10e+00	3 30e-14
Di-n-butyl phthalate	5 30e-09	1 00e-01	8 40e-12	NA	NA
Fluoranthene	2 80e-10	6 10e-04	7 20e-10	3 50e-01	7 60e-16
Indeno(1,2,3-cd)pyrene	5 30e-09	NA	0 00e+00	6 10e+00	2 50e-14
Methylene Chloride	2.30e-10	8 57e-01	4 20e-14	1 64e-03	2 90e-19

TABLE IV I-10
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Phenanthrene	2 80e-09	NA	0 00e+00	6 10e+00	1 30e-14
Pyrene	2 90e-08	NA	0 00e+00	2 00e-03	4 50e-18
Toluene	1 60e-09	1 50e+00	1 70e-13	NA	NA
Arochlor-1254	3 88e-03	NA	0 00e+00	4 30e+00	8 10e-14

TABLE IV I-11
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Barium	5 20e-09	1 43e-03	5 80e-10	NA	NA
Beryllium	1 90e-10	NA	0 00e+00	8 40e+00	6 30e-16
Cadmium	6 80e-04	NA	0 00e+00	6 30e+00	2 00e-14
Calcium	2 33e-01	NA	0 00e+00	NA	NA
Cyanide	4 00e-05	2 00e-02	6.10e-12	NA	NA
Lithium	4 00e-05	6 00e+00	1 80e-14	NA	NA
Manganese	7.00e-04	1 10e-04	4 80e-04	NA	NA
Mercury	8 20e-12	8 00e-05	1.50e-11	NA	NA
Nitrate	6 24e-03	1 00e+00	1 40e-11	NA	NA
Nitrite	6 24e-03	1 00e+00	1 40e-11	NA	NA
Potassium	8 51e-03	5 10e+02	4 30e-14	NA	NA
Silicon	4 55e-03	7 00e-01	4 20e-11	NA	NA
Silver	1 10e-10	3 00e-03	5 60e-12	NA	NA
Sodium	7 02e-03	3 00e+02	4 80e-14	NA	NA
Sulfide	1 20e-04	NA	0 00e+00	NA	NA

TABLE IV I-11
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Zinc	1 00e-05	3 50e-02	1 10e-12	NA	NA
2-butanone	1 40e-12	5 00e-02	4 50e-15	NA	NA
Acetone	3 40e-12	3 00e+00	1 80e-16	NA	NA
Benzo(a)anthracene	4 00e-11	NA	0 00e+00	6 10e+00	1 90e-16
Benzo(a)pyrene	4 30e-11	NA	0 00e+00	6 10e+00	2 00e-16
Benzo(b)fluoranthene	1 80e-11	NA	0 00e+00	6 10e+00	8 60e-17
Benzo(g,h,i)perylene	3 20e-11	NA	0 00e+00	6 10e+00	1 50e 16
Benzo(k)flouranthene	2 00e-11	NA	0 00e+00	6 10e+00	9 80e-17
Bis(2-ethylhexyl)phthalate	1 00e-05	2 00e-02	3 10e-12	6 80e-04	2 10e-19
Chloroform	0 00e+00	NA	0 00e+00	8 05e-02	NA
Chrysene	4 60e-11	2 00e-05	3 60e-10	6 10e+00	2 20e-16
Di-n-butyl phthalate	3 50e-11	1 00e-01	5 50e-14	NA	NA
Fluoranthene	1 80e-11	6 10e-04	4 70e-12	3 50e-01	5 00e-18
Indeno(1,2 3-cd)pyrene	3 40e-11	NA	0 00e+00	6 10e+00	1 60e-16
Methylene Chloride	1 50e-12	8 57e-01	2 70e-16	1 64e-03	1 90e-21

TABLE IV.I-11
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Phenanthrene	1 80e-11	NA	0 00e+00	6 10e+00	8 80e-17
Pyrene	1 90e-11	NA	0 00e+00	2 00e-03	2 90e-20
Toluene	1 00e-11	1 50e+00	1 10e-15	NA	NA
Arochlor-1254	3 88e-03	NA	0 00e+00	4.30e+00	5.30e-16

TABLE IV I-12
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Barium	3 60e-09	1 43e-03	1 40e-09	NA	NA
Beryllium	1 30e-10	NA	0 00e+00	8 40e+00	6 30e-16
Cadmium	6 80e-04	NA	0 00e+00	6 30e+00	2 00e-14
Calcium	2 33e-01	NA	0 00e+00	NA	NA
Cyanide	4 00e-05	2 00e-02	1 50e-11	NA	NA
Lithium	4 00e-05	6 00e+00	4 50e-14	NA	NA
Manganese	7 00e-04	1 10e-04	4 80e-04	NA	NA
Mercury	5 70e-12	8 00e-05	3 70e-11	NA	NA
Nitrate	6 24e-03	1 00e+00	3 50e-11	NA	NA
Nitrite	6 24e-03	1 00e+00	3 50e-11	NA	NA
Potassium	8 51e-03	5 10e+02	1 10e-13	NA	NA
Silicon	4 55e-03	7 00e-01	1 00e-10	NA	NA
Silver	7 30e-11	3 00e-03	1 40e 11	NA	NA
Sodium	7 02e-03	3 00e+02	1 20e-13	NA	NA
Sulfide	1 20e-04	NA	0 00e+00	NA	NA

TABLE IV.I-12
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Zinc	1 00e-05	3 50e-02	2 60e-12	NA	NA
2-butanone	9 70e-13	5 00e-02	1 10e-14	NA	NA
Acetone	2 30e-12	3 00e+00	4 40e-16	NA	NA
Benzo(a)anthracene	2 80e-11	NA	0 00e+00	6 10e+00	9 50e-17
Benzo(a)pyrene	3 00e-11	NA	0.00e+00	6 10e+00	1 00e-16
Benzo(b)fluoranthene	1 20e-11	NA	0 00e+00	6 10e+00	4 20e-17
Benzo(g,h,i)perylene	2 20e-11	NA	0 00e+00	6 10e+00	7 50e-17
Benzo(k)flouranthene	1.40e-11	NA	0.00e+00	6 10e+00	4 80e-17
Bis(2-ethylhexyl)phthalate	1 00e-05	2 00e-02	7 70e-12	6 80e-04	1 00e-19
Chloroform	0 00e+00	NA	0 00e+00	8 05e-02	NA
Chrysene	3 20e-11	2 00e-05	8 90e-10	6.10e+00	1 10e-16
Di-n-butyl phthalate	2 40e-11	1 00e-01	1 30e-13	NA	NA
Fluoranthene	1 30e-11	6 10e-04	1 20e-11	3 50e-01	2 50e-18
Indeno(1,2,3-cd)pyrene	2 40e-11	NA	0 00e+00	6 10e+00	8 10e-17
Methylene Chloride	1 00e-12	8 57e-01	6 70e-16	1 64e-03	9 40e-22

TABLE IV I-12
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT
FOR BUILDING 788

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Phenanthrene	1 30e-11	NA	0 00e+00	6 10e+00	4 40e-17
Pyrene	1 30e-11	NA	0 00e+00	2 00e-03	1 40e-20
Toluene	7 10e-12	1 50e+00	2 70e-15	NA	NA
Arochlor-1254	3 88e-03	NA	0 00e+00	4 30e+00	2 60e-16

TABLE IV I-13
WORKER RESULTS FOR EACH RADIONUCLIDE FOR BUILDING 788

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americum-241	2 60e+00	3 20e-08	8 20e-08	5 10e-01	1 30e+00
Cesium-134	0 00e+00	2 80e-11	0 00e+00	7 30e-05	0 00e+00
Cesium-137	6 80e-04	1 90e-11	0 00e+00	6 30e+00	0 00e+00
Plutonium-239/240	2 33e-01	3 80e-08	0 00e+00	4 90e-01	6 80e-01
Radium-226	4 00e-05	3 00e-09	0 00e+00	9.30e-03	1 30e-03
Strontium-89/90	4 00e-05	6 00e+00	0.00e+00	1 30e-03	6 40e-05
Tritium	7 00e-04	1 10e-04	4 80e-04	6 40e-08	3 30e-08
Uranium-233	0 00e+00	8 00e-05	0 00e+00	1 40e-01	1 90e-01
Uranium-234	6.24e-03	1 00e+00	0.00e+00	1 40e-01	1 90e-01
Uranium-235	6.24e-03	1 00e+00	0 00e+00	1 30e-01	2 10e-03
Uranium-238	8 51e-03	5 10e+02	0 00e+00	1 20e-01	1 10e-01

TABLE IV I-14
RADIATION DOSE TO RECEPTORS FOR BUILDING 788
Results of the CAP88-PC Aair Model

	On-site Adult	Off-site Adult	Off-site Child
Dose Equivalent (mrem)	1 40E-01	9 4E-04	6 5E-04
Cancer Risk	1 4E-06	9 0E-09	6 2E-09

TABLE IV I-15
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE
(NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
2-Butanone	2 1e-08	6 4E+02	3 2e-11	0 0E+00	0 0e+00
Acetone	8 9e-08	3 8E+04	2 3e-12	0 0E+00	0 0e+00
Arochlor-1254	6 5e-08	0 0E+00	0 0e+00	3 4E-06	2 2e-13
Arsenic	1 7e-06	0 0E+00	0 0e+00	3 9E-05	6 8e-11
Barium	3 9e-05	1 8E+01	2 1e-06	0 0E+00	0 0e+00
Benzo(a)anthracene	1 7e-08	0.0E+00	0 0e+00	4 8E-06	7 9e-14
Benzo(a)pyrene	1 8e-08	0 0E+00	0 0e+00	4 8E-06	8 4e-14
Benzo(b)fluoranthene	7.4e-09	0.0E+00	0.0e+00	4.8E-06	3 5e-14
Benzo(g,h,i)perylene	1 3e-08	0 0E+00	0 0e+00	4 8E-06	6 3e-14
Benzo(k)flouranthene	8 4e-09	0 0E+00	0 0e+00	4 8E-06	4 0e-14
Beryllium	8 3e-08	0 0E+00	0 0e+00	6 6E-06	5 4e-13
Bis(2-ethylhexyl)phthalate	2.3e-07	2 5E+02	9 0e-10	5 3E-10	1 2e-16
Cadmium	8.2e-05	0.0E+00	0 0e+00	4 9E-06	4 0e-10
Calcium	7 6e-09	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Chloroform	3 8e-09	0 0E+00	0 0e+00	6.3E-08	2 4e-16
Chromium	2 4e-05	6 4E+01	3 8e-07	3 2E-05	7 7e-10
Chrysene	1 9e-08	2.5E-01	7 4e-08	4 8E-06	9 0e-14
Cyanide (total)	5 2e-06	2.5E+02	2 0e-08	0 0E+00	0 0e+00
Di-n-butyl phthlate	8 1e-08	1 3E+03	6.3e-11	0 0E+00	0 0e+00
Fluoranthene	7 5e-09	7 8E+00	9 6e-10	2 7E-07	2 0e-15
Indeno(1,2,3-cd)pyrene	1 4e-08	0 0E+00	0 0e+00	4 8E-06	6 8e-14
Lithium	4 8e-06	7 6E+04	6 3e-11	0 0E+00	0 0e+00
Manganese	7 7e-05	1 5E+00	5 3e-05	0 0E+00	0 0e+00
Mercury	5 8e-07	1 1E+00	5 3e-07	0 0E+00	0 0e+00

TABLE IV I-15
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE
(NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Methylene Chloride	9 3e-09	1 1E+04	8 5e-13	1 3E-09	1 2e-17
Nitrate	5 9e-04	1 3E+04	4 6e-08	0 0E+00	0 0e+00
Nitrite	5 8e-04	1 3E+04	4 5e-08	0 0E+00	0 0e+00
Phenanthrene	7 6e-09	0 0E+00	0 0e+00	4 8E-06	3 6e-14
Potassium	8 7e-04	6 5E+06	1 3e-10	0 0E+00	0 0e+00
Pyrene	1 5e-08	0 0E+00	0 0e+00	1 6E-09	2 3e-17
Silicon	7 6e-05	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Silver	1 1e-06	3 8E+01	2 8e-08	0 0E+00	0 0e+00
Sodium	1 8e-03	3 8E+06	4 7e-10	0 0E+00	0 0e+00
Sulfide	1 2e-05	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	6 4e-08	1 9E+04	3 4e-12	0 0E+00	0 0e+00
Zinc	4 1e-06	4 5E+02	9 2e-09	0 0E+00	0 0e+00

TABLE IV I-16
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
2-Butanone	4 6e-10	6 4E+02	7 2e-13	0 0E+00	0 0e+00
Acetone	2 0e-09	3 8E+04	5 2e-14	0 0E+00	0 0e+00
Arochlor-1254	1 4e-09	0 0E+00	0 0e+00	3 4E-06	4 9e-15
Arsenic	3 8e-08	0 0E+00	0 0e+00	3 9E-05	1 5e-12
Barium	8 6e-07	1 8E+01	4 7e-08	0 0E+00	0 0e+00
Benzo(a)anthracene	3 7e-10	0 0E+00	0 0e+00	4.8E-06	1 8e-15
Benzo(a)pyrene	3 9e-10	0 0E+00	0 0e+00	4 8E-06	1 9e-15
Benzo(b)fluoranthene	1 6e-10	0.0E+00	0.0e+00	4.8E-06	7 9e-16
Benzo(g,h,i)perylene	2 9e-10	0 0E+00	0 0e+00	4 8E-06	1 4e-15
Benzo(k)flouranthene	1 9e-10	0 0E+00	0 0e+00	4 8E-06	8 9e-16
Beryllium	1 8e-09	0 0E+00	0 0e+00	6 6E-06	1 2e-14
Bis(2-ethylhexyl)phthalate	5 1e-09	2.5E+02	2 0e-11	5 3E-10	2 7e-18
Cadmium	1 8e-06	0.0E+00	0 0e+00	4 9E-06	9 0e-12
Calcium	1 7e-10	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Chloroform	8 4e-11	0.0E+00	0 0e+00	6.3E-08	5 3e-18
Chromium	5 3e-07	6 4E+01	8 4e-09	3 2E-05	1 7e-11
Chrysene	4 2e-10	2 5E-01	1 6e-09	4 8E-06	2 0e-15
Cyanide (total)	1 2e-07	2 5E+02	4 5e-10	0 0E+00	0 0e+00
Di-n-butyl phthlate	1 8e-09	1 3E+03	1 4e-12	0 0E+00	0 0e+00
Fluoranthene	1 7e-10	7 8E+00	2 1e-11	2 7E-07	4 5e-17
Indeno(1,2,3-cd)pyrene	3 2e-10	0 0E+00	0 0e+00	4 8E-06	1 5e-15
Lithium	1 1e-07	7 6E+04	1 4e-12	0 0E+00	0 0e+00
Manganese	1 7e-06	1 5E+00	1 2e-06	0 0E+00	0 0e+00
Mercury	1 3e-08	1 1E+00	1 2e-08	0 0E+00	0 0e+00

TABLE IV I-16
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Methylene Chloride	2 1e-10	1 1E+04	1 9e-14	1 3E-09	2 7e-19
Nitrate	1 3e-05	1 3E+04	1 0e-09	0 0E+00	0 0e+00
Nitrite	1 3e-05	1 3E+04	1 0e-09	0 0E+00	0 0e+00
Phenanthrene	1 7e-10	0 0E+00	0 0e+00	4 8E-06	8 1e-16
Potassium	1 9e-05	6 5E+06	3 0e-12	0 0E+00	0 0e+00
Pyrene	3 3e-10	0 0E+00	0 0e+00	1 6E-09	5 2e-19
Silicon	1 7e-06	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Silver	2 4e-08	3 8E+01	6 2e-10	0 0E+00	0 0e+00
Sodium	4 0e-05	3 8E+06	1 1e-11	0 0E+00	0 0e+00
Sulfide	2 8e-07	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	1 4e-09	1 9E+04	7 5e-14	0 0E+00	0 0e+00
Zinc	9 2e-08	4 5E+02	2 1e-10	0 0E+00	0 0e+00

TABLE IV I-17
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
2-Butanone	2 1e-08	6 4E+02	3 2e-11	0 0E+00	0 0e+00
Acetone	9 0e-08	3 8E+04	2.4e-12	0 0E+00	0 0e+00
Arochlor-1254	6 5e-08	0 0E+00	0 0e+00	3 4E-06	2 2e-13
Arsenic	1 7e-06	0 0E+00	0 0e+00	3 9E-05	6 8e-11
Barium	3 9e-05	1 8E+01	2 1e-06	0 0E+00	0 0e+00
Benzo(a)anthracene	1 7e-08	0.0E+00	0.0e+00	4.8E-06	7 9e-14
Benzo(a)pyrene	1 8e-08	0 0E+00	0 0e+00	4 8E-06	8 4e-14
Benzo(b)fluoranthene	7.4e-09	0 0E+00	0 0e+00	4.8E-06	3.5e-14
Benzo(g,h,i)perylene	1.3e-08	0 0E+00	0 0e+00	4.8E-06	6 3e-14
Benzo(k)flouranthene	8 5e-09	0 0E+00	0 0e+00	4 8E-06	4 0e-14
Beryllium	8 3e-08	0 0E+00	0 0e+00	6 6E-06	5 5e-13
Bis(2-ethylhexyl)phthalate	2 3e-07	2 5E+02	9 0e-10	5 3E-10	1 2e-16
Cadmium	8.2e-05	0 0E+00	0 0e+00	4 9E-06	4 1e-10
Calcium	7 6e-09	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Chloroform	3.8e-09	0 0E+00	0 0e+00	6.3E-08	2 4e-16
Chromium	2 4e-05	6 4E+01	3 8e-07	3 2E-05	7 7e-10
Chrysene	1 9e-08	2 5E-01	7 4e-08	4 8E-06	9 0e-14
Cyanide (total)	5 2e-06	2 5E+02	2 0e-08	0 0E+00	0 0e+00
Di-n-butyl phthlate	8 1e-08	1 3E+03	6 4e-11	0 0E+00	0 0e+00
Fluoranthene	7 5e-09	7 8E+00	9 6e-10	2 7E-07	2 1e-15
Indeno(1 2,3-cd)pyrene	1 4e-08	0 0E+00	0 0e+00	4 8E-06	6 8e-14
Lithium	4 8e-06	7 6E+04	6 3e-11	0 0E+00	0 0e+00
Manganese	7 7e-05	1 5E+00	5 3e-05	0 0E+00	0 0e+00
Mercury	5 8e-07	1 1E+00	5 4e-07	0 0E+00	0 0e+00

TABLE IV I-17
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Methylene Chloride	9 3e-09	1 1E+04	8 5e-13	1 3E-09	1 2e-17
Nitrate	6 0e-04	1 3E+04	4 7e-08	0 0E+00	0 0e+00
Nitrite	5 8e-04	1 3E+04	4 6e-08	0 0E+00	0 0e+00
Phenanthrene	7 6e-09	0 0E+00	0 0e+00	4 8E-06	3 6e-14
Potassium	8 8e-04	6 5E+06	1 4e-10	0 0E+00	0 0e+00
Pyrene	1 5e-08	0 0E+00	0 0e+00	1 6E-09	2 4e-17
Silicon	7 6e-05	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Silver	1 1e-06	3 8E+01	2 8e-08	0 0E+00	0 0e+00
Sodium	1 8e-03	3 8E+06	4 8e-10	0 0E+00	0 0e+00
Sulfide	1.3e-05	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	6 5e-08	1 9E+04	3 4e-12	0 0E+00	0 0e+00
Zinc	4 1e-06	4 5E+02	9 3e-09	0 0E+00	0 0e+00

TABLE IV.I-18
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))$^{-1}$	Incremental Cancer Risk
2-Butanone	3 2e-10	6 4E+02	1 8e-12	0 0E+00	0 0e+00
Acetone	1 4e-09	3 8E+04	1 3e-13	0 0E+00	0 0e+00
Arochlor-1254	1 0e-09	0 0E+00	0 0e+00	8 5E-06	8 5e-15
Arsenic	2.7e-08	0 0E+00	0 0e+00	9 9E-05	2 6e-12
Barium	5 9e-07	1 8E+01	1 2e-07	0 0E+00	0 0e+00
Benzo(a)anthracene	2 5e-10	0 0E+00	0 0e+00	1 2E-05	3 1e-15
Benzo(a)pyrene	2 7e-10	0.0E+00	0 0e+00	1 2E-05	3 3e-15
Benzo(b)fluoranthene	1.1e-10	0.0E+00	0 0e+00	1 2E-05	1 4e-15
Benzo(g,h,i)perylene	2 0e-10	0 0E+00	0 0e+00	1.2E-05	2 4e-15
Benzo(k)flouranthene	1 3e-10	0 0E+00	0 0e+00	1 2E-05	1 6e-15
Beryllium	1 3e-09	0 0E+00	0 0e+00	1 7E-05	2 1e-14
Bis(2-ethylhexyl)phthalate	3 5e-09	2 5E+02	4 9e-11	1 4E-09	4 7e-18
Cadmium	1 3e-06	0 0E+00	0 0e+00	1 3E-05	1 6e-11
Calcium	1 2e-10	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Chloroform	5.8e-11	0 0E+00	0 0e+00	1 6E-07	9 3e-18
Chromium	3 7e-07	6 4E+01	2 1e-08	8 1E-05	3 0e-11
Chrysene	2 9e-10	2 5E-01	4 0e-09	1.2E-05	3 5e-15
Cyanide (total)	8 0e-08	2 5E+02	1 1e-09	0 0E+00	0 0e+00
Di-n-butyl phthlate	1 2e-09	1 3E+03	3 5e-12	0.0E+00	0 0e+00
Fluoranthene	1 1e-10	7 8E+00	5 3e-11	7 0E-07	8 0e-17
Indeno(1,2,3-cd)pyrene	2.2e-10	0 0E+00	0 0e+00	1 2E-05	2 6e-15
Lithium	7 4e-08	7 6E+04	3 4e-12	0 0E+00	0 0e+00
Manganese	1 2e-06	1 5E+00	2 9e-06	0 0E+00	0 0e+00
Mercury	9 0e-09	1 1E+00	2 9e-08	0 0E+00	0 0e+00

TABLE IV I-18
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (NORMAL OPERATIONS)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
Methylene Chloride	1 4e-10	1 1E+04	4 6e-14	3 3E-09	4 7e-19
Nitrate	9 1e-06	1 3E+04	2 5e-09	0 0E+00	0 0e+00
Nitrite	8 9e-06	1 3E+04	2 5e-09	0 0E+00	0 0e+00
Phenanthrene	1 2e-10	0 0E+00	0 0e+00	1 2E-05	1 4e-15
Potassium	1 3e-05	6 5E+06	7 4e-12	0 0E+00	0 0e+00
Pyrene	2 3e-10	0 0E+00	0 0e+00	4 0E-09	9 2e-19
Silicon	1 2e-06	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Silver	1 6e-08	3 8E+01	1 5e-09	0 0E+00	0 0e+00
Sodium	2 8e-05	3 8E+06	2 6e-11	0 0E+00	0 0e+00
Sulfide	1 9e-07	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	9 9e-10	1 9E+04	1 8e-13	0 0E+00	0 0e+00
Zinc	6 3e-08	4 5E+02	5 0e-10	0 0E+00	0 0e+00

TABLE IV.I-19
WORKER RESULTS FOR EACH RADIOUCLIDE IN THE MIXTURE
(NORMAL OPERATIONS)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	2 3e-06	3 2E-08	7 5e-14	0.51	1 2e-06
Cesium 134	3 9e-06	2 8E-11	1 1e-16	7 30E-05	2 9e-10
Cesium 137	1 8e-06	1 9E-11	3 5e-17	5 00E-05	9 2e-11
Plutonium 239/240	6 7e-02	3 8E-08	2 5e-09	0 49	3 3e-02
Radium 226	4 4e-07	3 0E-09	1 3e-15	9.28E-03	4 0e-09
Strontium 89/90	1 8e-05	6 2E-11	1 1e-15	1 32E-03	2.4e-08
Tritium	1 6e-06	7 8E-14	1 3e-19	6 40E-08	1 0e-13
Uranium 233	1 3e-06	2 7E-08	3 4e-14	0.13	1.6e-07
Uranium 234	3 3e-03	2 6E-08	8 7e-11	0 14	4 7e-04
Uranium 235	1 5e-04	2 5E-08	3 7e-12	0 13	1 9e-05
Uranium 238	3 9e-03	2 4E-08	9.5e-11	0 12	4 7e-04

TABLE IV I-20
OFF-SITE ADULT RESULTS FOR EACH RADIOUCLIDE IN THE MIXTURE
(NORMAL OPERATIONS)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	5 2e-08	3 2E-08	1 7e-15	0 51	2 7e-08
Cesium 134	8 8e-08	2 8E-11	2 5e-18	7 30E-05	6 4e-12
Cesium 137	4 1e-08	1 9E-11	7 8e-19	5 00E-05	2 1e-12
Plutonium 239/240	1 5e-03	3 8E-08	5 7e 11	0 49	7 3e-04
Radium 226	9 7e-09	3 0E-09	2 9e 17	9 28E-03	9 0e-11
Strontium 89/90	4 1e-07	6 2E-11	2 5e-17	1 32E-03	5 4e-10
Tritium	3 6e-08	7 8E-14	2 8e-21	6 40E-08	2 3e-15
Uranium 233	2 8e-08	2 7E-08	7 6e-16	0 13	3 7e-09
Uranium 234	7 4e-05	2 6E-08	1 9e-12	0 14	1 0e-05
Uranium 235	3 3e-06	2 5E-08	8 3e-14	0 13	4 3e-07
Uranium 238	8 8e-05	2 4E-08	2 1e-12	0 12	1 1e-05

TABLE IV I-21
ON-SITE ADULT RESULTS FOR EACH RADIOUCLIDE IN THE MIXTURE
(NORMAL OPERATIONS)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	2.3e-06	3 2E-08	7 5e-14	0 51	1 2e-06
Cesium 134	4 0e-06	2 8E-11	1 1e-16	7 30E-05	2.9e-10
Cesium 137	1 9e-06	1 9E-11	3 5e-17	5 00E-05	9 3e-11
Plutonium 239/240	6 7e-02	3 8E-08	2 6e-09	0 49	3 3e-02
Radium 226	4 4e-07	3 0E-09	1 3e-15	9 28E-03	4 1e-09
Strontium 89/90	1 8e-05	6 2E-11	1 1e-15	1 32E-03	2 4e-08
Tritium	1 6e-06	7 8E-14	1 3e-19	6 40E-08	1 0e-13
Uranium 233	1 3e-06	2 7E-08	3 4e-14	0.13	1 6e-07
Uranium 234	3 4e-03	2.6E-08	8.7e-11	0 14	4 7e-04
Uranium 235	1 5e-04	2 5E-08	3 8e-12	0 13	2.0e-05
Uranium 238	4 0e-03	2 4E-08	9 5e-11	0 12	4 7e-04

TABLE IV I-22
OFF-SITE CHILD RESULTS FOR EACH RADIOUCLIDE IN THE MIXTURE
(NORMAL OPERATIONS)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	3 6e-08	3 2E-08	1 2e-15	0 51	1 8e-08
Cesium 134	6 1e-08	2 8E-11	1 7e-18	7 30E-05	4 4e-12
Cesium 137	2 8e-08	1 9E-11	5 4e-19	5 00E-05	1 4e-12
Plutonium 239/240	1 0e-03	3 8E-08	3 9e-11	0 49	5 0e-04
Radium 226	6 7e-09	3 0E-09	2 0e-17	9 28E-03	6 2e-11
Strontium 89/90	2 8e-07	6 2E-11	1 7e-17	1 32E-03	3 7e-10
Tritium	2 5e-08	7 8E-14	1 9e-21	6 40E-08	1 6e-15
Uranium 233	1 9e-08	2 7E-08	5 2e-16	0 13	2 5e-09
Uranium 234	5 2e-05	2 6E-08	1 3e-12	0 14	7 2e-06
Uranium 235	2 3e-06	2 5E-08	5 8e-14	0 13	3 0e-07
Uranium 238	6 1e-05	2 4E-08	1 5e-12	0 12	7 3e-06

TABLE IV I-23
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE
(ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
2-Butanone	1 1e-07	6 4E+02	1 6e-10	0 0E+00	0 0e+00
Acetone	3 3e-07	3 8E+04	0 0e+00	0 0E+00	1 1e-12
Arochlor-1254	8 5e-06	0 0E+00	0 0e+00	3 4E-06	3 3e-10
Arsenic	1 9e-04	0 0E+00	1 0e-05	3 9E-05	0 0e+00
Barium	8 4e-08	1 8E+01	0 0e+00	0 0E+00	4 0e-13
Benzo(a)anthracene	9 0e-08	0 0E+00	0 0e+00	4 8E-06	4 3e-13
Benzo(a)pyrene	3 8e-08	0 0E+00	0 0e+00	4 8E-06	1 8e-13
Benzo(b)fluoranthene	6 7e-08	0 0E+00	0.0e+00	4.8E-06	3.2e-13
Benzo(g,h,i)perylene	4 3e-08	0.0E+00	0 0e+00	4 8E-06	2 1e-13
Benzo(k)flouranthene	4 0e-07	0 0E+00	0 0e+00	4 8E-06	2 7e-12
Beryllium	1.2e-06	0 0E+00	4.6e-09	6 6E-06	6.2e-16
Bis(2-ethylhexyl)phthalate	4 2e-04	2 5E+02	0 0e+00	5.3E-10	2 1e-09
Cadmium	3 9e-08	0 0E+00	0 0e+00	4 9E-06	0 0e+00
Calcium	1 9e-08	0 0E+00	0 0e+00	0 0E+00	1 2e-15
Chloroform	1.2e-04	0 0E+00	1 8e-06	6 3E-08	3 7e-09
Chromium	9 6e-08	6 4E+01	3 8e-07	3 2E-05	4 6e-13
Chrysene	2.6e-05	2.5E-01	1 0e-07	4 8E-06	0 0e+00
Cyanide (total)	4 1e-07	2.5E+02	3 2e-10	0 0E+00	0 0e+00
Di-n-butyl phthlate	3 8e-08	1 3E+03	4 9e-09	0.0E+00	1 0e-14
Fluoranthene	7 2e-08	7 8E+00	0 0e+00	2 7E-07	3 5e-13
Indeno(1,2,3-cd)pyrene	2 2e-05	0 0E+00	2 9e-10	4 8E-06	0 0e+00
Lithium	3 7e-04	7 6E+04	2 5e-04	0 0E+00	0 0e+00
Manganese	3 0e-06	1 5E+00	2.7e-06	0 0E+00	0 0e+00
Mercury	4 7e-08	1 1E+00	4 3e-12	0 0E+00	6 1e-17

TABLE IV I-23
WORKER RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE
(ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Methylene Chloride	3 0e-03	1 1E+04	2 4e-07	1 3E-09	0 0e+00
Nitrate	3 0e-03	1 3E+04	2 3e-07	0 0E+00	0 0e+00
Nitrite	3 9e-08	1 3E+04	0 0e+00	0 0E+00	1 9e-13
Phenanthrene	4 5e-03	0 0E+00	6 9e-10	4 8E-06	0 0e+00
Potassium	7 7e-08	6 5E+06	0 0e+00	0 0E+00	1 2e-16
Pyrene	3 9e-04	0 0E+00	0 0e+00	1 6E-09	0 0e+00
Silicon	5 3e-06	0 0E+00	1 4e-07	0 0E+00	0 0e+00
Silver	9 1e-03	3 8E+01	2 4e-09	0 0E+00	0 0e+00
Sodium	7 3e-07	3 8E+06	0 0e+00	0 0E+00	4 6e-17
Sulfide	6 4e-05	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	3 3e-07	1 9E+04	1 7e-11	0 0E+00	0 0e+00
Zinc	7 3e-06	4 5E+02	1 6e-08	0 0E+00	0 0e+00

TABLE IV I-24
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day))[1]	Incremental Cancer Risk
2-Butanone	2 3e-09	6 4E+02	3 7e-12	0 0E+00	0 0e+00
Acetone	7 4e-09	3 8E+04	0 0e+00	0 0E+00	2 5e-14
Arochlor-1254	1 9e-07	0 0E+00	0 0e+00	3 4E-06	7 4e-12
Arsenic	4 1e-06	0 0E+00	2 3e-07	3 9E-05	0 0e+00
Barium	1 9e-09	1 8E+01	0 0e+00	0 0E+00	9 0e-15
Benzo(a)anthracene	2.0e-09	0 0E+00	0 0e+00	4 8E-06	9 5e-15
Benzo(a)pyrene	8 4e-10	0 0E+00	0 0e+00	4 8E-06	4 0e-15
Benzo(b)fluoranthene	1.5e-09	0.0E+00	0.0e+00	4.8E-06	7 1e-15
Benzo(g,h,i)perylene	9 6e-10	0 0E+00	0 0e+00	4 8E-06	4 6e-15
Benzo(k)flouranthene	9 0e-09	0 0E+00	0 0e+00	4 8E-06	5 9e-14
Beryllium	2 6e-08	0 0E+00	1.0e-10	6 6E-06	1.4e-17
Bis(2-ethylhexyl)phthalate	9 3e-06	2.5E+02	0 0e+00	5 3E-10	4 6e-11
Cadmium	8 6e-10	0 0E+00	0 0e+00	4 9E-06	0 0e+00
Calcium	4 3e-10	0 0E+00	0 0e+00	0 0E+00	2 7e-17
Chloroform	2 6e-06	0 0E+00	4 0e-08	6.3E-08	8 2e-11
Chromium	2 1e-09	6 4E+01	8 4e-09	3 2E-05	1 0e-14
Chrysene	5 9e-07	2.5E-01	2.3e-09	4 8E-06	0 0e+00
Cyanide (total)	9 2e-09	2 5E+02	7 2e-12	0 0E+00	0 0e+00
Di-n-butyl phthlate	8 5e-10	1 3E+03	1 1e-10	0 0E+00	2 3e-16
Fluoranthene	1 6e-09	7 8E+00	0 0e+00	2 7E-07	7 7e-15
Indeno(1,2,3-cd)pyrene	4 9e-07	0 0E+00	6 4e-12	4 8E-06	0 0e+00
Lithium	8 2e-06	7 6E+04	5 6e-06	0 0E+00	0 0e+00
Manganese	6 6e-08	1 5E+00	6 1e-08	0 0E+00	0 0e+00
Mercury	1 1e-09	1 1E+00	9 6e-14	0 0E+00	1 4e-18

TABLE IV I-24
OFF-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Methylene Chloride	6 7e-05	1 1E+04	5 3e-09	1 3E-09	0 0e+00
Nitrate	6 6e-05	1 3E+04	5 2e-09	0 0E+00	0 0e+00
Nitrite	8 6e-10	1 3E+04	0 0e+00	0 0E+00	4 1e-15
Phenanthrene	9 9e-05	0 0E+00	1 5e-11	4 8E-06	0 0e+00
Potassium	1 7e-09	6 5E+06	0 0e+00	0 0E+00	2 7e-18
Pyrene	8 6e-06	0 0E+00	0 0e+00	1 6E-09	0 0e+00
Silicon	1 2e-07	0 0E+00	3 1e-09	0 0E+00	0 0e+00
Silver	2 0e-04	3 8E+01	5 3e-11	0 0E+00	0 0e+00
Sodium	1 6e-08	3 8E+06	0 0e+00	0 0E+00	1 0e-18
Sulfide	1 4e-06	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	7 3e-09	1 9E+04	3 8e-13	0 0E+00	0 0e+00
Zinc	1 6e-07	4 5E+02	3 7e-10	0 0E+00	0 0e+00

TABLE IV I-25
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
2-Butanone	1 1e-07	6 4E+02	1 7e-10	0 0E+00	0 0e+00
Acetone	3 3e-07	3 8E+04	0 0e+00	0 0E+00	1 1e-12
Arochlor-1254	8 6e-06	0 0E+00	0 0e+00	3 4E-06	3 4e-10
Arsenic	1 9e-04	0 0E+00	1 0e-05	3 9E-05	0 0e+00
Barium	8 5e-08	1 8E+01	0 0e+00	0 0E+00	4 1e-13
Benzo(a)anthracene	9 0e-08	0 0E+00	0 0e+00	4 8E-06	4 3e-13
Benzo(a)pyrene	3 8e-08	0 0E+00	0 0e+00	4 8E-06	1 8e-13
Benzo(b)fluoranthene	6 7e-08	0 0E+00	0 0e+00	4 8E-06	3.2e-13
Benzo(g,h,i)perylene	4.3e-08	0 0E+00	0 0e+00	4.8E-06	2.1e-13
Benzo(k)flouranthene	4 1e-07	0 0E+00	0 0e+00	4 8E-06	2 7e-12
Beryllium	1.2e-06	0 0E+00	4.6e-09	6 6E-06	6.2e-16
Bis(2-ethylhexyl)phthalate	4 2e-04	2 5E+02	0 0e+00	5.3E-10	2.1e-09
Cadmium	3.9e-08	0.0E+00	0.0e+00	4.9E-06	0 0e+00
Calcium	1 9e-08	0 0E+00	0 0e+00	0 0E+00	1 2e-15
Chloroform	1 2e-04	0 0E+00	1 8e-06	6 3E-08	3 7e-09
Chromium	9 7e-08	6 4E+01	3 8e-07	3.2E-05	4 6e-13
Chrysene	2 7e-05	2 5E-01	1 0e-07	4 8E-06	0.0e+00
Cyanide (total)	4 1e-07	2 5E+02	3 3e-10	0 0E+00	0 0e+00
Di-n-butyl phthlate	3 8e-08	1 3E+03	4 9e-09	0.0E+00	1 0e-14
Fluoranthene	7 3e-08	7 8E+00	0 0e+00	2 7E-07	3 5e-13
Indeno(1 2,3-cd)pyrene	2 2e-05	0 0E+00	2 9e-10	4 8E-06	0 0e+00
Lithium	3 7e-04	7 6E+04	2 5e-04	0 0E+00	0 0e+00
Manganese	3 0e-06	1 5E+00	2 7e-06	0 0E+00	0 0e+00
Mercury	4 8e-08	1 1E+00	4 4e-12	0 0E+00	6 1e-17

TABLE IV I-25
ON-SITE ADULT RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Methylene Chloride	3 0e-03	1 1E+04	2 4e-07	1 3E-09	0 0e+00
Nitrate	3 0e-03	1 3E+04	2 3e-07	0 0E+00	0 0e+00
Nitrite	3 9e-08	1 3E+04	0 0e+00	0 0E+00	1 9e-13
Phenanthrene	4 5e-03	0 0E+00	6 9e-10	4 8E-06	0 0e+00
Potassium	7 7e-08	6 5E+06	0 0e+00	0 0E+00	1 2e-16
Pyrene	3 9e-04	0 0E+00	0 0e+00	1 6E-09	0 0e+00
Silicon	5 4e-06	0 0E+00	1 4e-07	0 0E+00	0 0e+00
Silver	9 2e-03	3 8E+01	2 4e-09	0 0E+00	0 0e+00
Sodium	7 4e-07	3 8E+06	0 0e+00	0 0E+00	4 6e-17
Sulfide	6 4e-05	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	3 3e-07	1 9E+04	1 7e-11	0 0E+00	0 0e+00
Zinc	7 4e-06	4 5E+02	1 7e-08	0 0E+00	0 0e+00

TABLE IV I-26
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
2-Butanone	1 6e-09	6 4E+02	9 0e-12	0 0E+00	0 0e+00
Acetone	5 1e-09	3.8E+04	0 0e+00	0 0E+00	1 7e-14
Arochlor-1254	1 3e-07	0 0E+00	0 0e+00	8 5E-06	5 1e-12
Arsenic	2 9e-06	0 0E+00	5 6e-07	9 9E-05	0 0e+00
Barium	1 3e-09	1 8E+01	0 0e+00	0 0E+00	6 2e-15
Benzo(a)anthracene	1 4e-09	0.0E+00	0 0e+00	1 2E-05	6 6e-15
Benzo(a)pyrene	5 8e-10	0 0E+00	0 0e+00	1 2E-05	2 8e-15
Benzo(b)fluoranthene	1 0e-09	0.0E+00	0.0e+00	1.2E-05	4.9e-15
Benzo(g,h,i)perylene	6 6e-10	0 0E+00	0 0e+00	1.2E-05	3 2e-15
Benzo(k)flouranthene	6.2e-09	0 0E+00	0 0e+00	1 2E-05	4 1e-14
Beryllium	1 8e-08	0 0E+00	2.5e-10	1 7E-05	9 6e-18
Bis(2-ethylhexyl)phthalate	6 4e-06	2.5E+02	0.0e+00	1.4E-09	3.2e-11
Cadmium	6 0e-10	0 0E+00	0 0e+00	1.3E-05	0 0e+00
Calcium	3 0e-10	0 0E+00	0 0e+00	0 0E+00	1 9e-17
Chloroform	1 8e-06	0 0E+00	9 9e-08	1.6E-07	5 7e-11
Chromium	1 5e-09	6 4E+01	2 1e-08	8 1E-05	7 1e-15
Chrysene	4 1e-07	2 5E-01	5 7e-09	1.2E-05	0 0e+00
Cyanide (total)	6 4e-09	2.5E+02	1 8e-11	0 0E+00	0 0e+00
Di-n-butyl phthlate	5 9e-10	1 3E+03	2 7e-10	0.0E+00	1 6e-16
Fluoranthene	1 1e-09	7 8E+00	0 0e+00	7 0E-07	5 3e-15
Indeno(1,2,3-cd)pyrene	3 4e-07	0 0E+00	1 6e-11	1 2E-05	0 0e+00
Lithium	5 7e-06	7 6E+04	1 4e-05	0 0E+00	0 0e+00
Manganese	4 6e-08	1 5E+00	1 5e-07	0 0E+00	0 0e+00
Mercury	7 3e-10	1 1E+00	2 4e-13	0 0E+00	9 4e-19

TABLE IV I-26
OFF-SITE CHILD RESULTS FOR EACH CHEMICAL CONTAMINANT IN THE MIXTURE (ACCIDENT CONDITION)

Contaminant of Concern	Intake (mg)	RfD (mg/(kg*day))	Hazard Quotient	Slope Factor (mg/(kg*day)) [1]	Incremental Cancer Risk
Methylene Chloride	4 7e-05	1 1E+04	1 3e-08	3 3E-09	0 0e+00
Nitrate	4 6e-05	1 3E+04	1 3e-08	0 0E+00	0 0e+00
Nitrite	6 0e-10	1 3E+04	0 0e+00	0 0E+00	2 9e-15
Phenanthrene	6 9e-05	0 0E+00	3 8e-11	1 2E-05	0 0e+00
Potassium	1 2e-09	6 5E+06	0 0e+00	0 0E+00	1 8e-18
Pyrene	6 0e-06	0 0E+00	0 0e+00	4 0E-09	0 0e+00
Silicon	8 2e-08	0 0E+00	7 6e-09	0 0E+00	0 0e+00
Silver	1 4e-04	3 8E+01	1 3e-10	0 0E+00	0 0e+00
Sodium	1 1e-08	3 8E+06	0 0e+00	0 0E+00	7 0e-19
Sulfide	9 8e-07	0 0E+00	0 0e+00	0 0E+00	0 0e+00
Toluene	5 1e-09	1 9E+04	9 4e-13	0 0E+00	0 0e+00
Zinc	1 1e-07	4 5E+02	9 0e-10	0 0E+00	0 0e+00

TABLE IV I-27
WORKER RESULTS FOR EACH RADIOUCLIDE IN THE MIXTURE
(ACCIDENT CONDITION)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	1 1e-05	3 2E-08	3 7e-13	0 51	5 9e-06
Cesium 134	1 9e-08	2.8E-11	5 4e-19	7 30E-05	1 4e-12
Cesium 137	7 7e-08	1 9E-11	1 5e-18	5 00E-05	3 9e-12
Plutonium 239/240	3 4e-01	3 8E-08	1 3e-08	0 49	1 7e-01
Radium 226	2 2e-06	3 0E-09	6 7e-15	9 28E-03	2 1e-08
Strontium 89/90	7 3e-07	6 2E-11	4 6e-17	1 32E-03	9 7e-10
Tritium	8 3e-06	7 8E-14	6 5e-19	6 40E-08	5 3e-13
Uranium 233	6 4e-06	2.7E-08	1 7e-13	0 13	8 4e-07
Uranium 234	1.6e-02	2 6E-08	4.2e-10	0.14	2 3e-03
Uranium 235	7 4e-04	2 5E-08	1 9e-11	0 13	9 6e-05
Uranium 238	2 0e-02	2 4E-08	4 7e-10	0 12	2 4e-03

TABLE IV I 28
OFF-SITE ADULT RESULTS FOR EACH RADIONUCLIDE IN THE MIXTURE
(ACCIDENT CONDITION)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	2 6e-07	3 2E-08	8 2e-15	0 51	1 3e-07
Cesium 134	4 3e-10	2 8E-11	1 2e 20	7 30E-05	3 1e-14
Cesium 137	1 7e-09	1 9E-11	3 3e-20	5 00E-05	8 6e-14
Plutonium 239/240	7 6e-03	3 8E-08	2 9e 10	0 49	3 7e-03
Radium 226	5 0e-08	3 0E-09	1 5e 16	9 28E-03	4 6e-10
Strontium 89/90	1 6e-08	6 2E-11	1 0e-18	1 32E-03	2 2e-11
Tritium	1 8e-07	7 8E-14	1 4e 20	6 40E-08	1 2e-14
Uranium 233	1 4e-07	2 7E-08	3 9e-15	0 13	1 9e-08
Uranium 234	3 6e-04	2 6E-08	9 4e-12	0 14	5 1e-05
Uranium 235	1 6e-05	2 5E-08	4 1e 13	0 13	2 1e-06
Uranium 238	4 4e-04	2 4E-08	1 0e-11	0 12	5 2e-05

TABLE IV I-29
ON-SITE ADULT RESULTS FOR EACH RADIONUCLIDE IN THE MIXTURE
(ACCIDENT CONDITION)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	1 2e-05	3 2E-08	3 7e-13	0 51	5 9e-06
Cesium 134	1 9e-08	2 8E-11	5 4e-19	7 30E-05	1 4e-12
Cesium 137	7 8e-08	1 9E-11	1 5e-18	5 00E-05	3 9e-12
Plutonium 239/240	3 4e-01	3 8E-08	1 3e-08	0 49	1 7e-01
Radium 226	2 2e-06	3 0E-09	6 7e-15	9 28E-03	2.1e-08
Strontium 89/90	7 4e-07	6 2E-11	4 6e-17	1 32E-03	9 7e-10
Tritium	8 3e-06	7 8E-14	6.5e-19	6 40E-08	5 3e-13
Uranium 233	6 5e-06	2 7E-08	1 7e-13	0 13	8.4e-07
Uranium 234	1 6e-02	2 6E-08	4 2e-10	0 14	2.3e-03
Uranium 235	7 4e-04	2 5E-08	1 9e-11	0.13	9 7e-05
Uranium 238	2 0e-02	2 4E-08	4 7e-10	0 12	2 4e-03

TABLE IV.I-30
OFF-SITE CHILD RESULTS FOR EACH RADIONUCLIDE IN THE MIXTURE
(ACCIDENT CONDITION)

Radionuclide	Intake (pCi)	Slope Factor (Risk/pCi)	Incremental Cancer Risk	Dose Conversion Factor (mrem/pCi)	Dose Equivalent (mrem)
Americium 241	1 8e-07	3 2E-08	5 7e-15	0 51	9 0e-08
Cesium 134	3 0e-10	2 8E-11	8 3e-21	7 30E-05	2 2e-14
Cesium 137	1 2e-09	1 9E-11	2 3e-20	5 00E-05	5 9e-14
Plutonium 239/240	5 3e-03	3 8E-08	2 0e-10	0 49	2 6e-03
Radium 226	3 4e-08	3 0E-09	1 0e-16	9 28E-03	3 2e-10
Strontium 89/90	1 1e-08	6 2E-11	7 0e-19	1 32E-03	1 5e-11
Tritium	1 3e-07	7 8E-14	9 9e-21	6 40E-08	8 2e-15
Uranium 233	9 9e-08	2 7E-08	2 7e-15	0 13	1 3e-08
Uranium 234	2 5e-04	2 6E-08	6 5e-12	0 14	3 5e-05
Uranium 235	1 1e-05	2 5E-08	2 8e-13	0 13	1 5e-06
Uranium 238	3 0e-04	2 4E-08	7 2e-12	0 12	3 6e-05

OU4 IM/IRA DECISION DOCUMENT
PART V - PROPOSED CONCEPTUAL POST-CLOSURE MONITORING AND ASSESSMENT PLAN

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PROPOSED CONCEPTUAL
POST-CLOSURE MONITORING AND ASSESSMENT PLAN
SOLAR EVAPORATION PONDS, OPERABLE UNIT 4
ROCKY FLATS PLANT, GOLDEN, COLORADO

V.1
INTRODUCTION

V.1.1 Purpose and Objectives

This plan is the proposed conceptual post-closure monitoring and assessment plan for the final engineered cover at the Solar Evaporation Ponds (SEP), Operable Unit 4 (OU4) at the Rocky Flats Environmental Technology Site (RFETS) in Golden, Colorado The purpose of this conceptual post-closure monitoring and assessment plan is to provide the basis for the detailed design of an integrated set of monitoring systems capable of providing the types of data required to assess the performance of the final engineered cover This plan also describes, in conceptual terms, the manner in which these data will be acquired, compiled, manipulated, interpreted, and utilized for the purpose of assessing the characteristics and dynamics of the final engineered cover, the vadose zone, and the upper hydrostratigraphic unit ground water system Finally, this plan provides the general basis for routine barrier inspection and care procedures once the system is in place This plan complies with applicable federal regulations (40 CFR 264 Subpart G) and state regulations (6 CCR 264 Subpart G and proposed Subpart S) and follows applicable guidance documents (Cullen and Everett, 1993) The plan is intended to also serve as the final post-closure care and monitoring plan for the solar ponds after closure occurs While review and approval will not occur until some time in the future, the plan has been prepared for submittal with the IM/IRA Decision Document so that agency input can be received early in the process, and so that any devices or monitoring approaches that may be deemed unacceptable to the regulatory agencies are modified to assure acceptability

The engineered barrier is a hybrid design with a performance period exceeding 1,000 years The CHWA regulations require a post-closure care and monitoring period of 30 years, which can be lengthened or shortened by the Department of Health This period will begin following closure and will be used to determine the initial effectiveness of the engineered barrier

V 1.2 Description of Post-Closure Monitoring Systems and Programs

Three primary monitoring systems and implementation programs are selected, conceptually designed, and described in this plan They include the following

- Final engineered cover monitoring system (including both moisture content monitoring and slope stability monitoring) and implementation program,
- Vadose zone monitoring system and implementation program, and
- Ground water monitoring system and implementation program

All three post-closure monitoring programs will be implemented concurrently with the objective of identifying impacts to environmental media from beneath the final engineered cover and assessing the performance of the final engineered cover Each program is designed to provide early warning of migration to a potential medium or receptor The final engineered cover monitoring system and program are designed to measure a loss of integrity of the cover and provide early warning of the potential for water movement into the waste pile The monitoring program also includes slope stability monitoring to assess the stability of the cover and to provide early warning of potential slope failure

The vadose zone monitoring system and program are designed to monitor for movement of liquids through the vadose zone and provide early warning of the potential for contaminant migration to the ground water system The vadose zone monitoring system is also designed to detect movement of water into the waste pile from sources other than infiltration The ground water monitoring system and program are designed to detect releases from beneath the cover and the vadose zone to the ground water The ground water monitoring system and program will function as an early warning system to downgradient potential receptors The ground water monitoring system includes an upper hydrostratigraphic unit ground water monitoring network

The three monitoring systems outlined above will provide several stages of early warning of conditions which may be precursors to a release from the closed unit Instrumentation will be included in the vadose zone monitoring network to verify the presence of excess moisture and to identify any waste constituents present in the pore liquids With this information, preemptive remedial actions can be taken to prevent a release and to avoid a costly ground water cleanup effort The traditional RCRA monitoring approach does not give warning of a release until ground water is already contaminated

A second and equally important consideration driving the need for the monitoring systems specified above is the eventual closure and cessation of the monitoring programs RCRA regulations specify a 30 year monitoring period, at the end of which the monitoring program and performance data must be evaluated to determine if the monitoring may be discontinued The amount and types of data required to satisfy the regulatory agencies that a facility is performing as designed have not yet been specified However, it is highly likely that ground water monitoring alone will be insufficient to justify cessation of monitoring The body of data available from the three monitoring programs outlined above should provide sufficiently detailed information to fully understand the performance of the final engineered cover, and to justify elimination of all or most of the monitoring after the specified 30 year period

The monitoring systems proposed in this conceptual design are not limited to monitoring to detect releases that occur from the closed unit They are also designed to provide an understanding of the performance characteristics of the engineered cover under varying climatological conditions This understanding is required in order to develop sufficient confidence in the cover design to eliminate active monitoring and maintenance of the cover system beyond the 30 year monitoring period In addition, sufficient areal coverage is required in the monitoring instrumentation to be able to pinpoint a specific portion of the cover in the event a potential release is detected A higher degree of areal coverage will allow for

identification of problems in limited areas, which may only require small repairs in the cover, versus a failure over the entire cover which would indicate a design problem

V.1.3 Organization of the Plan

This plan is organized into nine major sections Section V 2, Design Basis, includes an overview of the regulatory framework under which this post-closure monitoring plan was developed It also identifies the performance criteria that were established to facilitate appropriate selection of the three post-closure monitoring systems The section explains how the design of the final engineered cover is integrated with the post-closure monitoring systems

Section V 3, Technology Evaluation and Selection, explains how the various vadose zone monitoring technologies were selected based on the criteria of effectiveness, implementability, and relative cost, and how the optimum set of monitoring technologies were assembled in a manner that fulfills the applicable performance criteria identified in Section V 2 2

Section V 4, Conceptual Design of Monitoring System, develops the monitoring alternatives assembled in Section V 3 to the conceptual level At this point in the design process, the systems are portrayed schematically in plan view and profile (when applicable) and in the context of the final engineered cover design It is important to design the monitoring system in the context of the final engineered cover design at this conceptual level because the engineered barrier and the monitoring systems are so closely integrated The integration of the two designs will continue in all subsequent phases of design and construction

Section V 5, Sampling and Analysis Plan, identifies the types of samples that will be collected and the types of analyses that will be performed for all three components of the post-closure monitoring system The level of detail provided in this conceptual document is relatively low, but includes the proposed sampling/measurement frequencies and proposed analyses (when applicable)

Section V 6, Monitoring System Assessment Program, discusses what data will be evaluated and provided in the Annual Monitoring Assessment Reports The major components of these annual reports are outlined in this section

Section V 7, Post-Closure Care Activities, identifies the required components of the Engineered Barrier Inspection and Care Program The applicable record keeping and reporting practices that are currently used by EG&G during monitoring activities at the RFETS are also described These same practices will be utilized during post-closure monitoring system construction and monitoring Where applicable, RFETS Standard Operating Procedures (SOPs) are cited A brief description and the intent of each of these components is provided in this section

Section V 8, Post-Closure Performance and Assessment, describes the required types and frequency of reporting that will occur to document the performance of the final engineered cover The types of data and methods by which they will be presented in these Performance and

Assessment reports are outlined in this section These reports serve as a mechanism to assess the status of the post-closure monitoring systems and the reports may also serve as the basis for proposals regarding modifications to the sampling program or frequency Such modifications may include recommendations for the upgrade and/or abandonment of certain portions of the system through time

Section V 9, Monitoring System Abandonment, describes the methods that will be used to abandon specific components of the post-closure monitoring system Where applicable, RFETS SOPs are cited

Cost and Schedule information and an Implementation Plan (Construction Narrative) are not included in this document Because the cost, schedule, and implementation plan for the post-closure monitoring system are integrated with those for the final engineered cover, the cost, schedule, and implementation plans for the post-closure monitoring system were integrated into Part IV of this document A brief summary of important cost assumptions is provided in Section V 5 4

V 1 4 Integration with Future RFI/RI Activities

Planned future RFI/RI activities in OU4 will investigate potential impacts to ground water in the area Although the schedules are uncertain, efforts will be made to ensure communication between the groups developing and conducting the RFI/RI and the parties developing the post closure operation network An opportunity exists to combine and integrate the ground water monitoring system of the future RFI/RI activities with the monitoring system for the OU4 post-closure activities This is especially true since the planned future RFI/RI activities are scheduled to occur before construction of the final engineered cover and post-closure monitoring system This plan will be integrated to the greatest extent possible and practical with the future RFI/RI activities such that the data collected for each program complement but do not duplicate or compromise the other Commonality between the two activities will most likely occur in the ground water monitoring aspects of the two activities, including well locations

V 2
DESIGN BASIS

V 2.1 Regulatory Framework

Remediation of OU4 is part of a comprehensive, phased program of characterization, remedial investigations, feasibility studies, interim measures/remedial actions, and remedial/corrective actions currently in progress at RFETS These investigations are pursuant to an Interagency Agreement (IAG) among the U S Department of Energy (DOE), the U S Environmental Protection Agency (EPA), and the Colorado Department of Public Health and the Environment (CDPHE) dated January 22, 1991 The IAG addresses general and specific regulatory requirements identified in the following environmental acts as administered by the EPA

- Resource Conservation and Recovery Act (RCRA),
- Hazardous and Solid Waste Amendments [to RCRA] of 1984 (HSWA),
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and
- Superfund Amendments and Reauthorization Act of 1986 (SARA)

In addition to and consistent with the IAG, the remedial activities at the RFETS are conducted under the requirements stated in the HSWA permit issued to DOE by the CDPHE Under both the IAG and the HSWA permit, the IAG addresses general and specific regulatory requirements identified in the Colorado Hazardous Waste Act (CHWA) as administered by the CDPHE State regulations governing the management of hazardous wastes are contained in 6 CCR 1007-3 The final remedy for the SEPs, as addressed in the IAG and HSWA process, must meet the administrative and substantive requirements of State closure and post-closure plans

The IAG outlines the regulatory process which satisfies the requirements of these environmental acts (Table 6 in the IAG) Currently, the SEPs are considered an interim status unit under closure and post closure care per the requirements of 6 CCR Part 265 Subpart G for surface impoundments The IM/IRA is equivalent to the State's Closure Plan, the specifics of the post-closure activities will be contained in the Post Closure Permit By reference, the interim status regulations for post-closure care monitoring incorporate the substantive requirements of Part 264 Subpart F for permitted facilities Additionally, the HSWA permit requires post-closure care monitoring of the closed unit Therefore, the Post-Closure Care Monitoring and Assessment Plan will substantially meet the requirements of 6 CCR Part 264

The monitoring and assessment program is divided into three components 1) final engineered cover system, 2) vadose zone system, and 3) ground water system Each component was designed to be in conformance with applicable RCRA regulations, as well as other applicable or relevant and appropriate requirements (ARARs) Where applicable, the technical

rationale and detail of each monitoring system and associated data assessment programs was designed with the aid of relevant technical guidance documents

Note that other monitoring and maintenance activities will be required as part of post-closure care, specifically monitoring, inspection, and maintenance of the final engineered cover system (264 118(b), 264 310 (b)) The general scope and requirements of these activities are presented in Section V 7 of this document for informational purposes Specific requirements of these activities will become evident as the design progresses Then, specific details regarding inspection activities, monitoring and inspection frequencies, performance assessment and performance criteria will be developed This information will be presented in the post-closure plan

V.2 1.1 Final Engineered Cover Monitoring System

Specific regulations prescribing monitoring requirements for cover systems are not promulgated to date Available technical guidance for both cover design (USEPA, 1991) and vadose zone monitoring system (Durant et al , 1993) served as the design basis for a monitoring system that emphasizes the early detection of moisture migration within the cover and the waste

EPA (1992) states its position on vadose zone monitoring in the recent update to the RCRA Groundwater Technical Enforcement Guidance Document (TEGD) entitled "*RCRA Groundwater Monitoring Draft Technical Guidance*" (EPA/530-R-93-001) In this document, EPA states "**The Agency recommends unsaturated zone monitoring where it would aid in detecting early migration of contaminants into groundwater** The Regional Administrator also can require this monitoring on a case-by-case basis as necessary to protect human health and the environment under 3004(u) and 3005(c) " Federal direction for vadose zone monitoring is also provided in this EPA document wherein it is stated that vadose zone monitoring can be used to detect any release(s) from the hazardous waste management area before significant environmental contamination has occurred Further, the guidance states that "The use of vadose zone monitoring equipment can potentially save the owner/operator considerable expense by alerting him or her to the need for corrective action before large volumes of the subsurface have been contaminated " Lastly, the guidance document states "Moreover, the Agency is currently updating its existing guidance on vadose zone monitoring " That vadose zone guidance has been submitted in draft form to EPA (Cullen and Everett, 1993) In the interim, the elements, applications, and limitations of a vadose zone monitoring program are provided by Wilson (1980) and USEPA (1986)

It is highly likely, based on the current Federal EPA and State Agency trend toward requiring vadose zone monitoring, that vadose zone monitoring will eventually be required for the SEP unit Preliminary guidance from CDPHE confirms that this is the case In the event that vadose zone monitoring were required at a later date, the cost of retrofitting the SEP facility with vadose zone monitoring equipment would far exceed the cost of installing such equipment during the construction of the engineered cover In addition, the potential for damaging, and subsequently requiring repair of, the engineered cover during a vadose zone monitoring installation is extremely high Therefore, the design of the monitoring systems outlined in this

document represents a less costly alternative than retrofitting in the event that future regulations require vadose zone monitoring

With regard to CERCLA guidance, EPA states (Guidance for Remedial Actions for Contaminated Groundwater at Superfund Sites, EPA/540/G88/003) that "Another goal of performance monitoring is to ensure that any source control action completed at the site effectively prevents further degradation of ground water To achieve this goal, it may be necessary to monitor the unsaturated zone using techniques such as soil-gas monitoring to detect contaminants before they reach the ground water "

V 2.1.2 Vadose Zone Monitoring System

Regulations prescribing specific monitoring requirements for the vadose zone beneath closed surface impoundments, such as the SEP, have not been promulgated to date Technical guidance for such a program, however, is based on vadose zone monitoring requirements for land treatment units (CCR 264 278) Specific requirements of the vadose zone monitoring program for hazardous waste landfarms include the installation of a sufficient number of sampling points at appropriate locations and depths to yield samples to represent background concentrations not affected by the unit (CCR 264 278 (b)) and to detect statistically significant changes in concentrations for any hazardous constituent (CCR 264 278 (f)) In the case of the SEP closure, background concentrations are compared to soil-pore water quality conditions beneath the engineered barrier and above the subsurface drainage layer This program is presented in Section V 4 of this document

Vadose zone monitoring requirements under CCR 264 278 also include the development and use of consistent sampling and analysis procedures to ensure results that provide a reliable indication of soil-pore liquid quality These procedures include sample collection, preservation and shipment, analytical procedures, and chain of custody control These procedures are discussed in Section V 5 2 of this document

To aid in the design of a vadose zone monitoring program and the assessment of data collected under such a program, the USEPA has developed technical guidance document including EPA's approach to vadose zone monitoring (Durant et al , 1993) and the "*Draft Permit Writer's Guidance Manual for Monitoring Unsaturated Regions of the Vadose Zone at RCRA, Subtitle C Facilities*" (Cullen and Everett, 1993) These documents were used to develop the conceptual design for the vadose zone monitoring system for the SEP closure

V 2 1 3 Ground Water Monitoring System

Post closure monitoring of ground water is required under 6 CCR 1007-3, Part 265 This monitoring program is subject to regulations governing releases from applicable units (265 Subpart F) including requirements for the ground water monitoring system (265 91), sampling and analysis (265 92), data evaluation and response (265 93) and recordkeeping and reporting (265 94) Applicable units include those that received hazardous waste after July 26, 1992 and closed after January 1, 1983

The general ground water monitoring requirements include the design of a sufficient number of wells to 1) represent background water quality, 2) represent water quality at the point of compliance, and 3) allow for detection of contamination emanating from the regulated unit This program is described in Section V 4 3 of this document

The general ground water monitoring requirements include the adequate construction of monitoring wells (265 91(c)), the collection of ground water samples (265 92(a)), and the analysis of samples (265 92 (b)) These procedures are described in Section V 5 3 of this document

Finally, the general ground water monitoring requirements include procedures to be used in evaluating ground water monitoring data (265 93) and assessment of data These procedures are presented in Section V 6 of this document

To aid in the development of the ground water monitoring program, the USEPA has developed numerous technical guidance documents including "*Ground Water Monitoring Draft Technical Guidance*" (USEPA, 1992) and "*The Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities*" (USEPA, 1992) These guidance documents were used to develop the ground water monitoring program for the SEP

V 2.2 Performance Criteria

Preliminary performance criteria have been developed to evaluate technologies that may potentially be used in the monitoring system for the remedial action at OU4 Technologies that do not meet these performance criteria will not be considered for use The criteria were developed to establish the minimum level of performance for the post-closure monitoring and assessment system These performance criteria are based on limited quantitative requirements for the post-closure monitoring systems Specific, quantitative requirements will be negotiated with CDPHE during the Post Closure Permit application process This conceptual design and the performance requirements specified herein do not serve as final post-closure monitoring requirements The criteria in this section are for the purpose of identifying and screening potential technologies for use in monitoring the performance of the selected remedy

Because the engineered cover/barrier, vadose zone, and ground water components of the monitoring system will differ in design and methods, the performance criteria for each system are, for the most part, unique However, the primary goal of each monitoring system is to verify that the selected remedial alternative is providing the intended containment and isolation of potential ground water contaminants

V.2.2 1 Engineered Cover Monitoring System

The performance criteria for the engineered cover component of the monitoring system at OU4 are listed below In order for the engineered cover monitoring system to be selected for implementation, it must

1) **Be feasible to install, operate and sample with respect to the site hydrogeology and the selected engineered remedial alternative.**

It must be physically possible to install the proposed sampling and measurement instrumentation and equipment Sampling and measurement instrumentation and equipment to be installed as a part of the post closure cover/vadose zone monitoring system must be capable of operating under the site conditions as dictated by the hydrogeology and engineered design of the site

2) **Provide data that can be used to identify and provide early warning of conditions conducive to penetration of water through the final engineered cover**

The final engineered cover is designed to prevent movement of infiltrating precipitation waters into the consolidated materials The monitoring system must provide data that will indicate when conditions are such that infiltrating water can potentially move through the overlying final engineered cover system and into the underlying consolidated materials Such conditions are indicated by a combination of analysis of climatic (precipitation) data and soil moisture data in the cover material Monitoring by use of climatic data alone is not sufficient because of the potential concentration of runoff waters at the surface (it is assumed that a surface drainage system will be incorporated into the barrier design), and the consequences of unusually heavy and/or sustained periods of precipitation

3) **Provide adequate spatial coverage**

The monitoring system must provide spatial coverage such that it is reasonably certain that the development of conditions potentially conducive to infiltration into the waste pile will be detected The monitoring system must also provide adequate spatial coverage to allow specific problem areas to be identified where migration of fluids may be occurring

4) **Provide adequate temporal coverage**

The monitoring system must provide temporal coverage such that early warning of conditions conducive to infiltration and potential contaminant migration from the waste pile can be achieved before impacts to ground water occur The monitoring system must also be capable of collecting sufficient data to identify seasonal trends,

if any, in the monitoring parameters and allow analysis of the correlation between hydrologic events that occur outside of the cover with those that occur within

5) **Provide data upon which to base a release response action.**

Measurement of a change in the subsurface soil moisture conditions within the final engineered cover indicates potential subsurface migration It does not provide diagnostic evidence that contaminants have migrated from the waste pile The monitoring system must provide data of sufficient sensitivity necessary to make decisions regarding an appropriate response Threshold values of change that would trigger initiation of an appropriate response must be identifiable Appropriate release responses are varied and site-specific, but they may include actions such as an unscheduled maintenance inspection of the final engineered cover system

6) **Provide for remote and automatic monitoring of data.**

Regular manual monitoring over an extended period of time requires a significant annual expenditure of resources in terms of the labor and equipment required to obtain the data The monitoring system must be capable of automatic acquisition and logging of data to reduce long term operation and maintenance costs Remote access of data generated by the monitoring system must be available via telemetry or telephone hookup

7) **Be integrated into the design and construction of the selected remedial alternative**

The cost of installation of monitoring points is generally greater when implemented after construction of the remedial alternative In order to maximize efficiency of construction and the effectiveness of the monitoring system in terms of placement of the monitoring points, the monitoring system must be integrated into the design and construction of the final engineered cover The monitoring system must be integrated into the design of the final engineered cover such that it does not substantially or unnecessarily interfere or compromise the integrity of the final engineered cover

8) **Incorporate monitoring techniques that are precise**

The monitoring system must provide measurements and or samples that have an acceptable degree of precision Standards of precision will vary with the particular kind of instrumentation selected for use in the project Measurement precision standards will be identified, in subsequent documentation, that address evaluation of alternative parameter measurement techniques and equipment Variability that is measured/sampled with the monitoring system must be attributable to the media or conditions being monitored, and must be distinguishable from variability introduced by the monitoring system itself

9) **Incorporate planned redundancy.**

The system must be designed such that failure of one monitoring point does not result in failure of the entire monitoring system Redundant sampling and measurement systems are necessary due to the complexities of unsaturated conditions in the engineered cover and because of the construction cost associated with replacement of such systems Redundant systems must act in a confirmatory capacity in terms of acquisition and interpretation of monitoring data, as well as in the case of instrument failure

10) **Be cost effective to install, operate, and maintain**

The financial resources for remediation and post-closure monitoring are finite The design of the post closure monitoring system must be fiscally efficient as well as protective of human health and the environment by providing early warning of conditions conducive to contaminant migration to the water table Systems requiring excessive maintenance are not practical, and will not be considered

11) **Incorporate proven technologies that have a record of performance for measuring, sampling, and analyzing soil and vadose zone monitoring parameters.**

Implementation of a monitoring system for the final engineered cover does not represent a research effort, and is not intended as a development or testing program for innovative monitoring techniques The primary monitoring system will consist of equipment and techniques that have been previously tested

12) **Should not compromise the functioning of the engineered cover in any way**

The effect of the monitoring equipment upon the integrity of the engineered cover will be evaluated, and methods will be developed not to adversely impact or affect the engineered cover All necessary actions will be taken to ensure the integrity of the engineered cover is not compromised

V 2 2 2 Vadose Zone Monitoring System

The performance criteria for the vadose zone component of the monitoring system at OU4 are listed below In order for the vadose zone monitoring system to be selected for implementation, it must

1) **Be feasible to install, operate and sample with respect to the site hydrogeology and the selected engineered remedial alternative.**

It must be physically possible to install the proposed sampling and measurement instrumentation and equipment Sampling and measurement instrumentation and equipment to be installed as a part of the post-closure vadose zone monitoring system

must be capable of operating under the site conditions as dictated by the hydrogeology and engineered design of the site

2) **Provide data that can be used to identify the production and migration of leachate within the waste pile.**

Production of leachate within the waste pile (whether as the result of vertically infiltrating waters or laterally intruding waters) will be prevented by the final engineered cover, and by preserving low unsaturated hydraulic conductivity of the waste as indicated by soil moisture conditions in the waste pile The monitoring system must be capable of identifying moisture conditions within the waste pile that indicate the production of leachate or of significant migration of leachate from the waste pile Detection of water movement into, within, or out of the waste pile will be considered an indicator of conditions conducive to potential leachate migration

3) **Provide data that can be used to identify the movement of water into the waste pile.**

Water movement into the waste pile is undesirable as it may be a precursor to production and subsequent migration of leachate Monitoring points must be installed to identify water moving into the waste pile (from sources other than surface infiltration monitored by the final engineered cover monitoring system, Section V 2 2 1), including 1) lateral sources, as in the case of perched water moving along horizontal preferential flow pathways, and 2) below, as in the case of a rising water table Detection of water movement into, within, or out of the waste pile will be considered an indicator of conditions conducive to potential leachate migration

4) **Provide data that can be used to identify movement of leachate out of the waste pile**

Monitoring points must be installed such that conditions can be identified that indicate water movement out of the waste pile Detection of water movement into, within, or out of the waste pile will be considered an indicator of conditions conducive to potential leachate migration

5) **Provide adequate spatial coverage**

The OU4 subsurface was characterized in Part II of this IM/IRA-EA DD Part of the purpose of that characterization was to identify vadose zone contaminant transport pathways The monitoring system must be designed to monitor the vadose zone contaminant transport pathways as identified in Part II In addition, the monitoring system must provide sufficient spatial coverage to identify problem areas within the cover area

6) **Provide adequate temporal coverage.**

The monitoring system must provide temporal coverage such that early warning of conditions conducive to potential contaminant migration from the waste pile can be achieved in the underlying vadose zone before potential impacts to ground water occur The monitoring system must also be capable of collecting sufficient data to identify seasonal trends, if any, in the monitoring parameters and allow analysis of the correlation between hydrologic events that occur outside of the waste pile with those that occur within

7) **Provide data upon which to base a release response action.**

Measurement of changes in the vadose zone soil moisture conditions indicates the potential for subsurface migration It does not provide diagnostic evidence that contaminants have migrated from the waste pile The monitoring system must provide data of sufficient sensitivity to make decisions regarding an appropriate release response Threshold values of change in the measured parameters, that will trigger initiation of an appropriate release response, must be identifiable Appropriate release responses are varied and site-specific but may include actions such as an unscheduled maintenance inspection of the final engineered cover, direct sampling and laboratory analysis of vadose zone pore liquids using suction lysimetry, or dewatering of perched water layers Lysimetry will be used to determine the pore water chemistry in order to establish whether or not a release has occurred

8) **Provide for remote and automatic monitoring of data.**

Regular manual monitoring over an extended period of time requires a significant annual expenditure of resources in terms of the labor and equipment required to obtain the data The monitoring system must be capable of automatic acquisition and logging of data to reduce long term operation and maintenance costs Remote access of data generated by the monitoring system must be available via telemetry or telephone hookup

9) **Be integrated into the design and construction of the selected remedial alternative**

The cost of installation of monitoring points is generally greater when implemented after construction of the remedial alternative In order to maximize efficiency of construction and the effectiveness of the monitoring system in terms of placement of the monitoring points, the monitoring must should be integrated into the design and construction of the selected remedial alternative The monitoring system must be integrated into the design of the selected remedial alternative such that it does not substantially or unnecessarily interfere or compromise the integrity of the selected remedial alternative

10) **Incorporate monitoring techniques that are precise.**

The monitoring system must provide measurements and or samples that have an acceptable degree of precision Standards of precision will vary with the particular kind of instrumentation selected for use in the project Measurement precision standards will be identified, in subsequent documentation, that address evaluation of alternative parameter measurement techniques and equipment Variability that is measured/sampled with the monitoring system must be attributable to the media or conditions being monitored, and must be distinguishable from variability introduced by the monitoring system itself

11) **Incorporate planned redundancy**

The system must be designed such that failure of one monitoring point does not result in failure of the entire monitoring system Redundant sampling and measurement systems are necessary due to the complexities of unsaturated conditions in the vadose zone and because of the construction cost associated with replacement of such systems Redundant systems must act in a confirmatory capacity in terms of acquisition and interpretation of monitoring data, as well as in the case of instrument failure

12) **Be cost effective to install, operate, and maintain.**

The financial resources for remediation and post-closure monitoring are finite The design of the post closure monitoring system must be fiscally efficient as well as protective of human health and the environment by providing early warning of conditions conducive to contaminant migration to the water table Systems requiring excessive maintenance are not practical, and will not be considered

13) **Incorporate proven technologies that have a record of performance for measuring, sampling, and analyzing soil and vadose zone monitoring parameters.**

Implementation of a vadose zone monitoring system does not represent a research effort, and is not intended as a development or testing program for innovative monitoring techniques The primary monitoring system will consist of equipment and techniques that have been previously tested

V.2.2.3 Ground Water Monitoring System

The performance criteria for the ground water component of the monitoring system at OU4 are listed below In order for the ground water monitoring system to be selected for implementation, it must

1) **Comply with appropriate regulations.**

Ground water monitoring programs for HSWA permitted land units such as OU4 are regulated under 40 CFR (Resource Conservation and Recovery Act) Part 264 and 6 CCR (CHWA) Part 264 Standards for Owners and Operators of Hazardous Waste TSD Facilities Statistical analysis of ground water-quality data is governed by the EPA guidance document "Statistical Analysis of Ground Water Monitoring Data at RCRA Facilities" (USEPA, 1989)

2) **Be feasible to install, operate, and sample with respect to the site hydrogeology and the selected engineered remedial alternative.**

It must be physically possible to install and access the wells included in the monitoring system Individual components of the ground water monitoring system must be compatible and appropriate for site hydrogeology and the selected remedial alternative

3) **Be integrated into the design and construction of the selected remedial alternative.**

The monitoring system must be integrated into the design of the selected remedial alternative, to the extent required, such that it does not in any way interfere or compromise the integrity of the selected remedial alternative Wells may be located within the perimeter of the site remedial alternative These wells must be installed during construction of the alternative Access to the wells must also be ensured Sufficient room to perform well sampling also needs to be provided

4) **Be consistent with the "RCRA Ground Water Monitoring· Draft Technical Guidance" (USEPA, 1992).**

Well casing must be screened and the annulus filled with properly sized sand across the aquifer section(s) of concern The annulus shall be filled with cement grout or bentonite slurry above the aquifer The wells will require replacement and maintenance over time due to problems such as biological and sediment fouling of the screen Well maintenance must be consistent to ensure that the ground water-quality data are comparable over time Well replacement and/or maintenance activities should not compromise the accuracy or precision of the ground water quality data

5) **Be capable of yielding ground water in sufficient quantity to provide ground water samples for the required analyses.**

The wells must be of a large enough diameter and be correctly screened to allow purging and sample collection in sufficient quantity to complete the required analyses, recognizing that there may be limitations in ground water yield due to the aquifer characteristics Alternative purging methods will be evaluated and those judged appropriate will be incorporated into the SOP To the extent possible, monitoring wells will be installed in locations that yield a sufficient flow and recovery rate

6) **Provide ground water-quality data from wells both hydraulically upgradient and downgradient of OU4.**

There shall be an appropriate number of upgradient wells that are constructed in the upper hydrostratigraphic unit and are not affected by OU4 There shall be an appropriate number of wells at the downgradient limit of OU4 The downgradient wells may be located at the edge of the engineering barrier, or as close to the edge of the barrier as practical, given particular elements of the design such as access roads or drainage The downgradient wells shall be constructed in the appropriate aquifer and provide timely detection of constituents of concern that may have potentially migrated from the closed unit to the aquifer The location and number of wells shall be sufficient to provide ground water-quality data representative of the entire upgradient and downgradient flow across OU4

V 2 3 Integration of the Monitoring Systems with the Final Engineered Cover Design

Installation of the monitoring equipment for each of the proposed monitoring systems requires integration with the design of the final engineered cover to ensure compatibility of materials as well as feasibility of placement The ground water monitoring system may be constructed after completion of the final engineered cover, however, integration of existing wells and new wells constructed as part of future RI/RFI activities may require planning to prevent damage to wells during construction of the final engineered cover

The final engineered cover and vadose zone monitoring systems must be placed in concert with the construction schedule for the final engineered cover Much of the vadose zone monitoring equipment will be placed directly following removal of the liners, but installation must occur in concert with the placement of the gravel underdrain The installation of monitoring equipment in the final engineered cover itself must be closely coordinated with the placement plans for the final engineered cover

A precise description of the completion and installation of the monitoring system is not possible until details of the engineered barrier system are finalized Illustrations of the equipment, installation details, mounting details, and details on the abandonment procedures will be included as part of the detailed design

The majority of the coordination between the final engineered cover design and the monitoring systems design will occur during detailed design Additional details on the integration of the construction schedules are provided in the Master Implementation Plan (Construction Narrative) (see Part IV)

V.3
VADOSE ZONE MONITORING TECHNOLOGY EVALUATION AND SELECTION

V.3.1 Technology Evaluation and Selection Methodology

Vadose zone monitoring instrumentation and technologies was first considered as an integral component of a ground water quality monitoring system by Todd et al (1975) The Environmental Protection Agency recognized the merits of monitoring between the source (i e anthropogenic contaminants) and the target (i e ground water) and developed one of the first institutional evaluations (EPA, 1976) of vadose zone monitoring strategies and instrumentation Wilson (1980) and Morrison (1983) later presented general evaluations of vadose zone instrumentation and methodologies

Everett et al (1984) summarized the previous decade of research and evaluation of vadose zone monitoring methodologies, suggested methods for conceptualizing the design of a monitoring network, and identified appropriate direct and indirect methods for monitoring pollutant movement in the vadose zone Dorrance et al (1991) elaborated on direct monitoring methodologies for the vadose zone and identified sampling devices that have characteristics which will provide suitable vadose zone pore liquid samples Greacen (1981) and other authors (Kramer, 1990, 1991, and 1992, Franklin et al , 1992, Brose and Shatz, 1987) provided detailed evaluations of indirect monitoring devices with specific emphasis on neutron moderation

Weirenga et al (1993) discussed methods and practices currently accepted for use to monitor properties and conditions in the geologic profile in support of a license application for the disposal of low-level radioactive waste EPA (1993) provides an extensive list of subsurface monitoring instrumentation and techniques which are presented for the purpose of assisting in the development of a monitoring plan Cullen (1993) and Cullen et al (1993) provide a rationale and method of design for a multiphase vadose zone monitoring network Cullen et al (1994) expand on the design methodology and demonstrate that the cost of remediating a future contaminant release far exceeds the cost of current monitoring above the ground water in the vadose zone to prevent ground water degradation

Cullen and Everett (1993) summarized the extensive previous instrument and methodology evaluations in a draft guidance document under review as a companion document to EPA (1993) and rules previously drafted and under consideration for adoption which will facilitate implementation of vadose zone monitoring at the federal level Many states have already adopted vadose zone regulations more stringent than those under consideration by the federal government

This section presents the evaluation and selection methodology used to select the preferred monitoring alternative for the final engineered cover and the vadose zone monitoring systems The screening process is predated by and relies heavily upon published research into and evaluations of the applicable monitoring methodologies This process consists of two parts Monitoring technologies that are generally applicable to the monitoring objectives described in Section V 1 1 are first identified The technologies are screened to eliminate those that are

limited with respect to meeting the technical feasibility of the monitoring objectives Once technically feasible technologies are identified, they are evaluated with respect to the performance criteria described in Section V 2 2 Screening of the monitoring options will result in a preferred post-closure monitoring system which best satisfies the performance criteria and represents the most appropriate monitoring system for the site

An evaluation and selection of ground water monitoring technologies is not performed because ground water monitoring wells are considered the standard technology for monitoring ground water quality No other technologies are available which consistently produce reliable, high quality data and are capable of meeting the ground water monitoring system performance objectives described in Section V 2 2 3 Monitoring wells will be installed, maintained, monitored, and sampled according to accepted practices in SOPs (see Section V 6 3) used at the Rocky Flats Plant The conceptual design and layout of the ground water monitoring system is presented in Section V 4 3

V 3 1.1 Technology Screening Criteria

The screening criteria used to eliminate those technologies and process options that are limited with respect to meeting the technical feasibility of the monitoring objectives are described for each technology and process option in Tables V 3-1 and V 3-2 The screening criteria include the following, listed in order of importance

- Effectiveness
- Implementability
- Relative Cost

Effectiveness is defined as the ability of a given technology to monitor the performance of the cover systems, to collect sufficient spatial and temporal data within the final engineered cover and the vadose zone beneath the final engineered cover to provide early warning of conditions conducive to migration of precipitation and/or leachate through the final engineered cover and the waste layer, to have a proven record of providing precise and reliable data with respect to the soil moisture conditions of the unsaturated zone, and to protect human health and the environment during construction phases of the monitoring systems In addition, the technology should be reliable and proven with respect to monitoring under local conditions at the site The IAG schedule does not allow a lengthy research and development period, thus monitoring methodologies and technologies that have been proven only at bench or pilot-scale levels without a demonstrated record of full-scale implementability were not considered to be proven technologies

Implementability is defined as the ability of a given monitoring technology to obtain necessary approval from government agencies and to comply with regulatory requirements and the degree to which a monitoring options is feasible to install, operate, and sample with respect to site hydrogeology and the design of the final engineered cover Although implementability primarily considers institutional factors, technical implementability is also considered The

definition of implementability also includes consideration of the availability of required equipment and personnel, and integration with the cover system and the Phase II RFI/RI Monitoring options which may compromise the integrity of the final engineered cover when installed are determined to not be implementable at OU4 Monitoring systems that penetrate the engineered barrier in areas which do not overlie waste materials are considered acceptable

The cost evaluation criterion for this preliminary screening is defined as the relative capital, operation, and maintenance costs associated with a given monitoring technology Costs are estimated using best engineering judgement and are presented as low, medium, or high Cost comparisons are only performed between technologies that are comparable with respect to the type of remedial technology Cost is considered the least important criterion in evaluation of the technologies Technologies and process options which are not effective and/or implementable are not retained and are eliminated from further consideration The cost evaluation criterion is used only to eliminate technologies and process options which are substantially more expensive than options which are equally effective and implementable

The following subsections discuss the various monitoring technologies considered in this initial screening process Tables V 3-1 and V 3-2 summarize the screening of technologies for the engineered barrier/cover monitoring system and the vadose zone monitoring system, respectively More detailed descriptions of each process option and its effectiveness, implementability, and relative cost are presented in the following subsections

V 3 2 Description of Monitoring Technologies and Process Options

Two major vadose zone monitoring technologies are available to monitor the unsaturated zone The following sections provide brief descriptions of direct and indirect pore-liquid monitoring techniques which are potentially applicable to development of monitoring systems for the final engineered cover and the vadose zone beneath the final engineered cover Indirect pore-liquid monitoring refers to vadose zone monitoring techniques which do not directly measure the pore-liquids by physically collecting a sample of them Instead, indirect pore-liquid monitoring techniques rely on indirectly measuring the state of the unsaturated zone by correlating the soil moisture with other physical properties of the soil and pore-liquids Direct pore-liquid monitoring techniques are those monitoring methods which are able to collect samples of the pore-liquids directly from the vadose zone

V 3.2 1 Technology Type· Indirect Pore-Liquid Monitoring

V 3 2.1 1 Vadose Zone Indirect Pore-Liquid Monitoring Option: Tensiometers

Tensiometers can be used to measure soil water tension, also known as soil suction, in unsaturated portions of the vadose zone (ASTM, 1992) A tensiometer consists of a sealed body tube with a porous ceramic cup on one end and a vacuum measuring device, such as a gauge or transducer, on the other end Water in the pores of the ceramic cup are placed in intimate contact with water films in the pores and void spaces of unsaturated soils The pores of the ceramic cup are sufficiently small (less than 2 5 micrometers [μm] in diameter) such that water will be retained against a gradient of at least 100 centibar (cbar) across the cup by

capillary forces When placed in a soil with a soil suction greater than zero, water will move out of the body of the tube, through the porous ceramic, and into the surrounding soil As the water moves out of the tube, a vacuum or negative pressure, is created Water will cease to move out of the body of the tube when the vacuum exactly opposes the soil suction drawing the water out of the instrument As soil water is depleted by evaporation or transpiration, or replenished by precipitation, corresponding changes in soil suction can be measured using the tensiometer

Since tensiometers are vacuum based, the theoretical range of operation is 0 to 1 atmospheres (atm [1 atmosphere is approximately equal to 1 bar]) Because of small leaks, dissolved oxygen in water, and other inefficiencies, the practical range of measurement is approximately 0 to 0 8 bars at sea level Increasing altitude decreases the range of measurement by approximately 3 4 cbar per 1000 feet of elevation Measurements made with a tensiometer must be corrected for the vertical length of the water column between the ceramic cup and the vacuum measuring device Even when the soil surrounding the porous cup of a tensiometer is saturated, the uncorrected tension at the readout position will measure 0 1 cbar per centimeter (cm) (0 25 cbar per inch) of vertical length between the ceramic cup and the readout Furthermore, the range of measurement of the tensiometer is reduced by that length

For example, at the RFETS (elevation approximately 6,000 feet above sea level) with a tensiometer cup placed 2 meters below the gauge and ground surface, the range of measurement would be as follows

$$80\,cbars - \left(6{,}000\,ft \times \frac{3\,4\,cbar}{1{,}000\,ft}\right) - \left(200\,cm \times \frac{0\,1\,cbar}{cm}\right) = 39\,6\,cbar$$

The above calculation illustrates the fundamental constraints that are inherent to the use of tensiometers for subsurface measurement of soil suction Tensiometers are typically best suited for applications where the soil suction readings are made within three meters of the surface installation point or where soil samples can be brought to the surface so that a tensiometer can be subsequently inserted for measurement

Tensiometers can be successfully used to determine hydraulic head gradients in the unsaturated zone and to observe spatial and temporal variations in the soil water status of the unsaturated zone When used in combination with a soil water characteristic curve, tensiometers can be used to measure unsaturated water content

V 3 2 1 2 Vadose Zone Indirect Pore-Liquid Monitoring Option: Thermocouple Psychrometers

Psychrometers measure soil-water pressure under very dry conditions where a tensiometer unit is ineffective because of air entry problems Basically, the soil-water psychrometer measures the relative humidity of the subsurface atmosphere in the unsaturated

zone and infers the soil suction based on the relationship between negative soil-water potential and the relative humidity of soil water (Everett et al , 1984)

Psychrometers consist of a porous bulb chamber to sample relative humidity of a soil, a sensitive thermocouple, heat sink, reference electrode, and associated electronic circuitry Such units use the principle of Peltier cooling to lower the temperature of one junction of the thermocouple below the dew point, thereby allowing an evaluation of the relative humidity

Two types of thermocouple psychrometers (TCP) are available One unit, installed in access tubes, consists of positioning psychrometers in porous cups at the base of the tubing This unit may be withdrawn for re-calibration at regular intervals The second type of unit, called the "sealed cup" psychrometer, has the thermocouple unit permanently sealed into a porous enclosure

Each psychrometer must be calibrated before field installation Calibration stability of the units is variable depending on the type of psychrometer used Sealed cup psychrometers are generally more reliable than the access tube type Improved data accuracy can be achieved by taking multiple readings using automatic techniques and computer processing instead of manually operating the data collection system

Psychrometers have been employed at depths varying from a few inches to over 300 feet and in a wide variety of hydrogeologic settings They have been found to be most useful in measuring water potential in dry soils A primary assumption in their operation is that the ceramic material in which the thermocouple is embedded is in equilibrium with the native soil water The degree to which this assumption is met directly affects the accuracy of the measurements This assumption is most valid when the pore size distribution of the ceramic closely matches that of the surrounding soil When installing the psychrometer in coarse material, care must be taken to establish good contact between the cup and the surrounding formation In tight, well-indurated material or at great depths, this is difficult, and non-representative measurements may occur

Fluctuations in temperature affect the reading of thermocouple psychrometers and can cause errors Psychrometer readings are subject to hysteresis in their characteristic curves Determining whether the test area is drying or wetting during the measurements is important to accurately interpret the readings Field studies indicate that psychrometers perform very poorly in wet media (water pressures greater than 1 atm) Thermocouple psychrometers are poorly suited for use in acidic environments due to the potential for corrosion of thermocouple wires Contaminants can cause errors if allowed to enter the sample chamber or thermocouple junction

Thermocouple psychrometers are designed to measure negative soil water pressure from relative humidity versus output voltage relationships In relating water potential to water content, characteristic curves must be developed for each soil type in which the units are to be installed This is a time consuming process and may not be economically feasible for small projects Most units are fragile and require great care during installation Response times are generally slow, however, this problem is not severe in dry media

V.3.2.1.3 Vadose Zone Indirect Pore-Liquid Monitoring Option: Heat Dissipation Sensors

Heat dissipation sensors are based on the concept that heat dissipation in a soil is sensitive to water content (Phene et al , 1971) In soils, air is a good thermal insulator with respect to water When a soil is wet, the path length for thermal conduction is short and through the water When the soil dries, the water films become thinner and the path length for thermal conduction becomes much longer The result is that dry soils require a larger temperature gradient to dissipate a given amount of heat than wet soils Conversely, the water content can be measured by supplying a known quantity of heat with a sensor and measuring the resulting rise in temperature at that point

Measurement is made using a diode bridge which is connected to a sensor (Campbell and Gee, 1986) A change in the diode temperature generated as a heater current is applied causes electromotive force (emf) which is measured with the bridge Calibration curves are used to relate emf data to matrix potential Because of the time required for heat to dissipate between readings, measurements typically cannot be made more frequently than hourly

Heat dissipation sensors are subject to some of the same sources of errors as gypsum electrical resistance blocks including hysteresis, use of calibration curves which are not suited to the measurement range of interest, and differences in the pore size distribution between the sensor matrix and the measured soil matrix

Heat dissipation sensors have the advantage, however, of more easily lending themselves to automatic data acquisition than tensiometers Measurement precision is estimated to be about ± 0 1 bar when the optimum calibration curve is used

V 3 2 1 4 Vadose Zone Indirect Pore-Liquid Monitoring Option: Neutron Probe

The term neutron probe describes two basic types of instruments Neutron-porosity loggers are used primarily in liquid filled boreholes Neutron moisture probes are used in dry access tubes Both types use a fast neutron source and thermal neutron detectors Neutron porosity loggers are well established in the oil industry where they are used to infer the porosity in saturated sediments They employ strong sources (250 millicurie [mCi] to 5,000 Mci) to enhance sampling volume and dual detectors to isolate borehole effects These probes utilize long tool lengths (4-21 feet) and sophisticated and expensive logging vehicles Neutron moisture probes are designed for precise measurement of soil moisture in small diameter (2-inch) access tubes, but also have been employed in larger access tubes (Tyler, 1985, 1988, Keller et al , 1990, Kramer et al , 1990) These probes employ a low strength source (10-50 Mci) and a single, near-source detector Similar to nuclear density gauges used by many geotechnical firms, they require minimal operator training (8-hour radiation safety course) and are subject to less regulatory oversight than neutron porosity loggers Neutron moisture probes are the method of choice for vadose zone monitoring tasks, especially where frequent sequential data are required

The radius of influence for neutron moderation probes varies with source strength, hydrogen density, solids density, and chemistry Practical limits are from 6 to 24 inches from the point between the source and the detector (Kramer et al , 1990, Silvestri et al , 1991) The

cloud of thermalized neutrons is compact in wet and/or dense soils, and expanded in dry and/or loose soils Strong neutron absorbers, including boron and chlorine, will diminish the radius of influence

Sensitivity of the neutron probe to wetting fronts depends on the magnitude of the possible moisture change and the masking effects of grout and casing The neutron probe is most sensitive in ungrouted access tubes with minimal distance between the tube and soils (Teasdale and Johnson, 1970) Small diameter (2-inch) metal casings are best Steel, aluminum, stainless steel, and PVC in diameters up to 4-inches have been successfully used

The neutron moisture probe cannot distinguish chemical species (e g leachate from ground water) and is sensitive only to changes in hydrogen density or neutron absorbing solutes and liquids Neutron data cannot be used to distinguish between gasoline and water, which have similar hydrogen densities (Kramer et al , 1990), nor to detect a steady state flow situation which has no changing hydrogen content In high background moisture environments or in the presence of high boron or chlorine concentrations, detection of wetting fronts with a neutron probe would be difficult to impossible When used under the appropriate conditions, the precision and accuracy of the neutron probe as a means of counting hydrogen is considered to be less than 1% of full scale, depending on the counting times employed

V.3.2 1 5 Vadose Zone Indirect Pore-Liquid Monitoring Option· Time Domain Reflectometry

Field measurement of infiltration can be accomplished through the use of recently developed dielectric methods which include Time Domain Reflectometry (TDR) This method provides a means for determining volumetric water content in the subsurface virtually instantaneously at a level of accuracy and precision of 2%

TDR measures the velocity of a microwave pulse propagated down a parallel transmission line The velocity of propagation is dependent on the dielectric constant of the material in contact with and surrounding the transmission line The higher the dielectric constant, the slower the velocity of propagation

Soil is composed, in general, of air, mineral and organic particles, and water The dielectric constant for these materials is

- Air 1
- Mineral Particles 2-3
- Water 80

Since the dielectric constant for water is almost two orders of magnitude greater than the other constituents of soils and sediments, the velocity of propagation of a microwave pulse is highly dependent on the water content Although soils and sediments have a wide range of particle size distributions, the relationship between the dielectric constant and the water content remains essentially constant In addition, the bulk density, temperature, and/or salt content does

not significantly interfere with the dielectric-water content relationship The precision of the water content measurement by TDR has been reported as ± 2% by volume (Topp, et al , 1983)

While soil salt content does not interfere with the dielectric-water content relationship, highly conductive soils present problems when making TDR measurements Above a given conductivity, the electromagnetic pulse can be completely attenuated, resulting in no measurement

Using sophisticated electronic instrumentation, it is possible to measure the time required for a microwave pulse to travel down a known length of parallel transmission line, or wave guides, buried in the soil The apparent dielectric constant is then readily calculated and related to the water content of the soil TDR wave guides can be buried in the soil and used to monitor water content changes over short infiltration episodes, diurnal fluctuations in water content, or long-term seasonal soil water content variations

Many of the first applications of TDR to soil hydrologic applications were carried out using equipment originally designed for locating breaks in coaxial transmission cables Simple soil probes used in TDR consist of two parallel rods (called wave guides) inserted into the soil The wave guides are attached directly to twin lead cables A balance signal can then be provided to the wave guides An alternative to the twin lead setup uses coaxial cable connected to the wave guides Because coaxial cable carries an unbalanced signal, an impedance balancing transformer (also called a balun) is required In this configuration, a balun is required for each wave guide inserted in the soil Application of this configuration is generally limited to uses where the wave guide can be temporarily inserted and retrieved after a measurement is completed due the high cost of the balun

Recently, unbalanced TDR soil probes have become available which obviate the need for the expensive balun The wave guide emulates the coaxial configuration by using three or more rods In this configuration, the central rod of the wave guide is connected to the signal lead of the coaxial cable and the other rods are connected to the shield of the cable Since the cost of the wave guides is reduced in this configuration, unbalanced probes have found greater use in applications which require the wave guides to be buried at depth for long periods of time

Manual measurement and interpretation of the time travel of the microwave pulse can be made using traditional cable testing equipment The results can be converted to volumetric water content through a series of straight-forward calculations Software is available for use with cable testers to automatically process the signal return and calculate moisture content TDR instrumentation has also been developed commercially for specific application to soil hydrology Current TDR probe designs allow burying the wave guides up to 100 feet away from the signal processing unit Multiplexing is available which facilitates placement and measurement of hundreds of wave guides arranged in various three dimensional arrays

V.3.2 1.6 Vadose Zone Indirect Pore-Liquid Monitoring Option: Frequency Domain Capacitance Probe

The dielectric constant of soil, and thus the volumetric water content, can also be measured in the frequency domain by use of the capacitance method (Thomas, 1966, Dean et al 1987, Bell et al , 1987) A capacitance probe measures the capacitance of an electrode system based on the dielectric constant of the in situ soil surrounding the probe A capacitor forms the part of the feedback loop of a high frequency oscillator Currently, techniques for direct in situ measurement of non-aqueous pore liquids from the unsaturated zone remains a research topic

Once the dielectric constant is determined using the capacitance probe, the relationship between the capacitance and the volumetric water content of the soil can be used to directly calculate the volumetric water content Alternatively, the capacitance probe can be used directly by calibrating the probe frequency response against soil materials of known water content As with the TDR probe, one calibration curve works well with a wide variety of soil types

Capacitance probes are less than 2-inches in diameter and about 8-inches long Probes can be buried with leads brought back to a central measurement point Signal processing units are available for automatic data retrieval, acquisition, and storage Capacitance probes also have the advantage that they can be lowered down standard 2-inch well casing for monitoring water content with depth Accuracy and precision of capacitance probes is equivalent to that of TDR instruments and should conservatively be considered to be about ± 2% volumetric water content

V 3 2.1.7 Vadose Zone Indirect Pore-Liquid Monitoring Option· Soil Water Hydrographs

The water budget in an identifiable closed system in the unsaturated zone can be estimated by evaluating and accounting for precipitation, runoff, evapotranspiration, soil water storage, and infiltration Precipitation data may be acquired from local meteorological stations If local information is not accessible or appropriate for use, an on-site meteorological station should be established

Soil water hydrographs are useful for hydrologic accounting of inputs and outputs from facilities where conditions approximate a closed system and all uncontrolled hydrologic variables can be measured or otherwise accounted for Taking evaporation and precipitation into account, soil water hydrographs can be used to determine the quantity of infiltration and volume of liquid leached into the unsaturated zone beneath the final engineered cover

V 3 2.1 8 Vadose Zone Indirect Pore-Liquid Monitoring Option· Gypsum Blocks

Gypsum blocks are a specific example of what are more generally known as electrical resistance blocks Electrical resistance blocks measure the electrical potential between two wires spaced a known distance apart This distance is typically on the order of centimeters Some designs utilize concentric stainless steel coils which are carefully spaced during manufacture The wires or coils are embedded in a porous matrix which soil pore liquids can freely enter and

exit As the soil water potential changes, the water in the porous matrix of the block achieves an equilibrium with the surrounding soil When soils (and thus the electrical resistance block) are dry, the resistance to electrical current flow is high and can be read on a resistance meter Conversely, when the soil and block become wet, a low resistance is measured on the meter

Native salts can affect the electrolytic concentration of pore water and consequently the electrical resistance of the pore-liquid solution While the water condition in the soil may be dry, an increase in salt concentration of the pore-liquids could reduce the resistance measured across the resistance blocks and result in an incorrect reading To avoid this problem, the most effective electrical resistance blocks are constructed of gypsum (calcium sulfate), one of the most soluble of naturally occurring soil salts

Because of its high solubility, the gypsum in gypsum blocks is continuously dissolving into the soil solution and creating a background condition of electrolytes which buffers the effect of native soil salts on the measurement However, the constant dissolution of the gypsum blocks limits the life and accuracy of the blocks Experience in irrigation management and agriculture indicates that gypsum blocks typically have a life span of about three years This life span would be increased in an arid environment

The accuracy of gypsum blocks is generally considered to be approximately ± 15% Experience in agricultural applications indicates that they are most effectively used in fine-textured soils (silts to silty clays) in relatively arid environments Gypsum blocks provide a straight forward, inexpensive means of detecting wetting front movement in arid soil environments over limited time periods Gypsum blocks are recommended only as part of a short-term unsaturated zone monitoring program They can be effectively used in the short term to provide an inexpensive means of quality assurance

V 3 2.2 Technology Type· Vadose Zone Direct Pore-Liquid Monitoring

The term "pore-liquid" is applicable to any liquid residing in soil (ASTM, 1992) The sampling techniques described in the following sections are designed for sampling aqueous pore-liquids only (as opposed to non-aqueous liquids such as oil or other contaminants which may be present in the vadose zone) The performance of the described sampling techniques with other than aqueous liquids may be quite different than that described here

Most samplers designed for sampling liquid from unsaturated pores may also be used to sample liquid from saturated pores This may be useful in areas where the water table fluctuates, so that both saturated and unsaturated conditions occur at different times However, samplers designed specifically for sampling from saturated pores cannot generally be used in unsaturated conditions This is because the liquid held in unsaturated pores is held at less than atmospheric pressures and will not drain readily into cavities at atmospheric pressures Wells and open cavities cannot be used to collect liquids flowing in the vadose zone under negative pore pressures (soil suction)

Pore-liquid sampling devices for unsaturated media are categorized into three types

- Suction samplers
- Experimental suction samplers
- Absorption samplers

Pore-liquid sampling devices applicable to saturated media within the vadose zone are called perched ground water samplers Since experimental suction samplers are usually limited to research applications by their fragility and untested performance, they are not recommended for general use

V.3.2.2.1 Vadose Zone Direct Pore-Liquid Monitoring Option: Suction Lysimeters

The term lysimeter has two definitions Originally, the term applied to a soil column placed in a field environment in which the inputs and outputs are carefully measured and accounted for such that mass balance calculations are possible More recently the term lysimeter has been used to describe devices utilized for collecting percolating subsurface water for analysis Devices which induce flow along a hydraulic gradient under unsaturated conditions are termed suction lysimeters

The selection of an appropriate porous membrane for sampling in the unsaturated zone is perhaps the most critical aspect of selecting a suction lysimeter The porous membrane must be hydrophilic and have a maximum pore size small enough to prevent air entry and vacuum failure upon application of a vacuum to collect aqueous pore-liquids Two porous membrane materials are recommended for use in sampling ceramic and stainless steel For most applications, the ceramic membranes are appropriate because of their ability to sustain an applied vacuum of up to 1 bar Stainless steel, while having a lower air entry value of 0 25 bar, is appropriate for specifically sampling many biological agents The use of ceramic porous membranes for sampling biological agents is problematic because certain biological agents have dimensions greater than the pore size of the ceramic material

Suction lysimeters may be subdivided into the following four categories

- Shallow sampling suction lysimeters
- Pressure-vacuum lysimeters
- Deep sampling pressure-vacuum samplers
- Filter tip

Vacuum-operated lysimeters typically consist of a porous cup mounted on the end of a small diameter PVC body tube, similar to a tensiometer The upper end of the body tube projects above the soil surface A rubber stopper and outlet tubing are inserted into the upper end of the body tube Vacuum is applied to the system and soil water moves within films of water in the soil sediment through the water-saturated pores of the ceramic cup and collects in the body tube To extract a sample, a small diameter tube is inserted within the outlet tubing

and extended to the base of the porous cup The small diameter tubing is connected to a sample collection flask A vacuum is applied and the sample is sucked into the collection flask These units are generally used to sample to depths up to 6 feet below the ground surface Consequently, they are used primarily to monitor the near surface

To extract samples from depths greater than the vacuum lift of water (approximately 25 feet), a pressure-vacuum lysimeter can be used The body tube of the unit is typically about 2-feet long, holding a maximum of 850-900 milliliters (ml) of sample Two access tubes are forced through a 2-hole rubber stopper sealed into the body tube One access tube extends to the base of the porous cup and the other terminates a short distance below the rubber stopper The longer line connects to a sample bottle and the shorter line connects to a vacuum/pressure pump All lines and connections are sealed

In operation, a vacuum is applied to the system while the longer tube to the sample bottle is clamped closed When sufficient time has passed for the porous cup to fill with liquid, the vacuum is released and the clamp on the outlet line is released Air pressure is then applied to the system, forcing the sample into the collection flask A basic problem with this type of system is that when sufficient air pressure is applied to drive the sample solution to the ground surface for recovery, some of the solution in the cup may be forced back through the cup into the surrounding soil, or, in the worst case, the porous cup can be ruptured This type of pressure-vacuum system is therefore recommended for depths up to about 50 feet below ground surface

Deep sampling pressure-vacuum lysimeters overcome the main problem of the simple pressure-vacuum system (Wood, 1973) Solution is forced out of the final engineered cover during application of pressure Two chambers in the assembly are isolated with the exception of a connecting check valve A sample delivery tube extends from the base of the upper chamber to the surface This tube also contains a check valve A second, shorter tube terminating at the top of the sampler is used to deliver vacuum or pressure When a vacuum is applied to the system, it opens the lower, one-way check valve and causes the upper check valve in the delivery tube to close The sample is delivered in the upper chamber, which typically has a capacity of 850-900 ml The vacuum is released and pressure is applied to the shorter tube to deliver the sample to the surface The lower one-way valve is forced to close by the air pressure and the upper one-way valve is opened The sample is then forced to the surface High pressures can be applied without danger of damaging the porous cup Consequently, the sampler can be used to depths in excess of 300 feet below ground surface (Cullen et al , 1991)

Filter tip samplers also utilize a porous membrane as the sampling interface to the unsaturated subsurface They consist of a permanently installed filter tip and mechanically retrievable sample vial, a porous section, a nozzle, and a septum The filter tip includes a pointed end to assist installation The samplers can be installed in pre-drilled access holes or driven with cone penetration-style equipment The tip is threaded onto riser pipes which terminated at the surface and act as the conduit to deliver and retrieve the sampling vial When sampling, a pre-evacuated sample vial fitted with a septum port at one end is mechanically lowered down the riser pipe to the filter tip which is also fitted with a septum port A

disposable, double-ended hypodermic needle pierces both septa and pore liquids flow into the sample vial under the gradient created across the porous membrane by the vacuum in the sample vial

Filter tip samples are advantageous when use of a driven sampler is desirable While expensive, the filter tips are retrievable and the porous membrane can be fitted with materials of different porosity and construction for use in other sampling tasks (e g driven piezometers) The depth of sampling is only limited by the operator's ability to drive or drill access holes

V.3 2.2.2 Vadose Zone Direct Pore-Liquid Monitoring Option. Absorption Samplers

Absorption samplers are used to collect a sample by absorbing the pore-liquids in the matrix of the sampler The liquid is allowed to absorb into the sampler material over time and is later extracted for analysis Absorbent samplers are simple to use but are physically limited to soils close to saturation (Dorrance, et al , 1991) The ability of porous materials to absorb liquids is inversely related to the size of the pores in that material, assuming that the material is hydrophilic Potential problems with absorption samplers include chemical absorption, desorption, precipitation, cation exchange, and screening of various pore-liquid components as a function of sampler material For these reasons, absorbent samplers have largely been considered an experimental approach

V 3.3 Initial Screening of Technologies

Vadose zone monitoring technologies were described in Section V 3 2 These technologies represent the range of currently available methodologies for monitoring pore-liquids in the vadose zone In order to select monitoring systems which are most appropriate for monitoring the final engineered cover and the vadose zone beneath the final engineered cover at OU4, all of the monitoring options described above are initially screened against the broad criteria of effectiveness, implementability, and relative cost as described in Section V 3 1 1 This initial screening process retains only those monitoring options which may reasonably be expected to meet the performance criteria established for the final engineered cover and vadose zone monitoring systems in Section V 2 2

Initial screening of the monitoring options is performed separately for the final engineered cover monitoring system and the vadose zone monitoring system The results of the initial screening are presented in the following sections

V 3 3 1 Initial Screening of Monitoring Options for the Final Engineered Cover Monitoring System

The initial screening and evaluation of monitoring options for the final engineered cover monitoring system is presented in Table V 3-1 Each monitoring option is screened with respect to the broad criteria of effectiveness, implementability, and relative cost as described below Section 4 of the EPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA defines the evaluation of effectiveness to include "(1) the potential effectiveness of process options in handling the estimated areas or volumes of media and meeting

the remediation goals identified in the remedial action objectives, (2) the potential impacts to human health and the environment during the construction and implementation phase, and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site Under the same guidance document, implementability is defined as "the technical and administrative feasibility of implementing a technology process " Implementability is used as an initial evaluation of technologies and process options to eliminate those which will prove unfeasible at the site The evaluation of cost is also described in the guidance document referenced above In this evaluation, technologies are evaluated based upon whether capital and O&M costs are high, medium, or low relative to other process options The EPA guidance does not focus on quantitative cost estimates, rather it identifies a ranking among technology types based upon engineering judgement of cost Those monitoring options that are able to meet these criteria, as they specifically pertain to the final engineered cover monitoring system, are retained for further evaluation

As shown in Table V 3-1, TDR (time domain reflectometry) and frequency domain capacitance probes (FDC) were the only monitoring technologies which were retained as possible options for the final engineered cover TDR is a proven and effective monitoring option TDR is implementable at OU4 and will not compromise the integrity of the final engineered cover if correctly installed The relative capital cost of TDR is high compared to the other screened monitoring options However, TDR is compatible with automated data collection and storage systems, significantly reducing the operations and maintenance costs associated with TDR

FDC is also a proven and effective monitoring option FDC systems closely resemble TDR monitoring systems in form, and are therefore implementable and will not compromise the integrity of the final engineered cover if correctly installed The relative capital cost of FDC is high compared to the other screened monitoring options However, as with TDR, FDC is compatible with automated data collection and storage systems, significantly reducing the costs associated with FDC operations and maintenance

V 3 3.2 Initial Screening of Monitoring Options for the Vadose Zone Monitoring System

The initial screening and evaluation of monitoring options for the vadose zone monitoring system is shown in Table V 3-2 Each monitoring option is screened with respect to the broad criteria of effectiveness, implementability, and relative cost as described above Those monitoring options that are able to meet these criteria as they specifically pertain to the vadose zone monitoring system are retained for further evaluation

Vadose zone monitoring options retained for further evaluation include neutron probes, FDC, and suction lysimeters (Table V 3-2) Neutron probes are an effective and proven monitoring option They can be installed as part of the vadose zone monitoring system in horizontal access tubes which would not penetrate the overlying final engineered cover The capital cost of neutron probes is high relative to other monitoring options The operations and maintenance costs associated with neutron probes are also high if the monitoring system must be operated manually To reduce the operations and maintenance costs, an automated data collection and storage system will be installed and the neutron probes will be left in place in between monitoring events

FDC is also a proven and effective monitoring option FDC systems are implementable at OU4 and will not compromise the integrity of the final engineered cover if appropriately installed The relative capital cost of FDC is high compared to the other screened monitoring options However, FDC is compatible with automated data collection and storage systems, thereby reducing operations and maintenance costs

Suction lysimeters are an effective direct pore-liquid monitoring option Suction lysimeters are the only retained monitoring option capable of collecting a direct vadose zone pore-liquid sample Suction lysimeters are technically implementable and will not compromise the integrity of the final engineered cover if correctly installed The relative capital cost of suction lysimeters is low with respect to other direct pore liquid monitoring options The relative operations and maintenance cost of suction lysimeters is high because sample collection, data acquisition, and storage from suction lysimeters cannot be automated with currently available technology

V 3.4 Evaluation of Monitoring Options with Respect to Performance Criteria

Performance criteria for the final engineered cover monitoring system and the vadose zone monitoring system were developed in Section V 2 2 1 and V 2 2 2, respectively The following sections present an evaluation of the monitoring options selected in Section V 3 3 for the final engineered cover and vadose zone monitoring systems with respect to the performance criteria developed in Section V 2 2 for these monitoring systems

V.3.4.1 Evaluation of the Final Engineered Cover Monitoring System

TDR and FDC are the two monitoring options considered for the final engineered cover monitoring system These monitoring options will be combined to form the final engineered cover monitoring system These monitoring options are evaluated against the final engineered cover performance criteria The final engineered cover performance criteria are

1) Be feasible to install, operate and sample with respect to the site hydrogeology and the selected engineered remedial alternative

2) Provide data that can be used to identify and provide early warning of conditions conducive to penetration of water through the final engineered cover

3) Provide adequate spatial coverage

4) Provide adequate temporal coverage

5) Provide data upon which to base a release response action

6) Provide for remote and automatic monitoring of data

7) Be integrated into the design and construction of the selected remedial alternative

8) Incorporate monitoring techniques that are precise

9) Incorporate planned redundancy

10) Be cost effective to install and operate

11) Incorporate proven technologies that have a record of performance for measuring, sampling, and analyzing soil and vadose zone monitoring parameters

12) Not jeopardize the functionality or long-term integrity of the cover system

An evaluation of the retained final engineered cover monitoring options is presented in Table V 3-3 All of the final engineered cover performance criteria are individually satisfied by TDR or FDC monitoring options Since FDC probes are individually less cost-effective then TDRs, the conceptual design of the final engineered cover monitoring system will therefore incorporate TDR The conceptual design of the final engineered cover monitoring system is presented in Section V 4 1

V 3.4.2 Evaluation of the Vadose Zone Monitoring System

Neutron probes, FDC, and suction lysimeters are the vadose zone monitoring options which are considered for the vadose zone monitoring system Other monitoring options were eliminated from consideration based on the evaluation criteria of effectiveness, implementability, and relative cost (Section V 3 3) The retained monitoring options must satisfy the vadose zone monitoring system performance requirements that were developed in Section V 2 2 2 The vadose zone performance requirements are

1) Be feasible to install, operate and sample with respect to the site hydrogeology and the selected engineered remedial alternative

2) Provide data that can be used to identify the production and migration of leachate within the waste pile

3) Provide data that can be used to identify the movement of water into the waste pile

4) Provide data that can be used to identify movement of leachate out of the waste pile

5) Provide adequate spatial coverage

6) Provide adequate temporal coverage

7) Provide data upon which to base a release response action

8) Provide for remote and automatic monitoring of data

9) Be integrated into the design and construction of the selected remedial alternative

10) Incorporate monitoring techniques that are precise

11) Incorporate planned redundancy

12) Be cost effective to install and operate

13) Incorporate proven technologies that have a record of performance for measuring, sampling, and analyzing soil and vadose zone monitoring parameters

14) Not jeopardize the functionality or long-term integrity of the cover system

An evaluation of the retained vadose zone monitoring options with respect to the vadose zone performance criteria is presented in Table V 3-4 All three of the retained monitoring options meet the performance criteria with the exception of remote and automatic monitoring of data (criteria number 8) The requirement for remote and automatic monitoring of data is not satisfied because suction lysimeters cannot be sampled remotely using currently available technology However, no direct vadose zone monitoring options are available which can be operated remotely A direct pore-liquid monitoring option is necessary for the vadose zone monitoring system to provide diagnostic confirmation of the quality of potentially migrating soil pore liquids present in the vadose zone If elevated soil moisture conditions are detected by the vadose zone monitoring system, pore-liquid samples collected from the suction lysimeters can be used to help determine if leachate is being released from the waste layer

The planned redundancy criterion (performance criteria number 11) is not satisfied by the vadose zone monitoring options when they are considered individually However, when the monitoring options are evaluated together as pieces of a system composed of all three of the vadose zone monitoring options, this performance criterion is satisfied The selected vadose zone monitoring system will therefore consist of three components neutron probes, FDC, and suction lysimeters The conceptual design of the vadose zone monitoring system is presented in Section V 4 2

V.4
CONCEPTUAL DESIGN OF THE MONITORING SYSTEM

The post-closure monitoring system is designed to provide information that will allow the identification of the following conditions

- Penetration of water through the final engineered cover,
- Production and/or migration of leachate within the waste pile, and
- Migration of contaminants from the waste pile into the underlying shallow aquifer

This information will support the evaluation of the performance of the remedial design Data from the post-closure monitoring system will be generated in a timely fashion to facilitate early warning of conditions favoring contaminant migration, thereby providing protection against any potential threats to human health and the environment

The monitoring system will consist of three subsystems These are the

- final engineered cover monitoring system (including a geotechnical stability monitoring system),
- vadose zone monitoring system, and
- ground water monitoring system

The final engineered cover monitoring system is designed to identify and provide early warning of infiltrating waters that could potentially move through the overlying cover and into the underlying waste pile The vadose zone monitoring system (the vadose zone is defined for the purpose of this application as the backfilled contaminated soil materials beneath the cover and the native colluvium/alluvium above the historical mean annual high water table) is designed to identify moisture conditions within the waste pile beneath the barrier that are indicative of the production of leachate and to identify leachate migration from the waste pile Additionally, the vadose zone monitoring system is designed to identify and provide early warning of the movement of subsurface waters into the waste pile from lateral sources, or from below as in the case of a rising water table The ground water monitoring system will monitor the quality of the underlying ground water at the point of compliance boundary in the ground water underlying the site, and provide early warning of the potential migration of released COC's to potential downgradient receptors

Overview of the Performance Assessment and Monitoring System

The proposed performance assessment and monitoring program is, in large part, based on, and taken directly from, the long-term research and comprehensive testing programs

conducted at Hanford Washington, Yucca Mountain Nevada, and the UMTRA project Extensive interactions and visits with technical personnel at similar DOE facilities were made prior to formulating this monitoring plan The sensors proposed in this plan have been previously tested or utilized at DOE facilities As a result, the technologies employed represent the most cost-effective and accurate means of acquiring the data needed to provide assessment and warning of the impact of the IM/IRA on ground water at the site without risking further degradation of the ground water as the result of activities at OU4

TDR sensors provide direct volumetric measurement of soil moisture within the soil cover and serve to assess the performance of the cover in preventing the development of moisture conditions conducive to the development of saturated conditions, positive pore pressures, and potential water migration through the low permeability asphaltic layer The data generated by the TDR sensors should demonstrate that the cover as designed efficiently uses evapotranspiration to pump accumulated precipitation waters back into the atmosphere In the infrequent event that water penetrates the soil cover into the underlying drain layers, the monitoring system will demonstrate that the proposed drain layers efficiently conduct drainage water to the perimeter of the engineered cover and to the collector trench system The monitoring system will also show that water is not perennially accumulated above the low permeability asphaltic layer

It has been determined, as a part of the OU4 RFI/RI, that water movement (and therefore dissolved contaminant movement) within the contaminated soils at OU4 is not sufficient to impact ground water at the site when the soil moisture content is maintained at the field water levels detected during the RFI/RI investigation This is the essential principle which underlies the selected IM/IRA FDC sensors, although less cost effective than TDR sensors when considered only on a per unit basis, are proposed because of the increased cable lengths required to reach underneath the engineered cover and into the waste soil pile These sensors will provide additional spatial coverage and a measure of the potential mobility of pore liquids within the contaminated waste pile by measuring the soil moisture TDR sensors cannot be used beneath the engineered cover because of the limitation on cable lengths for each sensor (100') FDC probes will be used to assess the performance of the low permeability asphaltic layer in preventing moisture intrusion into the contaminated soils beneath the engineered barrier and to detect movement of water into the waste pile from sources other than surface infiltration

Neutron probes deployed in horizontal access tubes will be used to increase spatial coverage of the monitoring system and to detect migration of unsaturated wetting fronts through the waste pile and into the underlying vadose zone Neutron probes will also be used to assess the performance of the subsurface drain layer conducting water away from the contaminated waste in the unlikely event that rising ground water intersects the drain Specifically, the neutron probe readings will serve to augment water elevation measurements from adjacent ground water wells and to indicate the presence and spatial distribution of capillary rise of ground water through the subdrain In the event that downward migrating liquids are detected from within the waste pile, the neutron probe measurements in combination with the FDC sensor readings will be used to provide a determination of the spatial distribution of the migrating pore liquids Both FDC and neutron probes provide indirect measurement of migrating pore liquids with no analytical costs

Suction lysimeters are proposed as a means of collecting pore liquid samples when indirect monitoring techniques indicate that the potential for migrating pore liquids exists After an initial period required to established the initial pore liquid concentrations, it is unlikely that pore liquid sampling will be needed Sampling of pore liquids in unsaturated regions of the vadose zone is only possible when the soil water tension is between approximately 0 and 60 centibars Advection of soil pore liquids at tensions beyond this range occurs at extremely slow rates It is anticipated that pore liquid samples will not be collected The co-installed FDC sensors paired with each suction lysimeter probably will be used to confirm that the lysimeters are functioning properly, and that conditions do not exist in which pore liquid migration can occur

The monitoring system is designed so that monitoring data will be automatically acquired and processed for reporting State of the art data acquisition equipment will be used to efficiently process data for reporting Data processing includes generation of data summaries (to reduce the amount of data handling), automated data interpretation (eg by comparison with threshold values) and generation of tabular and graphical output of the data for reporting purposes Initially, after construction is concluded and performance assessment monitoring begins, data will be collected frequently As time progresses, the frequency of monitoring will be diminished as confidence is gained that the design is performing as predicted Eventually, monitoring systems will be abandoned As proof of the principle of the engineered barrier is attained with empirical data obtained through the performance assessment monitoring, it will be possible to consider and justify decommissioning and abandonment of a significant portion of the ground water monitoring wells (and associated analytical costs) at the site Anticipated monitoring frequency and abandonment schedules are given in this section

V 4 1 Final Engineered Cover Monitoring System

Conceptually, the final engineered cover is a multi-layer, composite barrier designed to prevent contaminant migration away from the confines of the waste pile The top layer of the cover/barrier consists of gravelly topsoil materials that will support vegetative growth and provide armoring to control erosion This top layer overlies a capillary barrier consisting of a sand filter and a gravel filter over angular riprap The purpose of these poorly sorted, coarse textured materials is to act as a capillary break against unsaturated flow from above and as a biotic barrier to plant root and wildlife penetration Beneath the riprap, a sand drainage layer will be placed over a composite asphaltic low-permeability barrier The cross sectional design of the final engineered cover is shown in Drawing 51045-150

The final engineered cover monitoring system is designed to provide monitoring data necessary to assess the performance of the cover in impeding percolation of precipitation water into the underlying waste pile In the event that the final engineered cover does not limit downward movement of infiltration water to above the capillary break, the monitoring system will provide data that can be used to identify and provide early warning of conditions conducive

to movement of infiltrating waters through the final engineered cover system and into the underlying waste pile Specifically, the final engineered cover monitoring system is designed to

- Provide data regarding site weather conditions sufficient to establish a correlation between hydrologic events occurring at the surface and hydrologic conditions measured within the cover

- Provide sufficient measurements of volumetric soil moisture content in the cover materials to determine if the water holding capacity of the topsoil materials is being exceeded such that percolation of water through the capillary break and into the underlying drainage materials can occur

- Provide sufficient measurements of volumetric soil moisture content in the sand drainage layer above the asphaltic low permeability layer such that saturated or near-saturated conditions can be identified Such conditions would exist before significant movement of percolating waters through the low permeability asphaltic layer could occur A distribution of sensors in the drainage layer down the slope will be used to determine if the drainage layer is functioning as designed

- Provide sufficient subsurface temperature measurements of the cover materials in order to identify the progression of winter freezing fronts and spring thawing fronts Temperature measurements are necessary to assess the impact of frozen soil layers on the distribution of soil moisture within the cover profile and to assess the potential for a slug of water moving through the cover profile at spring thaw

- Provide data regarding stability of the cover system and the north hillside Settlement measurements should be made available to evaluate effects of settlement on surface drainage patterns The stability of the north hillside should be monitored with inclinometers north of the final engineered barrier

- Provide sufficient surface and subsurface data to facilitate evaluation of the approximate water balance in the cover Determination of the approximate water balance in the cover will provide a backup means of identifying conditions conducive to the buildup of positive pore pressures and saturation above the low permeability asphaltic layer

V 4.1 1 Description of the Final Engineered Cover Monitoring System

The final engineered cover monitoring system will consist of TDR (time domain reflectometry) soil moisture sensors within the final engineered cover, slope stability and settlement monitoring equipment placed on top of the final engineered cover, and a meteorological station installed at OU4 to record climatic factors that affect the water balance in the cover/barrier Conceptual installation locations of the monitoring instrumentation are

discussed in the following sections and shown in cross section and plan view, respectively, in Drawings 51045-151 and 51045-152

V.4.1.2 Location and Spatial Distribution of TDR Wave Guides in the Final Engineered Cover

TDR sensors, more commonly known as wave guides, will be located in the cover above the low permeability asphaltic layer In order to avoid unnecessarily compromising the integrity of the barrier, no TDR wave guides will be installed in or through the low permeability asphaltic layer Two clusters of TDR wave guide arrays will be installed in the cover/barrier

Cluster locations were selected to provide monitoring data on representative slope conditions that are to be included in the design of the final engineered cover Drawing 51045-152 illustrates the conceptual location of the wave guide clusters and associated waveform interpretation modules in plan view The selected locations will specifically provide

- Soil moisture measurements representative of different engineered cover layers in the remedial design Conceptual location of the TDR arrays are illustrated in the cross sectional Drawing 51045-151

- Soil moisture measurements representative of differing slope conditions that may affect soil and surface temperatures and thus the propagation of freezing and thawing fronts in the soil Slope conditions can also affect evapotranspiration and consequently storage of soil moisture in the cover The selected locations illustrated in plan view (Drawing 51045-152) will yield soil moisture measurements beneath slopes that are oriented north, east, south and west

Each wave guide cluster will consist of arrays installed radially out from a centrally located waveform interpretation module In the cover monitoring system, an array will consist of two or more wave guides vertically distributed within the cover profile, more or less in line, at any radial distance up to 100 feet from the waveform interpretation module Conceptual locations of the wave guide clusters, arrays, and associated waveform interpretation modules are also shown in cross section in Drawing 51045-151

Wave guides will be vertically distributed in the portion of the cover above the asphaltic layer in order to monitor the performance of the cover in absorbing precipitation water and allowing escape of this precipitation to the atmosphere via evapotranspiration at the vegetative cover Additionally, TDR measurements used in combination with soil and surface temperature measurements will be used to evaluate the propagation of freezing and thawing fronts and the potential consequential impounding of water in the cover soil until final spring thaw allows a slug of water to pass through the soil material and onto the underlying low permeability layer

V.4.1.3 Meteorological Monitoring of the Final Engineered Cover

A meteorological station (MET) will be incorporated into a part of the final engineered cover system to monitor climatological factors affecting infiltration, evapotranspiration, and runoff These factors in turn affect the storage of water in the cover soils of the final engineered cover Monitoring of weather conditions will provide a baseline of data that will document the range of environmental conditions to which the remedial design is exposed over time In addition, a record of site-specific environmental data will provide the basis for developing a correlation between meteorological events at the surface and the hydrologic status of the subsurface of the final engineered cover

Based on a review of the locations and functions of existing stations, a new meteorological station may be constructed, or existing facilities may be utilized The meteorological monitoring station will consist of an array of sensors integrated into an automated system that will facilitate data acquisition for the interpretation of weather-related influences on the final engineered cover on a daily or weekly basis The meteorological monitoring station will be based on designs that have been traditionally used for site-specific agricultural and irrigation scheduling applications The station will be specifically designed to measure weather factors that affect the cover soil water storage and plant water consumption using calculations based on a modified Penman-Monteith equation (Penman, 1948) The weather station data acquisition system will be supported by a personal computer and associated software for data retrieval and analysis

Continuous measurements of meteorological conditions will be made by the monitoring station at intervals that will allow data interpretation and analysis on a daily, weekly, or monthly basis Meteorological variables that will be measured by the weather station include

- temperature
- relative humidity
- wind speed
- wind direction
- solar radiation
- precipitation (rainfall and snow)
- soil temperature

Measurement height for all sensors, except for the soil temperature sensors, is anticipated to be approximately 3 meters above ground surface All measurement electronics and communication peripherals will be protected in an environmentally-rugged housing Data will be electronically retrieved, processed, and transferred between the weather station and a base station computer via a telecommunication link The telecommunication link will consist of a

Hayes-compatible modem at a personal computer connected by phone line to a modem at the weather station The conceptual location of the meteorological monitoring station is shown in plan view and cross section, respectively, on Drawings 51045-152 and 51045 151

V.4.1.4 Final Engineered Cover System and Slope Geotechnical Stability Monitoring Systems

The geotechnical stability of the final engineered cover system must be monitored to determine if a local or general failure has occurred Stability monitoring efforts will be focused on evaluating the slope stability of the covered area and against on determining and settlement or horizontal movement of the cover structure It is important, however, to note that until the soil engineering parameters are properly defined and dimensions of the cap are known (during Title II design), the following proposed stability monitoring instrumentation and techniques may change and therefore, cost estimates for the monitoring activities may change

V.4.1 4.1 Slope Stability

To monitor the slope stability of the covered area, instruments are proposed to be installed at the critical areas of the engineered cover slopes The critical areas may be defined as the portion of the slope with the least factor of safety or increased potential for failure due to external forces Information regarding the slope dimensions and soil/waste engineering parameters (such as internal friction angle and shear strengths) will not be available until the Title II design is complete Therefore, the critical portion of the slope cannot be determined at this time It is assumed that each of the slopes of the covered area will be monitored

Monitoring instrumentation requiring limited installation effort has been selected to minimize the need for intrusive activities which may result in breaching the integrity of the final engineered cover The approach currently proposed for the slope stability monitoring includes installation of survey monuments at intervals on top of the engineered cover and regular surveys of the horizontal and vertical position of these monuments When the surveys are performed regularly in reference to a stable bench mark located off the cap (on a nearby building or power pole), they will indicate movements of the surveyed points on the cap which in turn will determine movement or slumping of the slope

V 4.1 4.2 Engineered Cover Settlement

The stability of the cover against horizontal short and long-term settlements can be monitored by several means Only options that require limited or no intrusion into the engineered cover structure have been considered As proposed for the slope stability monitoring, stable points for use in frequent surface surveys are proposed to be installed on a grid on the top of the cap structure The points would be surveyed in reference to a stable bench mark to determine if any movement has occurred

In addition to the surface survey, inclinometers are also proposed Inclinometers will be used to measure changes in the inclination of the cap as a result of soil consolidation and

differential settlement Inclinometers are particularly beneficial in determining the rotation rates that normally accompany settlement

V.4.2 Vadose Zone Monitoring System

Traditionally, the vadose zone is defined as that portion of the geologic profile from ground surface to the top of the water table The term vadose zone typically includes not only unsaturated soils and sediments, but also perched zones that are isolated zones of saturation or only periodically saturated At the OU4 remedial action site, the term vadose zone takes on a slightly modified meaning because of the substantial earth moving and reconfiguration of the subsurface that is planned as part of the selected remedial alternative The vadose zone includes the waste materials beneath the engineered cover as well as the unsaturated fill beneath the placed wastes, and is therefore referred to as an "engineered" vadose zone

The vadose zone consists of the unsaturated soil and waste materials and in-situ soils located from the underside of the final engineered cover down to the mean of the seasonal high ground water table as interpreted from the ground water hydrographs from ground water wells in OU4 presented in the "Part II, Phase I RCRA Facility Investigation/Remedial Investigation" report The interpreted seven-year mean seasonal high water table is illustrated in the context of the proposed remedial design in Drawing 51045-151

Complete coverage in terms of detecting a release in a vadose zone monitoring system is not realistic The design presented provides the minimum required effort in terms of assessing the performance of the remedial design As presented, the design will, 1) function to monitor areas of vulnerability in which contaminant migration is most likely to take place and provide a spatial and temporal distribution of monitoring points upon which to evaluate the remedial design performance in light of subsurface variability and heterogeneity, and 2) monitor representative components of the remedial design in order to assess the performance of the selected remedial approach The proposed monitoring system will yield data regarding inputs and outputs to a quasi-closed hydrologic system (i e , the contained consolidated material) which can be used to evaluate the performance of the selected remedial alternative Evaluation of the individual monitoring points and locations is inappropriate because it ignores the concepts and performance criteria of spatial coverage, replication, and planned redundancy

The primary region of concern with respect to contaminant mobility is the volume of soil in the waste pile that is located above the subsurface drain as shown in Drawing 51045-151 In order to impact ground water, potentially mobile COC's would have to travel from within the waste pile vertically down to the water table The subsurface drainage layer will act as a barrier to a rising water table and facilitate drainage into the collector trench system The subsurface drainage layer will not impede a vertically propagating wetting front that is at or near saturation

Based on the cross-sectional drawing of the proposed facility as illustrated in Drawing 51045-151, the depth of vadose zone at the OU4 proposed facility ranges from about 20 feet at the southeastern corner to more than 40 feet under the peak in the final engineered cover This range of depths provides a more than adequate cross-section over which to monitor changes in vadose zone moisture conditions

V.4.2.1 Description of the Vadose Monitoring System

The vadose zone monitoring system will consist of three horizontal neutron probe access tubes (NPATs) placed at the top of the subsurface drain layer two feet above the bottom of the waste pile, FDC probes installed in vertically distributed arrays within the waste pile, and nine paired installations of FDC probes and pressure/vacuum suction lysimeters placed adjacent to the NPATs Conceptual installation locations of the monitoring instrumentation are discussed in the following sections and shown in cross section and plan view, respectively, in Drawings 51045-151 and 51045-152

The vadose zone monitoring system is designed to identify moisture conditions within the waste pile that are indicative of the production of leachate, and to identify leachate migration from the waste pile Additionally, the vadose zone monitoring system is designed to identify and provide early warning of the movement of subsurface waters into the waste pile from lateral sources, or from below as in the case of a rising water table Specifically, the vadose zone monitoring system will

- Provide sufficient spatially distributed neutron moderation logs as a relative measure of soil water content in the vadose zone beneath the engineered cover The neutron logs will be taken from the waste materials two feet above the top of the subsurface drainage layer When used in conjunction with piezometers and ground water monitoring wells, the neutron moderation logs can be interpreted to indicate the presence of a capillary fringe as the result of a rising water table and to provide early warning of the downward propagation of a wetting front

- Collect pore liquid samples from the waste pile adjacent to the NPATs Collection of pore liquid samples will allow monitoring of pore liquid quality over time In either the case of a rising water table or in the case of downward leachate migration from the waste pile, pore liquid sampling will enable data regarding the quality of pore liquids to be collected for interpretation as to the source of contaminant migration This will prove to be especially significant in an area known to contain upgradient sources of ground water contamination FDC probes will be installed adjacent to each pore liquid sampler to identify and confirm whether soil moisture conditions appropriate for pore liquid sampling are present

V 4 2.2 Location and Spatial Distribution of Neutron Probe Access Tubes in the Vadose Zone

Three NPATs will be installed in the waste materials two feet above the top of the subsurface drainage layer as shown in the cross sectional Drawing 51045-151 Because the NPATs represent monitoring lines, as opposed to monitoring points, they will be used to increase the spatial coverage of vadose zone monitoring beneath OU4 for the purpose of

detecting vertically propagating wetting fronts that would be indicative of the potential for leaching of COC's from the waste pile The NPAT lines will be oriented in a north-south direction and will be spaced as shown in plan view on Drawing 51045-152 in order to maximize spatial coverage and provide data from representative areas beneath the facility

Vertically propagating wetting fronts moving downward through the waste pile would be intercepted by the subsurface drainage layer and conducted laterally away from ground water only when near-saturated conditions develop in the overlying waste pile In this case, some of the leachate would have the potential for percolating into the subsurface beneath the drainage layer and potentially impacting ground water NPATs will indicate the spatial extent of these potential wetting fronts

Data collected using the NPATs will be used to identify the location of vertically propagating wetting fronts, and to discriminate between a facility-wide design failure and the development of a localized preferential flow pathway that would indicate the need for repair of the final engineered cover When used in combination with data from the TDR waveguides and FDC arrays, data from the NPATs can be used to identify the location of, and discriminate between, downward propagating wetting fronts and upward moving water caused by a rising water table

Measurements taken with the NPATs will also be used as indicators of the need to implement unscheduled pore liquid sampling in the vadose zone using the pressure/vacuum lysimeters as discussed in Section V 4 2 3 Detection of a wetting front by the NPATs, whether from downward propagating wetting fronts or from a rising water table, will be used as an indicator to implement pore liquid sampling to monitor the chemical quality of the wetting front pore liquids

The neutron probes will be stored permanently at the site, and will be deployed at regular intervals using automated winches and data loggers The neutron probes contain a low-level radioactive source Specific security issues related to permanent storage of the neutron probes in the NPATs at the RFETS are currently unknown

V 4.2.3 Location and Spatial Distribution of Pressure/Vacuum Lysimeters in the Vadose Zone

Pore liquid sampling devices, known as pressure/vacuum lysimeters, will be placed in the waste materials two feet above the subsurface drain for the purpose of sampling pore liquids in the vadose zone Lysimeters will be installed at nine locations aerially distributed within the waste pile The distribution of the lysimeter locations is shown in plan view in Drawing 51045-152

Propagating wetting fronts moving downward out of the waste pile, laterally from the interface between ground surface and the final engineered cover, or upward because of a rising water table will cause an increase in saturation and a decrease in the negative pore pressures of the soil materials above the subsurface drain When these negative pore pressures are reduced to a level where significant flow (and the resulting potential for COC migration) can occur,

lysimeters will be utilized to determine the chemical quality of the migrating pore liquids Vertical position of the lysimeters relative to the subsurface drain is shown in Drawing 51045-150 FDC probes will be installed adjacent to each pore liquid sampler to identify and confirm whether soil moisture conditions appropriate for pore liquid sampling are present

The lysimeters will be located two feet above the top of the subsurface drain in order to sample potentially migrating liquids that are produced by leachate in the case that infiltration occurs through the final engineered cover Samples recovered from the lysimeters will indicate the composition of the pore liquids and the presence of migrating COC's

In accordance with the design of the final engineered cover, saturation levels in the vadose zone beneath the facility will be low and negative pore pressures high Data from Part II of the IM/IRA-EA DD confirm this and indicate that the observed negative pore pressures currently exceed the range in which lysimeters are capable of collecting a pore liquid sample Lysimeters are capable of collecting pore liquid samples in the negative pore pressure range of 0 to approximately 65 centibars It is anticipated that pore liquid samples will not be recoverable from the lysimeters on a regular basis However, installation of the lysimeters is critical to the monitoring plan so that they are available and in place to collect pore liquid samples if and when intrusion of a wetting front is detected by the other indirect techniques such as the TDR waveguides, NPATs, or FDC probes

Data from lysimeter samples will be used to identify migrating COC's in the vadose zone and to determine the chemical quality of downward moving wetting fronts or of wetting fronts caused by a rising water table Used in combination with the other indirect monitoring technologies at the facility, lysimeter data will be used to assess the performance of the final engineered cover in the unlikely event that leachate is produced within the waste pile and begins to vertically migrate Vertical migration of pore fluids alone is not diagnostic confirmation that a release to ground water will occur from the facility Lysimeters will be used to confirm the chemical quality of any detected migrating pore liquids that may impact ground water

V 4 2.4 Location and Spatial Distribution of Frequency Domain Capacitance Probes for Monitoring the Final Engineered Cover System Performance

FDC probes will be installed in vertical arrays within the waste pile beneath the final engineered cover Their principal purpose is to monitor and identify vertically propagating wetting fronts within the waste pile (migrating either upward or downward) Data from the FDC probes will be used to measure soil water content distribution within the waste pile and assess the performance of the final engineered cover in maintaining waste pile soil water contents low enough to prevent significant flow of percolating waters within the waste pile, thereby preventing vertical migration of soluble COC's Areal locations of the FDC arrays are shown in the plan view Drawing 51045-152 Vertical distribution of the FDC sensors is shown in the cross sectional Drawing 51045-151

Data from the FDC probes will also be used to assess the performance of the subsurface drainage layer By design of the subsurface drainage layer, a rising water table should have no impact on the water content of the soil materials in the waste pile In the event of a

rising water table, an increase in the water content of the soil materials in the waste pile would indicate a potential failure in the subsurface drainage layer Data on the water content distribution within the waste pile will be collected using a vertical and areal distribution of FDC probes and will be used to identify the location of any such problems that might arise

Data regarding identification of vertically propagating wetting fronts are partially redundant to the data provided by the neutron probe access tubes As with neutron probe access tube data described in Section V 4 2 2, data collected using the FDC probes will be used to identify the location of vertically propagating wetting fronts and discriminate between a facility-wide design failure and the development of a localized preferential flow pathway that would indicate the need for repair of the final engineered cover When used in combination with data from the TDR waveguides and the neutron probes, data from the FDC arrays can be used to identify the location of, and discriminate between, downward propagating wetting fronts and upward moving water caused by a rising water table

V 4.3 Ground Water Monitoring System

The purpose of the ground water monitoring system for the OU4 is to detect the introduction of waste constituents from the waste piles into the uppermost aquifer underlying the facility The system will be used to monitor ground water quality and flow in the upper hydrostratigraphic unit The upper hydrostratigraphic unit consists of several distinct lithostratigraphic units These units are the Quaternary alluvium, colluvium, valley-fill alluvium, landslide deposits, weathered bedrock of the Arapahoe/Laramie Formation, and all sandstones within the Arapahoe/Laramie Formation that are in hydraulic connection with overlying unconsolidated deposits, or that crop out at the surface Specifically, the ground water monitoring system is designed to

- Provide sufficient coverage of hydraulically downgradient locations to detect the potential migration of waste constituents from IHSS 101 at the point-of-compliance boundary

- Provide sufficient coverage of hydraulically upgradient locations to characterize upgradient ground water quality, and detect the migration of ground water contaminants beneath IHSS 101 from upgradient sources

- Allow the collection of quantitative and defensible ground water flow and quality data through the application of monitoring well construction specifications that are consistent with existing and accepted SOPs at the RFETS

The data collected from the ground water monitoring system for the OU4 will be suitable for appropriate statistical evaluations designed to facilitate comparison of upgradient and downgradient ground water quality conditions, and identify trends at individual monitoring locations

V.4.3.1 Well Locations

The location of ground water monitoring wells is based on an evaluation of observed ground water flow conditions at OU4, as reported in the "1992 Annual RCRA Ground water Monitoring Report for Regulated Units at the Rocky Flats Plant" (EG&G, 1993) Four quarters of ground water flow data were evaluated to determine adequate coverage of both upgradient and downgradient locations In the 1992 RCRA report, discussions of ground water flow in the upper hydrostratigraphic unit were separated into flow in the "surficial materials" (alluvium, colluvium, fill, etc) and flow in the weathered bedrock

The point of compliance (POC) boundary was determined for the proposed remedy based on the conceptual design location of the toe of the final engineered cover RCRA specifies that the POC be located at the downgradient boundary of the RCRA unit To maintain the integrity of the final engineered cover, wells are not located where they would vertically penetrate the cover materials To provide an adequate margin of safety during well installation, and to allow for regular access to the monitoring wells without impacting the final engineered cover, a buffer zone ten feet wide was established around the toe of the final engineered cover The POC was then set along a line ten feet outside the toe of the cover Upgradient and downgradient portions of the POC were then assigned based on an evaluation of the "1992 Annual RCRA Ground water Monitoring Report for Regulated Units at the Rocky Flats Plant" (EG&G, 1993)

Ground water flow conditions in the alluvium/colluvium, for four quarters of 1992, are illustrated in Drawing 51045-153 Generalized ground water flow lines originate at the four corners of the final engineered cover system waste pile The flow lines were developed manually by extending flow paths from the waste pile corners in directions perpendicular to equipotential lines The illustration of ground water flow potential with equipotential lines is representative of site-specific hydrologic conditions, however, the use of ground water flow lines is based on the assumption that the alluvium/colluvium is homogeneous and isotropic Although this assumption is known not be entirely accurate, any variation from homogeneous and isotropic conditions is expected to be localized and on a limited scale Therefore, over the areal extent of the SEP, flow conditions as depicted in Drawing 51045-153 are expected to be reasonably representative

The predominant direction of ground water flow in the alluvium/colluvium is to the north and northeast There is also a localized southeasterly component of flow at the eastern end of the southern boundary of the SEP This divergence of flow results from an apparent east-west trending ground water divide, near the southeast corner of the SEP, that may be related to the topography of the bedrock surface Because this ground water divide occurs near the southern point-of-compliance boundary, it does not affect flow beneath the waste material Therefore, the southern point-of-compliance boundary, south of former Ponds 207-A and 207-B, is considered to be upgradient

Ground water flow conditions in the weathered bedrock, for four quarters of 1992, are illustrated in Drawing 51045-154 Generalized ground water flow lines were developed in the same fashion, and based on the same assumptions, as described above for the

alluvium/colluvium Ground water flow in the weathered bedrock is, for the most part, similar to flow in the alluvium/colluvium The predominant direction of ground water flow in the weathered bedrock is to the north and northeast However, the southeasterly component of flow identified in the alluvium/colluvium, at the eastern end of the southern boundary of the SEP, is more pronounced in the weathered bedrock The apparent east-west trending ground water divide in the weathered bedrock is located in the center of the SEP Similar to the alluvium/colluvium, ground water flowing toward the SEP within the weathered bedrock originates primarily in the area to the southwest However, a portion of the southern boundary of the SEP unit that was determined to be upgradient for the alluvium/colluvium may be downgradient in the weathered bedrock

For the purpose of monitoring ground water in the upper hydrostratigraphic unit at the SEP, new wells will be screened across the uppermost saturated intervals, regardless of which lithostratigraphic unit (i e , alluvium, weathered bedrock, or hydraulically connected sandstone) the water table is encountered in The results of the Phase II RI will be used to confirm this well design As presented above, flow conditions are quite similar in both the alluvium/colluvium and the weathered bedrock The only appreciable difference is along the southern point-of-compliance boundary, where flow may vary slightly between the two lithologies

Proposed locations for monitoring wells screened in the upper hydrostratigraphic unit are illustrated in Drawing 51045-155 Where appropriate, existing wells will be incorporated into the monitoring system New and existing wells that are located on the point-of-compliance boundary will be used for compliance monitoring In addition, existing wells located away from the point-of-compliance boundary will be used for compliance and performance monitoring

Alluvial/colluvial wells 2686, 3887, and P207689 are located along the southern point of compliance boundary for the SEP and will be included in the ground water monitoring system for compliance monitoring if they are still present after construction Weathered bedrock wells 2586, P207589, P207789, P208989, 3186, 3286, and P209489 are located along the southern and northern portions of the compliance boundary for the SEP, and will also be included in the ground water monitoring system for compliance monitoring if still present and undamaged Drawing 51045-155 shows all well locations around the toe of the engineered cover as proposed new wells based on the assumption that the existing wells will be destroyed during construction

Ground water flowing toward the point of compliance boundary originates primarily in the plant area west of the SEP, where several potential ground water contaminant sources are present Historic data from existing alluvial/colluvial wells 2286, 5687, 2486, and P207489, and weathered bedrock wells P209189, P210189, 2386, and P207389 indicate significant variations in ground water quality between these upgradient locations In the case of wells 2286 and 5687, water-quality conditions provided in the 1993 RCRA Ground water Report (EG&G, 1993) show significant disparity over a relatively short lateral distance (Drawing 51045-155) These data point to the potential for various discreet and discontinuous upgradient plumes Therefore, it is important that a sufficient number of data collection points be established to allow a reasonably complete characterization of upgradient ground water quality, and a statistically significant distinction between upgradient and downgradient ground water quality

conditions Alluvial/colluvial wells 2286, 5687, 2486, and P207489, and weathered bedrock wells P209189, P210189, 2386, and P207389 will be incorporated into the ground water monitoring system for compliance and performance monitoring

Three additional weathered bedrock wells (3987, P208889, and P209589) are located approximately 100 feet to the northeast of the northeast corner of the compliance boundary, and one alluvial/colluvial well (P207889) and one weathered bedrock well (P207989) are located approximately 100 feet east of the eastern point-of-compliance boundary These five wells will be included in the post-closure monitoring system for compliance and performance monitoring

Where existing wells are not present along the point-of-compliance boundary, new wells will be installed at approximate 200-foot intervals The distribution of downgradient and upgradient wells depicted in Drawing 51045-155 is sufficient to allow the detection of waste constituents that would potentially migrate from the SEP should conditions arise that would cause leaching of the waste piles, and to allow a statistically significant distinction between upgradient and downgradient ground water quality conditions In all, seven existing weathered bedrock wells, three existing alluvial/colluvial wells, and seven new wells to be completed in the upper hydrostratigraphic unit are proposed to be used for post-closure compliance monitoring in OU4 An additional eight existing wells screened in the weathered bedrock, and five existing wells screened in the alluvium/colluvium, will be included in the post-closure monitoring system for the purposes of compliance and performance monitoring Based on available data (Drawings 51045-153 and 51045-154), it was assumed that the west point of compliance boundary for the upper hydrostratigraphic unit represents the upgradient point of compliance boundary (Drawing 51045-155) It was also assumed that the south, east, and north boundaries are downgradient point of compliance boundaries (Drawing 51045-155) These assumed upgradient and downgradient boundaries must be confirmed through water level measurements once the network is established Moreover, it seems likely that quarterly water level measurements conducted concurrently with water quality sampling would be prudent to ensure a clear understanding of the upper hydrostratigraphic unit flow regime in OU4 over time

V 4.3 2 Well Construction

Monitoring well construction specifications are consistent with existing and accepted SOPs at the RFETS Both bedrock and alluvial wells will be installed to monitor upgradient and downgradient ground water flow and quality conditions at the SEP Wells will be installed in accordance with RFETS EMD Operating Procedure No GT 06, "Monitoring Wells and Piezometer Installation", No GT 03, "Isolating Bedrock from Alluvium with Grouted Surface Casing," and RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD) Applicable RCRA monitoring well construction specifications will be reviewed and, to the extent practicable, wells will be constructed in compliance with both RFETS SOPs and RCRA specifications Specific differences between RFETS SOPs and RCRA will be resolved in concert with the appropriate regulatory agencies

V.5
SAMPLING AND ANALYSIS PLAN

V.5.1 Final Engineered Cover Monitoring System

This final engineered cover monitoring system sampling and analysis plan description presents data quality and quality assurance/quality control objectives for the final engineered cover monitoring program at the SEP In most cases, detailed descriptions of field and laboratory procedures are not included here, however, a detailed final engineered cover monitoring sampling and analysis plan will be developed and kept at the facility for post-closure monitoring

V.5.1.1 Data Quality Objectives

The overall DQO (data quality objective) for the final engineered cover monitoring program is to ensure that data of known and acceptable quality are produced Specifically, data produced through the post-closure final engineered cover monitoring program must be suitable for appropriate evaluations designed to facilitate the positive and timely identification of conditions conducive to, or indicative of, infiltration of surface waters and/or precipitation into the final engineered cover Proper execution of each sampling and analysis task will yield consistent results that are representative of actual conditions within the final engineered cover, and are useful for meeting the intended project objectives

V.5 1 2 Quality Assurance/Quality Control (QA/QC) Objectives

QA/QC objectives are established to ensure that all data collected during post-closure monitoring are of acceptable quality to support response action decisions and the DQOs The implementation of appropriate QA/QC procedures allows development of meaningful technical conclusions Components of the QA/QC program include evaluations of the following characteristics of measured data

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability

Data from the final engineered cover monitoring system can vary in quality due to measuring protocol, data logging protocols, data processing techniques, instrumentation, and available documentation QA programs include all of the activities necessary to provide measurement data at a requisite precision and accuracy (ASTM, 1993, Vol 11 03, Practice

1357-82) No laboratory analysis is expected from the final engineered cover monitoring system based on the proposed design Therefore, the QA/QC program for the final engineered barrier monitoring system will not include laboratory QA/QC or QA/QC procedures for analytical chemistry

The precision of a measurement process is a generic concept related to the closeness of agreement between test results obtained under prescribed like conditions from the measurement process being evaluated Accuracy is a generic concept of exactness related to the closeness of agreement between the average of one or more test results and an accepted reference value (ASTM, 1993, Vol 14 02, Practice E 177-86) Overall precision and accuracy targets for soil moisture content and neutron probe measurements can be set at 2 percent allowable deviation with 90 percent confidence limits

Representativeness is a measure of the degree to which analytical results reflect true field conditions Field errors in data logging and sampling intensity are two factors affecting representativeness The comparability of the data collected refers to the ability to interpret the results in light of previous data collection efforts and data collection efforts published as the result of other similar investigations Completeness refers to the number of samples collected and analyzed compared to the planned number of samples

In all of these quality assurance activities it should be noted that factors including geophysical conditions and definition of sampling volume in the vadose zone often have higher variability than the instrumentation and equipment calibration procedures Table V 5-1 provides preliminary quantitative limits for QA/QC objectives

V 5 1.3 Measurement Procedures

The quality of the data collected from the final engineered cover depends on the quality of the measurement procedures and sampling activities Therefore, field operations will be carefully planned and implemented Procedures and protocols for monitoring the final engineered cover will be in accordance with applicable existing SOPs for vadose zone monitoring and sampling at the RFETS As described in Section V 4 1, the conceptual design of the final engineered cover monitoring system includes indirect pore-liquid monitoring techniques using time domain reflectometry and frequency domain capacitance Specific procedures for installing and monitoring this equipment are provided in existing Vadose Zone SOP VZ 4, "Procedures for Dielectric Water Content Measurement," included in Technical Memorandum No 1 for OU4

V 5 1.4 Frequency of Measurement

The sampling and analysis plan is designed such that the intervals between measurement and sampling event are shortest at the beginning of the remedial action and become greater as time elapses and the performance of the remedial design is assessed and verified Data collected during the initial 3-year period will be used to develop an understanding of the effect of seasonal weather changes on the monitoring data, identify gaps in the data, further

characterize the completed remedial design, identify any additionally required monitoring locations, and evaluate sources of uncertainty such as sampling, analysis, and site conditions

The recommended long-term frequency for measurement and sampling depends in part on the effectiveness of the remedial action as determined through the ongoing monitoring program If the monitoring data demonstrates that a steady, predictable stabilization of the pore liquids in the waste pile has occurred, then reducing the sampling frequency will be a reasonable course of action Frequency of monitoring is also dependent upon the labor intensity of the measurement process as it effects the cost of acquiring data For example, there is little cost differential between weekly and daily monitoring of weather parameters when data from the sensors are electronically logged, acquired and presented in report format

Frequency is also dependent upon the status of other sensors in the overall system Measurement redundancy is built into the system in anticipation of the contingency that sensors may become disabled in the future For example, if the FDC sensors (which are part of the final engineered cover monitoring system) become disabled at some point in the future, the NPAT can also perform the function of detecting downward migration of leachate The frequency of NPAT data acquisition would be increased in the event that FDC probes become disabled Likewise, once it can be shown that the final engineered cover and vadose zone monitoring system data are reliably and consistently being used to demonstrate no leachate migration from the waste pile, the frequency of monitoring at all or some of the proposed ground water monitoring wells could be reduced or even eliminated

The monitoring data will provide the basis for determining that the remedial action objectives have been met and that the source control action, which is the goal of the remedial action, prevents further degradation of ground water

Monitoring data from MET and TDR sensors in the final engineered cover system will be electronically acquired on a daily basis throughout the period of monitoring During the initial 3 years of data acquisition, the data will be used to assess the performance of the cover system and to develop a baseline of meteorological data that will be used to define the site-specific environmental conditions affecting the remedial action The meteorological data may also be used to develop the statistical basis for de-seasonalizing the soil moisture data if required

At the end of the initial 3-year monitoring period, MET and TDR data will be used in conjunction with the water elevations from the ground water monitoring wells to determine the appropriate time of the year to collect pore liquid samples (PLS) from the pressure vacuum lysimeters A statistical correlation between the MET data, ground water elevation data, and TDR data will be developed for the purpose of defining the time of year when development of leachate within the pile is most likely, when a rising water table is most likely, and when the concentration of COC's is likely to be highest because of the concentrating effect of soil desaturation

Statistical correlation will be developed during the initial monitoring phase (0 to 3 years) and in the secondary phase (3 to 10 years) between the MET data and TDR data for the

purpose of developing a tool to predict the performance of the final engineered cover system design based on weather data For example, precipitation events will be identified that are most likely to saturate the cover soils and penetrate the capillary barrier portion of the final engineered cover Likewise, additional climatic data will be examined in order to assess the effect of weather patterns and intensity on the performance of the final engineered cover For example, soil temperature sensing data will be collected and evaluated to determine the effect of freezing and thawing fronts on saturation of the final engineered cover system

Assuming that the remedial design performs as intended, MET and TDR sensors in the final engineered cover system will be the primary means of monitoring performance of the remedial action 10 years after installation of these systems FDC monitoring of the final engineered cover and vadose zone monitoring will be reduced in frequency as described in Sections V 5 1 3 and V 5 2 3, respectively

Thirty years after installation of the facility, all of the sensors will remain in place However, it is anticipated that only the MET and TDR sensors will be used for data collection thereafter, as part of a normal operating weather station Based on the statistical correlations established during the 30-year monitoring period, weather events or climatic trends will be identified that could trigger additional monitoring of the unsaturated zone beneath the final engineered cover

Table V 5-2 summarizes the frequency of measurement of the monitoring instrumentation planned as a part of the design of the monitoring system

V.5.2 Vadose Zone Monitoring System

This vadose zone monitoring system sampling and analysis plan description presents data quality and quality assurance/quality control objectives for the vadose zone monitoring program at the SEP In most cases, detailed descriptions of field and laboratory procedures are not included here, however, a detailed vadose zone monitoring sampling and analysis plan will be developed and kept at the facility for post-closure monitoring

V 5 2.1 Data Quality Objectives

The overall DQO for the vadose zone monitoring program is to ensure that data of known and acceptable quality are produced Specifically, data produced through the post-closure vadose zone monitoring program must be suitable for appropriate evaluations designed to facilitate the positive and timely identification of conditions conducive to, or indicative of, the production of leachate, the movement of fluids through the waste pile, and/or the infiltration of fluids into the waste pile from the final engineered cover or from rising water-table conditions Proper execution of each sampling and analysis task will yield consistent results that are representative of actual conditions within the vadose zone, and are useful for meeting the intended project objectives

V.5.2.2 Quality Assurance/Quality (QA/QC) Control Objectives

QA/QC objectives for monitoring the vadose zone are similar to those for the final engineered cover monitoring system However, the vadose zone monitoring system must also address data that will result from collection of pore liquid samples using the pressure/vacuum lysimeters and data generated using the neutron probe In addition to the factors affecting data quality from the measuring techniques as described in Section V 5 2 3, pore liquid sampling data can vary in quality due to measurement protocol, sampling methodology, sample preparation, analytical procedures, laboratory quality control, and available documentation Specific Data Quality Assurance procedures used to evaluate analytical data from pore liquid samples will follow those negotiated in the RCRA Ground Water Monitoring Plan at the time of the pore water sampling It is anticipated that all laboratory analyses will be performed consistent with Level III quality assurance procedures, and that a full QA/QC package will be required as a deliverable from the laboratory for all samples analyzed The laboratory deliverables will include all QC sample results, such as matrix spikes and surrogate recoveries, for review by the data collection and analysis contractor

The vadose zone monitoring system sampling and analysis plan includes activities necessary to provide measurement data at a requisite precision and accuracy (ASTM, 1993, Vol 11 03, Practice 1357-82) The QA/QC program described herein will be implemented by the data collection/analysis contractor In addition to the steps described below, the laboratory performing the analyses will be responsible for performing QA/QC in support of Level III data The analytical laboratory deliverables will include the QA/QC results from the laboratory The overall quality assurance objective for measurement data is to ensure that data of known and acceptable quality are provided In order to meet these objectives, QA/QC objectives are defined for data measurements in support of the vadose zone monitoring data interpretation These data characteristics include precision, accuracy, representativeness, completeness, and comparability

The precision of a measurement process is a generic concept related to the closeness of agreement between test results obtained under prescribed like conditions from the measurement process being evaluated Accuracy is a generic concept of exactness related to the closeness of agreement between the average of one or more test results and an accepted reference value (ASTM, 1993, Vol 14 02, Practice E 177-86) Overall precision and accuracy targets for chemical constituent measurements can be set at 10 percent allowable deviation with 90 percent confidence limits General precision and accuracy targets for soil moisture content and neutron probe measurements can be set at 2 percent allowable deviation with 90 percent confidence limits

Representativeness is a measure of the degree to which analytical results reflect true field conditions Field contamination of pore liquid samples, field measurement data logging errors, and sampling intensity are two factors affecting representativeness Completeness refers to the number of samples collected and analyzed compared to the planned number of samples The comparability of the data collected refers to the ability to interpret the results in light of previous data collection efforts

In all of these quality assurance activities it should be recognized that factors including geophysical conditions and definition of sampling volume in the vadose zone often have higher variability than analytical equipment calibration procedures Table V 5-1 provides preliminary quantitative limits for QA/QC objectives

V.5.2.3 Measurement Procedures

The quality of the data collected from the vadose zone depends on the quality of the measurement procedures and sampling activities Therefore, field operations will be carefully planned and implemented Procedures and protocols for monitoring and sampling of the vadose zone beneath the final engineered cover and the waste layer will be in accordance with applicable existing SOPs for vadose zone monitoring and sampling at the RFETS (included in Technical Memorandum No 1 for OU4) As described in Section V 4 2, the conceptual design of the vadose zone monitoring system includes both direct and indirect pore-liquid monitoring techniques using suction lysimeters, neutron probes, time domain reflectometry and frequency domain capacitance Specific procedures for installing and monitoring this equipment are listed in existing SOPs as follows

- Vadose Zone SOP VZ 4, "Procedures for Dielectric Water Content Measurement"
- Vadose Zone SOP VZ 7, "Procedure for Neutron Moisture Logging"
- Vadose Zone SOP VZ 10, "Procedure for Lysimeter Installation and Sampling"

SOP VZ 7 is specifically applicable to neutron moisture logging in vertical neutron probe access tubes The conceptual design of the vadose zone monitoring system includes horizontal access tubes As required, SOP VZ 7 will be modified to include procedures specific to neutron moisture logging from horizontal access tubes

V 5 2.4 Frequency of Measurement

General comments that relate to the development of the monitoring schedule are similar to those presented in Section V 5 1 4 and summarized in Table V 5-2 The sampling and analysis plan is designed such that the intervals between measurement and sampling events are shortest at the beginning of the remedial action and become greater after a period of time within which the performance of the remedial design is assessed and verified

The proposed long-term plan for the frequency of measurement and sampling depends, in part, on the effectiveness of the remedial action as determined through the ongoing monitoring program If the monitoring data demonstrate that a steady, predictable stabilization of the pore liquids is maintained in the waste pile, then reducing the sampling frequency will be a reasonable course of action Frequency of monitoring is also dependent upon the labor intensity of the measurement process as it affects the cost of acquiring data Scheduling and costing of the NPAT monitoring data acquisition is based on the assumption that substantial field labor will be required to acquire the data An evaluation of the cost/benefit of designing and

constructing an automatic data acquisition system for collecting and analyzing NPAT data will be conducted before the monitoring system design is finalized Results of that evaluation will be presented with the final monitoring system design

Monitoring of the vadose zone with the NPAT will be conducted on a monthly schedule for the initial 3 years after installation of the facility Data collected during the initial 3-year period will be used to develop an understanding of the effect of seasonal weather changes on the monitoring data, assess gaps in the data, further characterize the completed remedial design, identify any additionally required monitoring locations, and evaluate sources of uncertainty such as sampling, analysis, and site conditions

In the second phase of monitoring the remedial facility, NPAT data will be collected quarterly If a significant rise in neutron counts is detected at any measuring event, the measurement will be immediately repeated to verify the data Once the count rise is verified, NPAT data collection frequency will be increased to monthly until an appropriate response is initiated or until, in the judgement of the interpreting hydrologist with the concurrence of the Colorado Department of Health, the event has stabilized and is shown to not represent migrating COC's NPAT monitoring will also be conducted at monthly intervals whenever a significant rise is detected in the FDC probes of the final engineered cover monitoring system The same criteria as above will apply in determining when and if a return to quarterly monitoring intervals is appropriate

Ten years after installation of the facility, the NPAT monitoring interval will be reduced to semiannual Unscheduled monitoring during this interval would be triggered by a rising water table that is anticipated to enter the waste pile or by a significant increase in normally scheduled NPAT or FDC measurements NPAT data collection frequency will be increased to monthly until an appropriate response is initiated or until, in the judgement of the interpreting hydrologist with the concurrence of the Colorado Department of Health, the event has stabilized and is shown to not represent migrating COC's

Assuming the remedial design performs as intended, no monitoring of the NPAT is anticipated beyond 30 years unless triggered by data that would indicate a rise in the water table into the subsurface drain, or sequential detections by the MET/TDR, FDC, and NPAT that would indicate an increase in soil water content

V 5 2 5 Pore Liquid Sampling Procedures

Field operations will be carefully planned and implemented to ensure high quality of the sampling data collected Procedures and protocols for pore liquid sampling will be in accordance with applicable existing SOPs for pore liquid sampling at the RFETS Specifically, SOP VZ 10, "Procedure for Lysimeter Installation and Sampling" (in Technical Memorandum No 1 for OU4), will be closely adhered to when sampling pore liquids

Initially, pore liquid samples will be collected from the pressure/vacuum lysimeters on pre-determined quarterly intervals based on conformance to the protocols for ground water sampling After the initial 3-year period, PLS data will be collected four times a year

However, the exact times of the year will be determined by examining the previous 3 years of MET, TDR, NPAT, and ground water monitoring well elevation data Based on ground water hydrographs, soil water hydrographs, and their correlation with cyclic weather patterns, sampling dates will be selected that will optimize characterization of pore liquids with respect to seasonal cycling of hydrologic parameters

No pore liquid sampling is planned after 10 years of monitoring unless data from the NPAT, TDR, FDC or ground water elevations indicate the presence of a downward propagating wetting front or a rising water table

It should be noted that it is likely that the lysimeters will not be capable of collecting samples when the design of the remedial action is performing as intended This is because the range of negative pore pressures within which lysimeters are capable of collecting samples is approximately 0 to 60 centibars Preliminary data interpreted from Part II of the IM/IRA indicate that these sampling pressures have only been observed in the capillary fringe above a rising water table The design of the remedial action is intended to block movement of soil water into the waste pile vadose zone and into the underlying native vadose zone By design, it is intended that the soil water content will be maintained at low levels which would relate to negative pore pressures well above 60 centibars If the initial 3 years of attempting to collect pore liquid samples indicate that the pore pressures are not sufficient to allow collection of pore liquid samples, all attempts at pore liquid sampling will be discontinued until data from the NPAT or FDC indicate the presence of a wetting front or of a rising water table

V.5.2.6 Sample Preservation and Shipment

Procedures and protocols for sample preservation and shipment of pore liquid samples will be in accordance with applicable existing SOPs for ground water sample preservation and shipment at the RFETS as per Procedure No GW 06, "Ground Water Sampling," and FO 13, "Containerization, Preserving, Handling, and Shipping of Soil and Water Samples "

V.5 2.7 Analytical Parameters and Procedures for Lysimeter Pore Liquids

The SEP are currently undergoing ground water monitoring as specified in 6 CCR 1007-3 Section 265 93 (d) (40 CFR 265 93(d)), because it has been determined that ground water quality has been affected by the ponds, which are regulated as interim-status units Once interim-status is terminated and final administrative disposition of the post-closure permit is made, monitoring will be pursuant to 40 CFR Part 264 In accordance with the IAG, analytical parameters for post-closure monitoring will be derived from the RCRA Appendix IX Ground Water Monitoring List (40 CFR Part 264, Appendix IX) but will focus on contaminants of concern identified for the OU4 IM/IRA Only four IM/IRA contaminants of concern are not listed in Appendix IX, these are Americium 241, Plutonium 239/240, Uranium 235, and Tritium

The complete list of potential analytical parameters for post-closure ground water monitoring at the SEP is provided in Table V 5-3 The same analyses that have been suggested for ground water monitoring will make up the candidate analyte list for pore liquid sampling

It must be noted that the list of analytes for the pore liquid sampling can not be finalized at this time The analytes will be derived from the RCRA Appendix IX list, but will focus on the OU4 contaminants of concern These may include contaminants not yet identified in OU4 media, or contaminants in other materials disposed in the SEPs prior to final closure The specific list of analytes, methods, and their frequency of analysis will be negotiated as part of the post-closure permit application process The listings provided in Table V 5-3 are for reference only, and may be modified in the post-closure permit

Also listed in Table V 5-3 are suggested analytical methods and practical quantitation limits (PQLs) for Appendix IX analyses Specific analytical methods will be identified in the post-closure permit application, and will be consistent with the most recent RCRA Ground Water Monitoring Plan for the RFETS at the time of the permit application Analytical methods and PQLs for Americium 241, Plutonium 239/240, Uranium 235, and Tritium are consistent with established analytical SOPs for the RFETS In some cases, individual Appendix IX compounds are listed with more than one suggested analytical method and corresponding PQL In these cases, the analytical method and PQL that are consistent with current RFETS SOPs will be selected Efforts will be made to reduce the number of analytical methods by selecting those methods that encompass the greatest number of individual analyses Field parameters will include pH, specific conductance, and ground water temperature The analyte list will be reduced after a sufficient number of sampling events to reduce the costs associated with the monitoring effort

V 5 2 8 Chain-of-Custody Control

Sample custody is widely recognized as vitally important in achieving the goals of quality data collection and reporting Samples must be traceable from the time of sample collection until the analyses are performed and reported Procedures and protocols for chain-of-custody control of pore liquid samples will be in accordance with applicable existing SOPs for ground water sampling at the RFETS Specific SOPs that will be implemented as a part the pore liquid sample chain-of-custody control are FO 13, "Containerization, Preserving, Handling, and Shipping of Soil and Water Samples," and FO 14, "Field Data Management "

V 5.3 Ground Water Monitoring System

This ground water monitoring system sampling and analysis plan description presents the data quality and quality assurance/quality control objectives for the ground water monitoring program at the Solar Evaporation Ponds, and for the field and laboratory procedures that will be followed to ensure that these objectives are met In most cases, detailed descriptions of field and laboratory procedures are not included here Instead, the reader is referred to established SOPs for the RFETS A detailed ground water sampling analysis plan will be developed and maintained at the facility for post-closure monitoring

V 5.3 1 Data Quality Objectives

The overall data quality objective (DQO) for the ground water monitoring program at the Solar Evaporation Ponds is to ensure that data of known and acceptable quality are

produced Specifically, data produced through the post-closure ground water monitoring program must be suitable for appropriate statistical evaluations designed to facilitate comparison of upgradient and downgradient ground water quality conditions, and to identify trends at individual monitoring locations In addition, data must be of sufficient quantity to support statistical evaluations The comparison of upgradient and downgradient ground water quality must take into consideration sources of contamination located upgradient from the ponds Proper execution of each sampling and analysis task will yield consistent results that are representative of actual ground water quality conditions, and are useful for meeting the intended project objectives Data will be reported in units consistent with those of other agencies and organizations to allow comparability of databases

In addition, analytical results must support an evaluation of potential threats to human health and the environment for those compounds that are being monitored That is, ground water contaminants must be detectable at concentrations that are at or below applicable or relevant and appropriate requirements (ARARs) for the OU4 ARARs may include, but may not be limited to, federal and/or state drinking water standards, Colorado ground water standards, and published and unpublished risk-based standards For the conceptual design, it is assumed that currently published practical quantitation limits (PQLs) (40 CFR Part 264, Appendix IX) will satisfy the DQOs If it is determined through the RI/RFI process at OU4 that PQLs will not support the detection of ground water contaminants at concentrations at or below ARARs (including an analysis of the most current RFETS "Benchmark" tables), analytical methodologies will be reevaluated prior to the development of a detailed ground water sampling and analysis plan PQLs for non-Appendix IX contaminants of concern (americium 241, plutonium 239/240, uranium 235, and tritium) will be consistent with established SOPs for the RFETS

V.5 3.1.1 Background Ground Water Quality

Ground water flowing towards the Solar Evaporation Ponds originates primarily in the plant area, southwest of the ponds Several potential ground water contaminant sources are present in the plant area The comparison of upgradient and downgradient ground water quality must take into consideration sources of contamination located upgradient from the ponds Four existing alluvial/colluvial wells and four existing weathered bedrock wells located south and west (upgradient) of the Solar Evaporation Ponds will be included in the post-closure ground water monitoring system to help achieve this DQO

V 5 3.2 Quality Assurance/Quality Control Objectives

QA/QC objectives are established to ensure that all data collected during post-closure monitoring are of acceptable quality to support response action decisions and the DQOs The implementation of appropriate QA/QC procedures allows development of meaningful technical conclusions The QA/QC program described herein will be implemented by the data collection/analysis contractor In addition to the steps described below, the laboratory performing the analyses will be responsible for performing QA/QC in support of Level III data The analytical laboratory deliverables will include the QA/QC results from the laboratory

Components of the QA/QC program include evaluations of the following characteristics of measured data

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability

In addition, standard analytical data quality assurance evaluations will be performed on all ground water data collected Specific Data Quality Assurance procedures used to evaluate analytical data from ground water samples will follow those negotiated in the RCRA Ground Water Monitoring Plan at the time of the ground water sampling It is anticipated that all laboratory analyses will be performed consistent with Level III quality assurance procedures, and that a full QA/QC package will be required as a deliverable from the laboratory for all samples analyzed The laboratory deliverables will include all QC sample results, such as matrix spikes and surrogate recoveries, for review by the data collection and analysis contractor

V 5.3.2.1 Precision

Precision is a measure of the reproducability of measurements under a given set of conditions Precision is assessed through a comparison of duplicate measurements, and is usually quantified in terms of a relative percent difference between primary and replicate samples In the analysis of ground water, duplicate analyses are performed on replicates of the primary sample Replicates prepared in the field are submitted blind to the laboratory The relative percent difference (RPD) test will be used to assess the laboratory's ability to reproduce test results from replicate or split samples The RPD is defined as

$$(X-Y)/[(X+Y)/2)] \; x \; 100$$

where

X = primary sample concentration

Y = replicate/split/laboratory duplicate sample concentration

V 5 3 2.2 Accuracy

Accuracy is a measure of the bias that exists in a measurement system That is, it is a measure of the trueness of a particular measurement, where the actual measurement is compared to the known value of a true standard Sources of bias in the sampling and analysis of ground water include field contamination and improper sampling, preservation techniques, sample handling, and/or analytical procedures

The accuracy of analytical procedures is assessed by analyzing known standards, or spiking an unknown sample with a known quantity of standard, and analyzing the resultant

mixture The first approach quantifies measured values as a percentage of true values The latter technique quantifies accuracy in terms of percent recoveries of the added spike, and takes into account matrix effects specific to a particular sample The constituents added to a sample by the laboratory in order to measure recovery are referred to as surrogates Spiked samples and other quality control results generated by the laboratory (as opposed to those generated in the field by the sample collection contractor) are referred to as Laboratory Control Samples (LCSs) USEPA Contract Laboratory Program Statement of Work (SOW) (USEPA, 1990) stipulates those constituents appropriate for spiking and subsequent measurement, and defines the percent recovery required for proper QA/QC The acceptable percent recoveries vary from constituent to constituent Laboratories performing analyses as part of the Solar Evaporation Pond post-closure sampling effort will employ one or both of these methods as part of their project-specific QA/QC measures Evaluation of the significance of laboratory percent recovery data, with respect to accuracy, will be performed as part of the data validation process Percent recovery measurements must fall within the ranges defined by the SOW (USEPA, 1990) for each particular constituent Acceptability is evaluated by the laboratory as part of Level III data validation Acceptable percent recoveries will be taken as evidence of accuracy in laboratory data measurement

V.5.3.2.3 Representativeness

Representativeness is the extent to which sample data accurately and precisely represent selected characteristics of the sampled population The assessment of representativeness is qualitative and addresses the overall design of a sampling program Considerations in evaluating the representativeness of the data include, but are not necessarily limited to, the proper selection of sample locations, the methods used to obtain environmental samples at the site, and the appropriateness of the analytical method for the type of sample obtained The following factors will be considered as part of the implementation and subsequent evaluation of sampling and analysis programs to ensure that representative data are obtained during the performance of this program

Sample locations will be carefully selected to characterize ground water quality both upgradient an downgradient of the waste material Efforts will be made to minimize or reduce the effects of environmental conditions on sampling efforts For example, field instrumentation will be isolated from field conditions so that data accurately reflect site conditions The parameters selected for analysis will be based on the analytical requirements as specified in Colorado regulations and will include the list of contaminants of concern for the OU4

V 5.3 2.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system or program compared to the amount that was expected to be obtained under ideal conditions It can be expressed as a percentage, as follows

$$\frac{ValidData}{TotalData} X\ 100 = Percent\ Completeness$$

Completeness will be routinely assessed using this equation Based on information presented by USEPA (1987), and the QA/QC procedures that will be implemented as part of this sampling and analysis plan, completeness ratings of 90 percent should be expected The goal for data completeness for all field data collection activities is 100 percent, however, variations in field conditions from the sampling plan, problems during sample transportation, and matrix interference usually prevent achievement of the 100 percent complete goal A certain amount of redundancy is typically built into any sampling and analysis plan to account for this problem The minimum acceptable completeness for this project is 90 percent Data that do not meet the completeness data quality objective will be cause for re-sampling for the analytes determined to be deficient

V.5.3.2 5 Comparability

Comparability expresses the confidence with which one data set can be compared to another Data comparability is assessed in a qualitative manner, and only after accuracy and precision of each data set are known The comparability of data sets is determined by identifying the difference, if any, between data sets in terms of sampling methods, handling, preservation, holding times, location, analytical methods, and quantifiable accuracy and precision

Given that post-closure monitoring can extend over a considerable time period, and can involve different contractors, subcontractors, personnel, and laboratories, and often include new and currently evolving analytical techniques, the QA/QC standards necessary to ensure data comparability are a critical element For data collected in the field during this investigation, sample collection and handling procedures are specified in the sampling and analysis plan The consistent use of these procedures throughout the remedial actions will ensure that data sets are comparable on the basis of these field variables

Laboratory QA/QC techniques for the analysis of environmental samples have become standardized, and many of the currently accepted techniques are outlined in the USEPA SOW (1990) For non-USEPA methodologies, ASTM methods (or their equivalents) provide standardization These methods, together with the specific QA plans and data validation procedures for sample analysis, will help ensure that laboratory procedures are comparable between data sets obtained by parties to the remedial action

V 5 3 2.6 Field Quality Assurance and Quality Control Samples

During implementation of the field sampling program described in the SAP, field QA/QC samples will be collected to assess the reproducability of the field collection techniques, the quality of preservation reagents and sample bottles, and the effectiveness of field decontamination procedures

QA/QC samples will be collected and shipped to the Contract Laboratory for analysis These samples, which are described below, consist of trip blanks, field replicates, and equipment blanks

- Trip Blanks (volatile organic compounds (VOCs) only) A trip (travel) blank is a sample container filled with organic-free water in the laboratory that travels unopened with the sample bottles It is returned to the laboratory with the field samples, opened in the laboratory and analyzed along with the field samples for VOCs

- Field Replicate A field replicate is a sample prepared at the sampling location from equal portions of all sample aliquots combined to make the field sample Both the field replicate and the field sample are collected at the same time, in the same container type, preserved in the same way, and analyzed by the same laboratory as a measure of sampling and analytical precision

- Equipment Blank An equipment blank (also called an equipment rinsate blank) is made by pouring organic-free water into or through the field sampling equipment (bailer, pump tubing, soil sampling equipment) that conceivably could be a source of contamination The water is then collected and sealed in the same type of sample container as the other field samples, preserved in the same manner (using the same preservative) transported to the laboratory with the field samples, and analyzed for the same parameters as the associated soil or water samples Equipment blanks will be collected before the associated field sample is collected

Field replicate and equipment blank samples will be collected at the site at a minimum frequency of one per 20 samples per matrix Trip blank samples will be supplied by the laboratory and one set of trip blanks will be returned to the laboratory in each cooler containing samples for VOCs analysis These samples will be collected, preserved, and handled in the same manner as the field samples Each field QA/QC sample will be packed and shipped along with the field samples to the laboratory for analysis of the same constituents using the same analytical procedures as the field samples

V 5 3.3 Sampling Procedures

The quality of the data collected in an environmental study depends on the quality of the sampling activities Therefore, field operations will be carefully planned and implemented Procedures and protocols for ground water sampling will be in accordance with applicable existing SOPs for ground water sampling at the RFETS Specific ground water sampling activities are as follows

- GW 01 Water Level Measurements in Wells and Piezometers
- GW 02 Well Development
- GW 05 Field Measurement of Ground water Field Parameters
- GW 06 Ground water Sampling
- FO 03 General Equipment Decontamination
- FO 13 Containerization, Preserving, Handling, and Shipping of Soil and Water Samples

V 5.3.4 Sample Preservation and Shipment

Procedures and protocols for sample preservation and shipment will be in accordance with applicable existing SOPs for ground water sampling at the RFETS (SOP FO 13)

V.5.3.5 Analytical Parameters and Procedures

The Solar Evaporation Ponds are currently undergoing ground water monitoring as specified in 6 CCR 1007-3 Section 265 93 (d) (40 CFR 265 93 (d)), because it has been determined that ground water quality has been affected by the ponds, which are regulated as interim-status units Once interim-status is terminated and final administrative disposition of the post-closure permit is made, monitoring will be pursuant to 6 CCR 1007-3 In accordance with the IAG, analytical parameters for post-closure monitoring will be derived from the RCRA Appendix IX Ground water Monitoring List (6 CCR 1007-3) but will focus on the contaminants of concern identified for the OU4 IM/IRA Only four IM/IRA contaminants of concern are not listed in Appendix IX, these are americium 241, plutonium 239/240, uranium 235, and tritium

The complete list of potential analytical parameters for post-closure ground water monitoring at the Solar Evaporation Ponds is provided in Table V 5-3 The list of analytes for the ground water sampling can not be finalized at this time The analytes will be derived from the RCRA Appendix IX list, but will focus on the OU4 contaminants of concern These may include contaminants not yet identified in OU4 media, or contaminants in other materials disposed in the SEPs prior to final closure The specific list of analytes, analytical methods, and the frequency of analysis will be negotiated as part of the post-closure permit application process The listings provided in Table V 5-3 are for reference only, and may be modified in the post-closure permit

Also listed in Table V 5-3 are suggested analytical methods and practical quantitation limits (PQLs) for Appendix IX analytes Specific analytical methods will be identified in the post-closure permit application, and will be consistent with the most recent RCRA Ground Water Monitoring Plan for the RFETS at the time of the permit application Analytical methods and PQLs for americium 241, plutonium 239/240, uranium 235, and tritium are consistent with established analytical SOPs for the RFETS In some cases, individual Appendix IX compounds are listed with more than one suggested analytical method and corresponding PQL In these cases, the analytical methods and PQLs that are consistent with current RFETS SOPs will be selected Efforts will be made to reduce the number of analytical methods by selecting those methods that encompass the greatest number of individual analytes Field parameters will include Ph, specific conductance, and ground water temperature The analyte list will be reduced after a sufficient number of sampling events to reduce the costs associated with the monitoring effort

V 5 3 5 1 Sampling Frequency

Ground water sampling will be conducted quarterly Samples will be collected annually for analyses encompassing the contaminants of concern and Appendix IX analytes

Sample parameters for the remaining three quarters will consist of the contaminants of concern Field parameters will be measured during each sampling event Water levels will be measured at the beginning of each quarterly sampling event, and ground water elevation/flow maps will be generated

V.5.3.6 Chain-of-Custody Control

Sample custody is a vital aspect of collecting quantifiable and legally-defensible analytical data The samples must be traceable from the time of sample collection until the analyses are performed Procedures and protocols for chain-of-custody control will be in accordance with applicable existing SOPs for ground water sampling at the RFETS Specific elements of chain-of-custody control SOPs that will be implemented are FO 13, "Containerization, Preserving, Handling, and Shipping of Soil and Water Samples," and FO 14, "Field Data Management "

V 5.4 Important Cost Assumptions

Cost information including estimates of capital expenditures and annual operation and maintenance costs were prepared for the monitoring systems discussed herein The cost and schedule information is presented in Part IV However, it is important to note at this time some of the important assumptions and limitations inherent in the cost estimates These are

- The costs for operation and maintenance (O&M) of the final engineered cover and vadose zone monitoring systems are based on the frequencies of data collection specified for the first year Since the cost for sampling of these systems is directly proportional to the sampling frequency, as sampling frequencies are reduced over time the costs will also diminish over time It is expected that the O&M costs will diminish rapidly with time

- The O&M costs for the vadose zone monitoring system include a substantial dollar amount for analysis of soil-pore liquid samples It is unlikely that these samples will be collected on a regular basis if the design performs as expected due to lack of soil moisture Therefore, the costs included for these analyses may not in fact be incurred

- The O&M costs for the ground water monitoring program are based on the currently expected list of COCs for OU4 However, this list may be expanded or reduced following the Phase II RI and final construction However, the cost of chemical analyses of ground water samples can only be reduced when an entire group of chemicals is eliminated from the list of required analytes This is because analytical methods typically report a large group of compounds, and if even one of the compounds is required for a specific analytical method then the entire method must be run Therefore, significant reductions in ground water monitoring O&M are not expected until the results of the final engineered cover and vadose zone monitoring programs can justify substantial reductions in ground water monitoring

V.6
MONITORING SYSTEM ASSESSMENT PROGRAM

V 6.1 Final Engineered Cover Monitoring System Assessment

The purpose of the final engineered cover monitoring system is to assess the performance of the final engineered cover and to identify the potential for moisture to enter the waste material via infiltration through or around the final engineered cover Instruments will be placed at various locations within the final engineered cover to detect changes in moisture content which may be indicative of the potential for water movement The following sections specify the approach to be used in evaluating the data collected from the engineering barrier/cover monitoring system (statistical evaluation), determining what results constitute grounds for further action (threshold values), and the steps to be taken when action is warranted (response actions)

V.6.1.1 Statistical Evaluation

Statistical tests will be performed on data from the engineering barrier/cover monitoring systems to satisfy general performance standards for statistical analysis of ground water monitoring data from RCRA facilities according to EPA guidance (EPA 1989, EPA 1992) Initial testing will be performed on a baseline suite of data collected in a short time period immediately after the instrumentation becomes operational to determine if an assumption of normally distributed data is appropriate for the instrumentation installed at the site This will also permit the definition of precision for each type of monitoring data at each monitoring point It is anticipated that normal theory tests will be appropriate for the treatment of TDR and FDC data Meteorological instruments will be tested and calibrated according to manufacturer specifications and a precision for field-installed instruments will be measured if possible

A time series data analysis will be used to detect trends from measurements of interrelated processes Control charts of selected parameters will be maintained using a Shewhart-Cusum control chart methodology (EPA, 1989) Calculated evapotranspiration will be plotted alongside soil water contents, runoff, and soil temperature at all monitored points The number of consecutive measurements used for each measurement type in the Cusum running average will be evaluated after one year of data acquisition

For detection of moisture increases, an out-of-control level will be set to signal significant changes in data Initially, the Type I error level of 0 01 (approximately three standard deviations) above or below the mean determined from the initial baseline data at each position will be set as the out-of-control level If the standard deviation of the original baseline data is too small to measure, a measured volumetric moisture content change of 2 percent will be considered significant After one year of data acquisition this will be reevaluated and reset, if appropriate (e g if it is deemed likely that construction-water redistribution has elevated the background moisture at any positions)

V.6.1.2 Threshold Values

Threshold values for soil moisture content measurements will be set for each type of material monitored, the natural materials at the ground surface/engineered cover interface, the upper soil of the final engineered cover and the compacted waste Threshold values will be selected based on laboratory characterization of the natural soils, the cover soil and the compacted waste material The unsaturated hydraulic conductivity as a function of water content for each material will be measured directly or calculated from soil moisture characteristics using the van Genuchten or other well-accepted technique (van Genuchten, 1980, 1991) For each material type, the moisture content at which flow is considered significant will be selected as a threshold The threshold value for the sand layer beneath the angular riprap layer will be set at the statistically determined out-of-control level, regardless of the hydraulic conductivity implications of the increase This is done as an early warning measure to trigger evaluation of the adequacy of the overlying soil layer and possible appropriate response as early as possible

V 6.1.3 Response Actions

An exceedence event occurs if threshold values at any monitored point are exceeded The initial response action to an exceedence event will be to intensify monitoring efforts by immediately (within days) re-sampling or remeasuring the point of the exceedence event and adjacent points in the monitoring network If the threshold is not exceeded again, hydrological events prior to the initial exceedence event will be examined to determine the likelihood that a slug of water moved rapidly through the system, and monitoring schedules may be adjusted to capture subsequent similar events If the threshold is exceeded again a variety of response actions are triggered All monitoring systems involved will be checked and tested to identify any malfunctions that could cause false-positives If any are identified, they will be corrected Re-sampling must be performed and all measurements must be below threshold values to return to standard monitoring schedules Otherwise, the monitoring schedule will be intensified at the discretion of the project manager in order to characterize the hydrologic event under observation Visual inspection of the final engineered cover system, guided by monitoring data and all monitoring systems, will be performed An evaluation of an exceedence event will be made in writing with recommendations for alteration of the final engineered cover design, repairs, and/or increase of threshold values at any monitoring points as necessary

V 6 2 Vadose Zone Monitoring System Assessment

The purpose of the vadose zone monitoring system is to detect moisture either entering the waste material via upward movement (i e , capillary action or rising water table) through the vadose zone Instruments will be placed at various locations within the vadose zone to detect changes in moisture content which may be indicative of the potential for water movement The following sections specify the approach to be used in evaluating the data collected from the vadose zone monitoring system (statistical evaluation), determining what results constitute grounds for further action (threshold values), and the steps to be taken when action is warranted (response actions)

V.6.2.1 Statistical Evaluation

Statistical evaluation of FDC data from beneath the subsurface drain layer will be the same as for FDC measurements related to the final engineered cover monitoring system described above

Neutron probe data from the access tubes beneath the gravel drain will consist of position/count data pairs from either neutron counts taken at set positions or from counts integrated across known distances from digitized continuous logs A set of baseline logs (subject to budgetary constraints, but ideally greater than 20) will be run to determine the precision at each position using parametric statistical tests The total error at each position will consist of a relocation error component and an instrumental error component related to the counting statistics of the neutron probe used

It is useful to separate the two error types when evaluating numerous neutron probe logs The repositioning error can be estimated by observing the reported location of a known sharp interface where neutron counts increase or decrease sharply It is appropriate to adjust morphologically similar logs to reduce obvious offsets in data before precision is calculated The instrumental error can be calculated from the original baseline data set using parametric statistical tests, including the Student T test for samples smaller than 20, or it can be estimated by assuming the standard deviation is equal to the square root of the mean of the counts at any position For the purposes of this analysis, a significance level of 95 percent will be used to define meaningful increases in neutron counts

Lysimeter data will consists of chemical concentrations of the COC's present in pore fluids (not necessarily readily mobile depending on the tensions at which they are extracted) Current information on subsurface conditions at RFETS indicate that it may frequently be impossible to collect a pore liquid sample The unknown availability of future samples from all lysimeters at the site make determination of statistical tests inappropriate at this stage of the design effort Availability of pre-existing lysimeters that could serve as background samplers, and the quantity and chemistry of past and future pore liquid samples taken at the site, will ultimately determine the appropriate method For example if most values are below detection, a test of proportions is suggested After a sufficient number of independent samples (minimum 4) has been taken, three approaches will be considered

- Comparison to background at each time
- Comparison with a constant limit
- Intrasampler comparisons

It is anticipated that after the first 3-year period there will be sufficient data to define a relevant procedure

In the interim, comparison with chemistry of soil samples taken during installation of the lysimeters, ground water chemistry and appropriate PRG's will be used to identify upward trends or conditions that would signal leachate releases

Statistical tests will be reviewed in the event that ground water rises to flood the pore liquid sampling (PLS) positions Ground water is already contaminated and the potential for residual liquids from ground water influencing future detection tests must be evaluated

V 6 2.2 Threshold Values

Two threshold values for the FDC samplers placed at the top of the gravel sub-drain layer are appropriate The first will be at a moisture content in equilibrium with 60 cbars of pore water tension as defined by laboratory characterization of soils at the site This threshold will signal the possibility for collecting a pore liquid sample (at this tension, a small gradient can be generated into the sampler at the elevation of RFETS) The second threshold will be at a moisture content that corresponds to the "field capacity" of the site soils This threshold will indicate mobility of pore liquids is possible

Threshold values for the neutron probe will be established as neutron counts at each position that signal a significant increase in moisture content A reasonable expectation, based on other sites, is that neutron counts corresponding to a five percent volumetric water content increase can be detected at the 95 percent level

Threshold values for PLS will initially consist of MCL's or other appropriate constant limits PLS threshold values are subject to reevaluation after data from the initial 3-year monitoring period is available (assuming no release has occurred)

V 6 2 3 Vadose Zone System Response Actions

An exceedence event occurs if threshold values at any monitored point are exceeded Exceedence events involving the first (lowest) FDC threshold value at positions with a record of moisture contents below the threshold will trigger PLS sampling and intensified neutron logging In cases where FDC indicate conditions conducive to sampling are ever-present, PLS sampling will occur on pre-scheduled intervals

The initial response action to any other exceedence events will be to intensify monitoring efforts by immediately (within days) re-sampling or remeasuring the point of the exceedence event and adjacent points in the monitoring network If the threshold is not exceeded again, hydrological events prior to the initial exceedence event will be examined to determine the likelihood that a slug of water moved rapidly through the system, and monitoring schedules may be adjusted to capture subsequent similar events If the threshold is exceeded again a variety of response actions are triggered All monitoring systems involved will be checked and tested to identify any malfunctions that could cause false-positives If any are identified they will be corrected Re-sampling must be performed and all measurements must be below threshold values to return to standard monitoring schedules Otherwise, the monitoring schedule shall be intensified at the discretion of the project manager in order to characterize the hydrologic event under observation Visual inspection of the final engineered cover system, guided by monitoring data and all monitoring systems shall be performed Evaluation of an exceedence event will be made in writing with recommendations for alteration of the final engineered cover design, repairs, and/or increase of threshold values at any monitoring points

V.6.3 Ground water Monitoring System

The purpose of the ground water monitoring system is to detect releases of hazardous constituents from the closed unit to ground water Ground water monitoring wells will be placed at various locations upgradient and downgradient of the units to detect changes in ground water quality which may be indicative of a release The following sections specify the approach to be used in evaluating the data collected from the ground water monitoring system (statistical evaluation), determining what results constitute grounds for further action (threshold values), and the steps to be taken when action is warranted (response actions)

V 6.3.1 Statistical Evaluation

The purpose of the ground water monitoring system surrounding the SEP is to detect a release from the SEP to ground water A release is defined as an exceedence of applicable ground water quality standards for one or more constituents which is directly attributable to migration of those constituents from the waste material in the closed unit Due to the presence of other sources of OU4 constituents of concern upgradient of OU4, as well as existing contamination in ground water, the identification of a release from the SEP requires careful evaluation of upgradient ground water quality as it relates to concentrations of constituents detected in downgradient wells A statistical evaluation will be performed in compliance with the Statistical Analysis of Ground water Monitoring Data at RCRA Facilities (USEPA, 1992) This guidance document provides guidance on using several different types of statistical tests in comparing upgradient and downgradient ground water monitoring data and in comparing downgradient ground water monitoring data against applicable standards to determine if a release has occurred

The amount and nature of the data collected from the ground water monitoring system will influence the choice of statistical test employed There are six types of statistical tests for significance discussed the RCRA guidance for analysis of detection monitoring data

- Test of Proportions
- Nonparametric One-Way ANOVA
- Parametric One-Way ANOVA
- Tolerance Limits
- Prediction Intervals
- Control Charts

Once an adequate ground water quality baseline has been established for the OU4 area, other appropriate statistical analysis methods will be considered in lieu of the recommended methods, however, if another method is submitted, it must meet certain requirements regarding statistical accuracy and confidence (Type I and Type II error rates) The general process for selecting a statistical test is documented in the RCRA guidance document In addition to standard statistical tests for determining significant differences between upgradient and downgradient ground water quality, Shewhart-Cusum Control Charts will be maintained for each ground water quality parameter to identify time-varying trends in the data

During the first several years of operation of the ground water monitoring system, other factors will likely complicate the analysis of the ground water monitoring system data, such as active remediation of ground water or remedial actions taking place upgradient of the OU4 area These factors will be taken into account in any evaluation of the ground water monitoring system data Since the engineering barrier/cover and vadose zone monitoring systems will act as an early warning system, identifying any potential releases prior to their impacting ground water, it is suggested that the first several years of ground water monitoring data serve as a baseline for evaluation, particularly while other remedial actions (either ground water remediation or other upgradient surface remediations) are taking place

Following the initial data-gathering period, trigger levels will be established against which all further data will be compared Only in cases where collected data show exceedences of the trigger levels will any additional evaluation take place The trigger levels will be set based on the pattern of variation observed in the initial one to two years of data collection The levels will be designed to filter out natural variations in concentrations, and to screen out known and identified external sources not associated with releases from the closed unit The trigger levels will be set based on acceptable levels of Type I and II error, to be negotiated during the Post Closure Permit application process

V 6.3 2 Threshold Values

Threshold values for identifying a release to ground water will be established in two parts This first threshold value is expressed as a statistically significant difference between upgradient and downgradient ground water quality for one or more of the constituents monitored This type of threshold indicates that constituents may have migrated from the closed unit, and will be established following the RCRA guidance described in Section V 5 3 1 In addition, a threshold value identifying an exceedence of applicable ground water quality standards will be established for each constituent regulated under the RCRA program and monitored in the ground water sampling and analysis program described in Section V 5 3 5 Threshold values will be established using promulgated ground water quality regulations at the time of submittal of the Post Closure Permit application

V 6.3.3 Response Actions

In the event a condition is detected in ground water exceeding applicable threshold values, an immediate re-sampling event will be initiated The re-sampling will include the well(s) where the exceedence was detected, and may include other wells for the purpose of identifying potential upgradient sources If the re-sampling event confirms the exceedence of the threshold value(s) with no identifiable upgradient sources, the monitoring schedule will be intensified at the discretion of the project manager to characterize the nature and extent of the release Visual inspections of the final engineered cover system and evaluation of the current and historical final engineered cover and vadose zone monitoring data will also be initiated An evaluation of the exceedence event will be submitted in writing with recommendations for any necessary remedial actions such as alteration or repair of the final engineered cover system, and/or increasing the monitoring frequency and network scope to identify any potential impacts to human health or the environment

V.7
POST-CLOSURE CARE ACTIVITIES

Pursuant to CCR 264 112, the SEP will be subject to post-closure care requirements including unit-specific monitoring, operations, maintenance, inspections, and associated record keeping These activities will be presented in a Post-Closure Plan Ground water and Vadose Zone monitoring objectives and procedures have been developed and are presented in Section V 4 of this document Upon review and acceptance by the regulatory agencies, this monitoring program will be reiterated in the Post-Closure Plan The remaining post-closure operating, maintenance, and inspection objectives and procedures are conceptually outlined below, and will be presented in detail for review and comment by CDPHE in the Post-Closure Plan Specifically, the proposed post-closure activities include

- Inspection and monitoring of the cover system and surface-water control system, including mitigation procedures
- Maintenance of the cover system, including erosion prevention,
- Inspection and maintenance activities associated with security,
- Monitoring for settlement and lateral displacement,
- Inspection and monitoring activities associated with the ground water and vadose zone monitoring systems,
- Record keeping and reporting

V.7 1 Cover System Inspection and Monitoring

Throughout the post-closure care period at the SEP, regular inspections of the cover system and associated structures will occur The cover will be inspected for signs of erosion, cracking, differential subsidence, lack of vegetation, and accumulation of standing water The surface-water control system will be inspected for breaches, erosion, damage, silting and other obstructions to flow An inspection schedule for each of these elements will be presented in the Post-Closure Plan In addition to regular inspection schedule, inspection will occur after significant precipitation events, defined as greater than 1 inch magnitude over a 24-hour period

As part of the inspection program, physical indicators may be placed in the part of the cover so that the extent and severity of any erosion or cracking can be readily detected These indicator layers may consist of a geomembrane fabric or a layers of distinctively colored gravel, and would be placed at depths below which a loss of soil material may cause saturated flow to reach the underlying capillary break layer leading to frequent infiltration of the cover materials above the low permeability hydraulic barrier

For each inspection, pre-printed forms will be used to record inspection findings, unusual conditions and corrective actions taken These forms will be presented in the Post-Closure Plan along with associated record keeping procedures

If a problem is discovered during inspection, the severity of the situation will be assessed to determine whether the integrity of the cover system has been compromised A standard set of mitigation procedures and implementation schedule will be developed in the Post-Closure Plan These measures will generally include erosion and cracking repairs, replacement of compatible fill material, repairs to runoff controls system, and revegetation In addition, if the assessment indicates that the integrity of the cover has been compromised, relevant regulatory agencies will be notified

V.7.2 Cover Maintenance

The cover system maintenance program will include components for the prevention of erosion damage, revegetation care, surface-water conveyance care and repair, and leachate collection system care and maintenance This program is conceptually outlined below and will be presented in detail in the Post-Closure Plan

Inspection for erosion control will be performed on a regular basis plus after significant rainfall events Steps will be taken to ensure that drainage pathways and cover thickness established during closure are maintained

Drainage ditches and cover-system pipe outlets will also be inspected on regular basis and after significant rainfall events At the time of inspection, standard maintenance activities will be undertaken such as removal of accumulated sediment

Vegetation will be inspected on a regular basis plus after significant rainfall events A regular schedule of mowing, subject to seasonal climatic conditions, will be followed to establish the vegatative cover, promote root growth and to allow cover inspection Maintenance activities will also include removal of undesirable foreign vegetation and revegetation of bare areas

All of the above activities are most essential as the cover vegetative system is established, which will likely occur over several growing seasons It is important that the desired plant species are established to a significant degree, and that drainage systems are maintained free of sediment until fully populated by the desired cover plants Finally, once the system is determined to be as desired, maintenance activities will be curtailed Monitoring will continue throughout the post-closure period

V 7 3 Security

The existing security measures at the Rocky Flats plant include

- Three-strand barbed wire cattle fence surrounding the facility posted to identify the land as a government reservation/restricted area,

- A fence surrounding and armed guards posted 24 hours per day at two gates to the controlled area of the facility,

- 6-foot high chain link fence topped by 2 feet of three-strand barbed wire surrounding and guards posted 24 hours per day at gates to the perimeter security zone (PSZ),

- Guards patrolling the controlled area and the PSZ 24 hours per day, and

- Surveillance by security cameras 24 hours per day

The existing security measures are sufficient to meet the requirements of CCR, Section 264 14

The existing fences and gates are operated and maintained by the U S Department of Energy Maintenance requirements will be performed by the U S Department of Energy, regardless of the activities at the solar evaporation ponds

During the post-closure period, the SEP will be secured by a 8-foot chain link perimeter fence and a locking gate to prevent unauthorized entry Signs will be placed around the fenced area to indicate that unauthorized access is prohibited

V 7.4 Monitoring for Settlement and Subsidence

As described in Section V 7 1, inspection for excessive settlement will be performed on a regular basis, with inspection frequency to be established in the Post-Closure Plan In addition to these inspections, a long-term monitoring and assessment program will be established to detect longer-term, more subtle changes in vertical elevations and slope angles that may be indicative of cover system failure The monitoring program will begin with the installation and surveying of benchmarks, settlement markers and slope indicators (Section V 4 1 5) Monitoring procedures, measurement frequency, and performance criteria will be presented in the Post-Closure Plan If the vertical, horizontal or slope angle movements exceed performance criteria established in the Post-Closure Plan, then an assessment and mitigation plan will be submitted within a specified period Note that all settlement/subsidence markers and measurement instruments will be inspected for damage and functionality during the regular inspection program

V.7.5 Ground water and Vadose Zone Monitoring System Maintenance

The ground water and vadose zone monitoring systems have been conceptually designed and are presented in Section V 4 of this document, including associated maintenance of these systems These activities will be reiterated in the Post-Closure Plan

V.7.6 Record Keeping and Reporting

The monitoring system to be used for this project will consist of data collection, storage, transmission, and analysis/archival subsystems, to allow for remote site monitoring The subsystems will provide the means to collect data from strategically placed sensors which will monitor soil moisture, soil temperature, air data, rainfall, and snowfall The system will be able to integrate additional sensors if found necessary

The data collection subsystem (DCS) will interrogate sensors at programmable intervals, store raw data for up to one week, and download to an off-site data management system The DCS will be connected to commercial power, but will have a back-up power system to assure continuous operation in the event of a commercial power outage

The data analysis/archival subsystem will accomplish the following

- Automatically interrogate the DCS via landlines at periodic intervals, and download all raw data collected since the previous interrogation,
- Convert the raw data into standard engineering units,
- Analyze and display the data in forms that are suitable to allow for adequate management decisions with regard to the site,
- Store the raw data and any analysis in suitable archival form,
- Alert the site management of any rapid changes in the data from the site sensors

This system will be used to meet the record keeping requirements stated in the IAG (Interagency Agreement), and those applicable requirements provided under the Colorado Hazardous Waste Act regulations, 6 CCR 1007 3

The IAG states that DOE shall preserve, for a minimum of ten (10) years after termination of the IAG, all of its records and documents in its possession which relate in any way to the presence of hazardous substances, pollutants, and contaminants at the site After this ten-year period, DOE shall notify EPA and the State at least 45 days prior to destruction or disposal of any such documents or records Upon request by EPA or the State, DOE shall make available such records or documents to either party

DOE will also be required to establish and maintain an Administrative Record at or near the site in accordance with Section 113(k) of CERCLA The Administrative Record will be established in accordance with EPA policy and guidelines and will be updated on at least a quarterly basis A master copy will be maintained by DOE at the RFETS in the Environmental Restoration Department currently located in Building T130B Four additional locations will satisfy the requirement of public access These four repositories are as follows

Rocky Flats Reading Room
Front Range Community College
3645 W 112th Avenue
Library
Westminster, Colorado 80030
(303) 469-4435

Colorado Department of Public Health and the Environment
Records Center-B2
4300 Cherry Creek Drive South
Denver, Colorado 80222-1530
(303) 692-3331

Rocky Flats Environmental Monitoring Council
1536 Cole Blvd , Suite 150
Golden, Colorado 80401
(303) 232-1966

U S Environmental Protection Agency (EPA)
Superfund Documents Room
5th Floor
999 18th Street
Denver, Colorado 80202
(303) 293-1444

The EPA will make the final determination of whether a document should be included in the Administrative Record The State will take part in this determination if found necessary The EPA or the State may also submit documents to DOE that are to be included in the Administrative Record

As a part of post-closure care, compliance monitoring reports will be submitted to the EPA and the State regarding results collected from four separate modes of monitoring the integrity of the cover system These methods include cover system monitoring, vadose zone monitoring, ground water monitoring, and cover system inspections Each of these are addressed below

Cover System Monitoring

Reporting results of the cover system monitoring program will be completed at the same frequency as determined necessary for the vadose zone

Vadose Zone Monitoring

Monitoring of the vadose zone will follow the methods described in Section V 5 2 The frequency that the reports will be generated and distributed will be determined during the final monitoring system design This frequency, at a minimum, will be on a quarterly basis

Ground Water Monitoring

The purpose of the ground water monitoring report is to present monitoring data as required under Colorado Hazardous Waste Act regulations, 6 CCR 1007-3, Part 265, Subpart F, Section 265 94 for RCRA interim status waste management units at the RFETS These regulations require that a ground water monitoring program be implemented that will determine the facility's impact on the uppermost hydrostratigraphic unit beneath the facility Records are to be maintained throughout the post-closure care period of the analyses required in Section 265 92, and the evaluations required in Section 265 93

Information should be reported during the first year when initial background concentrations are being established for the facility, concentrations or values of the parameters listed in Section 265 92 for each ground water monitoring well are reported within 15 days after completing each quarterly analysis Another report should be generated annually, identifying concentrations or values of the parameters listed in Section 265 92 for each ground water monitoring well, along with the required evaluations for these parameters under Section 265 93 The owner or operator must separately identify any significant differences from initial background found in the upgradient wells, in accordance with Sec 265 93 Results from the evaluation of ground water surface elevations performed under Section 265 93 should be submitted no later than March 1 following each calendar year

V 7 6.1 Cover System Inspections

Physical inspections of the final engineered cover will be completed as described in Section V 7 1 Results from these inspections will be recorded on pre-printed forms These forms will then be included in the ground water monitoring reports If a problem is detected which may effect the integrity of the cover system, the extent of the problem will be assessed and when necessary, a corrective action plan submitted Appropriate regulatory agencies will be notified

Five-year and thirty-year assessments will also be completed to evaluate the integrity of the cap These assessments are discussed in Section V 8 under Post Closure Performance and Assessment

V.8
POST CLOSURE PERFORMANCE AND ASSESSMENT

V.8.1 Five Year Assessment

At five year intervals following approval of the Post Closure Permit for OU4, a Five Year Assessment report will be submitted describing the performance of the final engineered cover as measured by the final engineered cover, vadose zone, and ground water monitoring systems The purpose of the five year assessment report is to provide a detailed assessment of the monitoring data collected and visual inspections performed over the five year period and to determine if the data indicate that either remedial actions or modifications to the monitoring program are warranted The Five Year Assessment reports will contain similar analyses to the annual reports, and will follow the procedures outlined in Section V 6, Monitoring System Assessment Program

Additional details on the content and format of the Five Year Assessment reports will be provided in the detailed engineering design report and in the Post-Closure Permit Application for OU4

V.8.2 Thirty Year Assessment

The RCRA regulations currently specify a thirty-year monitoring period for post closure care of regulated units A Thirty Year Assessment report will be submitted thirty years after approval of the Post Closure Permit for OU4 The purpose of the Thirty Year Assessment report is to document the performance of the final engineered cover system for OU4 over the thirty year period, and to determine if post-closure care may be discontinued

Additional details on the content and format of the Thirty Year Assessment report will be provided in the detailed engineering design report and in the Post Closure Permit application for OU4

V 8.3 Reduction in Monitoring

The sampling and analysis plan is designed such that the intervals between measurement and sampling event are shortest at the beginning of the remedial action and become greater as time elapses and the performance of the remedial design is assessed and verified Data collected during the initial 3-year period will be used to develop an understanding of the effect of seasonal weather changes on the monitoring data, identify gaps in the data, further characterize the completed remedial design, identify any additionally required monitoring locations, and evaluate sources of uncertainty such as sampling, analysis, and site conditions

The costs associated with initiating the final engineered cover monitoring system and vadose zone monitoring activities will be relatively high during the first few years of operation Therefore, the effort expended and associated costs will decrease substantially through time

The recommended long-term frequency for measurement and sampling depends in part on the effectiveness of the remedial action as determined through the ongoing monitoring program If the monitoring data demonstrates that a steady, predictable stabilization of the pore liquids in the waste pile has occurred, then reducing the sampling frequency will be a reasonable course of action Frequency of monitoring is also dependent upon the labor intensity of the measurement process as it effects the cost of acquiring data For example, there is little cost differential between weekly and daily monitoring of weather parameters when data from the sensors are electronically logged, acquired and presented in report format

Frequency is also dependent upon the status of other sensors in the overall system Measurement redundancy is built into the system in anticipation of the contingency that sensors may become disabled in the future For example, if the FDC sensors (which are part of the final engineered cover monitoring system) become disabled at some point in the future, the NPAT can also perform the function of detecting downward migration of leachate The frequency of NPAT data acquisition would be increased in the event that FDC probes become disabled Likewise, once it can be shown that the final engineered cover and vadose zone monitoring system data are reliably and consistently being used to demonstrate no leachate migration from the waste pile, the frequency of monitoring at all or some of the proposed ground water monitoring wells could be reduced or even eliminated

The monitoring data will provide the basis for determining that the remedial action objectives have been met and that the source control action, which is the goal of the remedial action, prevents further degradation of ground water

Statistical correlation will be developed during the initial monitoring phase (0 to 3 years) and in the secondary phase (3 to 10 years) between the MET data and TDR data for the purpose of developing a tool to predict the performance of the final engineered cover system design based on weather data For example, precipitation events will be identified that are most likely to saturated the cover soils and penetrate the capillary barrier portion of the final engineered cover Likewise, additional climatic data will be examined in order to assess the effect of weather patterns and intensity on the performance of the final engineered cover For example, soil temperature sensing data will be collected and evaluated to determine the effect of freezing and thawing fronts on saturation of the final engineered cover system

Assuming that the remedial design performs as intended, MET and TDR sensors in the final engineered cover system will be the primary means of monitoring performance of the remedial action 10 years after installation of the facility FDC monitoring of the final engineered cover and vadose zone monitoring will be reduced in frequency as described in Sections V 5 1 4 and V 5 2 4, respectively

Thirty years after installation of the facility, all of the sensors will remain in place Only the MET and TDR sensors will be used for data collection thereafter, as part of a normal operating weather station Based on the statistical correlations established during the 30-year monitoring period, weather events or climatic trends will be identified that could trigger additional monitoring of the unsaturated zone beneath the final engineered cover

The proposed long-term plan for the frequency of measurement and sampling depends, in part, on the effectiveness of the remedial action as determined through the ongoing monitoring program If the monitoring data demonstrates that a steady, predictable stabilization of the pore liquids is maintained in the waste pile, then reducing the sampling frequency will be a reasonable course of action Frequency of monitoring is also dependent upon the labor intensity of the measurement process as it affects the cost of acquiring data Scheduling and costing of the NPAT monitoring data acquisition is based on the assumption that substantial field labor will be required to acquire the data An evaluation of the cost benefit of designing and constructing an automatic data acquisition system for collecting and analyzing NPAT data will be conducted before the monitoring system design is finalized Results of that evaluation will be presented with the final monitoring system design

Assuming the remedial design performs as intended, no monitoring of the NPAT is anticipated beyond 30 years unless triggered by data that would indicate a rise in the water table into the subsurface drain, or sequential detections that would indicate an increase in soil water content by the MET/TDR, FDC, and NPAT Sampling intervals and collection procedures for the PLS (pore liquid sampling) devices are discussed in Section V 5 2

V.9
MONITORING SYSTEM ABANDONMENT

V.9.1 Access Casing and Sensor Abandonment Procedures

The abandonment procedures for the Rocky Flats OU4 final engineered cover monitoring system and vadose zone monitoring system will follow the ASTM designation D5299-92 entitled "Standard Guide for Decommissioning of Ground water Wells, Vadose Zone Monitoring Devices, Bore Holes, and Other Devices for Environmental Activities" (unless superseded by existing RFETS SOPs) (ASTM, 1993) This standard was published formally in January 1993 and has been unanimously approved by the membership of ASTM The guide was established to cover procedures that are specifically related to permanent closure of environmental activities The guide was intended for use where solid or hazardous materials or waste are found

Abandonment is necessary to

- Eliminate the possibility that the sensor or access holes are used for purposes other than intended,
- Prevent migration of contaminants into the subsurface aquifer
- Prevent migration of contaminants through the vadose zone
- Reduce the potential for vertical or horizontal migration of fluids in the access hole or adjacent to the access hole, and
- Remove the sensor or access casing from active use when the device is no longer capable of rehabilitation, or has failed structurally, no longer required for monitoring, no longer capable of providing representative samples or is providing unreliable samples, or, required to be abandoned, or, to meet regulatory requirements

V 9 1 1 Abandonment Procedure

The abandonment procedure will proceed in order of the following steps

V 9 1 1 1 Planning·

1 Records Review All available records and information relating to use of the monitoring device, casing, etc will be carefully reviewed This review may include the following information

1a Review applicable Federal, state, and local regulations contacting the applicable Federal, state or local agency having jurisdiction and preparation of the necessary documentation to start

1b Collection of drillers' logs, geophysical logs, access well construction, or geologic logs, including stratigraphy, structural geology, subsurface information, construction materials, depth, hydraulic gradients (if water levels are available from other wells for its determination), legal location, date of installation, and photographs of the site

1c Review of analytical chemical data for soil pore-water and ground water over the life of the site and variations in water levels over time

1d Review of records of the repairs, modifications, or other changes made to the site during the lifetime of the site

1e Evaluation of historic, current, and planned land use

1f While not directly part of the decommissioning activity, proper disposal of displaced fluids and other materials (such as pulled or drilled out casing and cement seals) should be considered Some of these materials may be classified as a hazardous waste under Federal, state, or local regulations Conduct a review of these regulations and appropriate analytical documentation prior to classifying a material as a hazardous waste

2 Verification of Field Data The variety and quality of field practices and reporting require that the site be inspected to verify the actual field situation prior to decommissioning The following list of procedures is recommended so that the actual condition of the site is know

2a Inspection of casing head installation for integrity

2b Current length measurement of the casing

2c Water Quality Sampling and Analysis A final sample collected from the devices may be required for regulatory purposes

2d Down-hole Inspections Including caliper logs to measure inside diameter, television logs to determine in-well conditions such as casing breaks, etc , gamma logs to verify geologic information, if not already available, cement bond logs (sonic) to determine if the casing is firmly attached to grout (presently available for holes 2 1/2-inch (6 35-cm) or larger in diameter), flow logs (flow meter or spinners) to determine if flow occurs within the casing, and hydraulic integrity test to determine if the neutron access is intact

2e Verification of field data is an ongoing responsibility Use verified information to modify plans in order that the decommissioning activity is correctly conducted Continue this activity during the field phase and change specifications as needed

3 Review of Decommissioning Options After the records have been thoroughly reviewed and verified in the field, select an appropriate decommissioning procedure Evaluate each possible option to determine the most appropriate method for the selection The following list of evaluation criteria is recommended

3a The potential for fluid movement should be eliminated

3b Materials to be used in plugging must be compatible with well casing and screen (if left in place), and with subsurface formation and ground water, etc over the period of time hazardous materials are found at these sites

3c Future land use (as is known at the time of decommissioning) should be compatible with decommissioning plans

3d Closure options should be compatible with applicable Federal, state, and local requirements

V 9 1 1 2 Implementation

1 All work performed on the site should be completed by competently trained drillers, equipped with appropriate tools, under the direction of a geological or engineering professional who is qualified to certify that the decommissioning is completed according to the planned procedures and is consistent with applicable regulations

1a Approve any modifications to the proposed work plan and record in writing by the on-site geologist or engineer (or their representatives) prior to implementation

1b The geologist or engineer should be on-site during the field activities to verify that the activities are completed as planned Maintain documentation of decommissioning activities for the post-closure period or period required by regulations (if specified) While regulations may require documentation for a period of 30 years, it is advisable to continue this activity for a period lasting as long as hazardous materials occur at the site

V 9 1 1 3 Decommissioning of Neutron Probe Access Tubes, Lysimeter Installations, and Time Domain Reflectometry Devices.

The NPAT will not be removed as a part of the decommissioning because of potential erosion, settlement, and other detrimental effects that could impact the facility design The casing will be abandoned in place using commercially available perforating

equipment Since the casing will not penetrate the asphalt liner, bentonite-grouted perforations will maintain the integrity of the barrier Decommissioning should be completed in accordance with ASTM D5299 Note that a complete discussion of plugging materials, cement additives, extenders (bentonite), accelerators, retarders, and density improvers is found in D5299 A detailed discussion of the required plugging material volume, grout water, and bentonite mixing is provided in D5299

V.9.2 Ground Water Monitoring Well Abandonment Procedures

The compliance monitoring wells for the SEP do not penetrate the waste piles, therefore, abandonment procedures for the ground water monitoring system are less rigorous than the abandonment procedures for the final engineered cover monitoring system and vadose zone monitoring system Unless superseded by existing (and more stringent) RFETS SOPs, ground water monitoring wells will be abandoned in accordance with the abandonment standards of the State of Colorado Division of Water Resources (CDWR)

Prior to abandonment, all well construction logs/information will be assembled and reviewed to determine the construction specifications of each well to be abandoned All monitoring wells at the SEP are to be completed into unconfined aquifers For abandonment, each well will be backfilled with clean sand to approximately 2 feet above the top of the screened interval Well casing will be cut off at a depth of 5 feet below land surface, and the remaining solid casing will be filled with grout A permanent cap will be affixed to the top of the casing and sealed with cement The remaining hole will then be backfilled with materials that are compatible with the surrounding soils

V.10
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Table V 3-1 Initial Screening and Evaluation of Technologies for the Final Engineered Cover Monitoring System, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Technology Type	Monitoring Option	Effectiveness	Implementability	Relative Cost	Retained
Indirect Pore-Liquid Monitoring	Tensiometer	Effective range of tensiometers is reduced by the altitude of the site and depth of placement	Requires penetration of the engineered cover to collect samples from the vadose zone beneath the cover	High	No
	Thermocouple Psychrometer	Precision of instruments is affected by a variety of environmental factors Not effective in long-term, permanent installations	Implementable	Medium	No
	Heat Dissipation Sensors	Calibration of probes to specific soil types is required	Implementable	High	No
	Neutron Probe	Effective	Horizontal access tubes not implementable Vertical access tubes require penetration of cover	High	No
	Time Domain Reflectometry	Effective Probes may require replacement prior to the end of the post-closure monitoring period	Implementable Probe leads are limited to 100' in length	High	Yes
	Frequency Domain Capacitance	Effective Probes may require replacement prior to the end of the post-closure monitoring period	Implementable Probe leads may be up to 700' in length	High	Yes

Table V 3-1 Initial Screening and Evaluation of Technologies for the Final Engineered Cover Monitoring System, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Technology Type	Monitoring Option	Effectiveness	Implementability	Relative Cost	Retained
	Soil Water Hydrographs	Effective as a reporting technique, but not as a stand-alone monitoring option	Implementable Would require construction of lysimeters external to OU4 to monitor infiltration and evapotranspiration	Medium	No
	Gypsum Blocks	Not effective in long term Block life is insufficient for a long-term monitoring program	Not implementable Probe replacement may compromise the integrity of the engineered cover	Low	No
Vadose Zone Direct Pore-Liquid Monitoring	Suction Lysimeter	Not applicable Soil water in engineered cover will consist of infiltrated precipitation, not leachate	Implementable	Medium	No
	Absorption Sampler	Effectiveness is questionable due to anticipated low moisture content of soils	Implementable	Medium	No

Table V 3-2 Initial Screening and Evaluation of Technologies for the Vadose Zone Monitoring System, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Technology Type	Monitoring Option	Effectiveness	Implementability	Relative Cost	Retained
Vadose Zone Indirect Pore-Liquid Monitoring	Tensiometer	Effective range of tensiometers is reduced by the altitude of the site and depth of placement	Requires penetration of the engineered cover to collect samples from the vadose zone beneath the cover	High	No
	Thermocouple Psychrometer	Precision of instruments is affected by a variety of environmental factors Not effective in long-term, permanent installations	Implementable	Medium	No
	Heat Dissipation Sensors	Calibration of probes to specific soil types is required	Implementable	Medium	No
	Neutron Probe	Effective	Vertical access tubes may require penetration of the engineered cover Horizontal access tubes are implementable	High	Yes
	Time Domain Reflectometry	Effective Probes may require replacement prior to the end of the post-closure monitoring period	Probe leads are limited to 100' in length, limiting placement to perimeter of cover	High	No
	Frequency Domain Capacitance	Effective Probes may require replacement prior to the end of the post-closure monitoring period	Implementable Probe leads may be up to 700' in length	High	Yes

Table V 3-2 Initial Screening and Evaluation of Technologies for the Vadose Zone Monitoring System, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Technology Type	Monitoring Option	Effectiveness	Implementability	Relative Cost	Retained
	Soil Water Hydrographs	Effective as a reporting technique, but not as a standalone monitoring option	Implementable Would require construction of lysimeters external to OU4 to monitor infiltration and evapotranspiration	Medium	No
	Gypsum Blocks	Not effective in long term Block life is insufficient for a long-term monitoring program	Not implementable Block replacement may compromise the integrity of the engineered cover	Low	No
Vadose Zone Direct Pore-Liquid Monitoring	Suction Lysimeter	Deep sampling pressure-vacuum samplers are effective for all sample depths	Implementable	Medium	Yes
	Absorption Sampler	Effectiveness is questionable due to anticipated low moisture content of soils	Implementable	Medium	No

Table V 3-3 Evaluation of the Final Engineered Cover Monitoring Options with respect to the Final Engineered Cover Performance Criteria, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

	Performance Criteria Number*										
Monitoring Option	1	2	3	4	5	6	7	8	9	10	11
Frequency Domain Capacitance (FDC)	Feasible with respect to the site hydrogeology and engineered cover	Capable of collecting data that may be used to provide early warning	May provide adequate spatial coverage if correctly designed	May provide adequate temporal coverage if correctly designed	Capable of providing data upon which to base a response action	May be sampled remotely	Can be integrated into the design of the engineered cover	Provide precise monitoring data	Is redundant when used with TDR or multiple instruments	Cost effective relative to other available monitoring techniques	Proven technology
Time Domain Reflectometry (TDR)	Same as above TDR cables limited to 100 in length	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Is redundant when used with FDC or multiple instruments	Same as above	Same as above

*See Section V 3 4 1

NOTE 1) A meteorological station will be installed in OU4 as part of the final engineered cover monitoring system to account for only those climatological factors which will affect infiltration, evapotranspiration and runoff at the OU4 IM/ IRA Regional climatic data will be obtained from established meteorological stations at and near RFP

2) While individual TDR probes are more cost effective for use in near surface positions, FDC probes allow longer cable lengths and the installations of monitoring points at deeper and laterally distant locations These locations are required to provide adequate spatial monitoring of the engineered cover at positions beneath the low permeability layer within the contaminated soil pile

Table V 3-4 Evaluation of the Vadose Zone Monitoring Options with respect to the Vadose Zone Performance Criteria, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

	Performance Criteria Number*												
Monitoring Option	1	2	3	4	5	6	7	8	9	10	11	12	13
Frequency Domain Capacitance	Feasible with respect to the site hydrogeology and engineered barrier	Capable of collecting data that may be used to identify the production of leachate within the waste layer	Capable of collecting data that may be used to identify the production of leachate in the waste layer	Capable of collecting data that may be used to identify the movement of leachate out of the waste layer	May provide adequate spatial coverage if correctly designed	May provide adequate temporal coverage if correctly designed	Capable of providing data upon which to base a response action	May be sampled remotely	Can be integrated into the design of the engineered barrier	Provides precise monitoring data	Is redundant when used with TDR	Cost effective relative to other available monitoring techniques	Proven technology
Neutron Probe	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	May be sampled remotely if neutron probes are stored in place	Same as above	Same as above	Is redundant when used with FDC and suction lysimeters	Same as above	Same as above
Suction Lysimeter	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Same as above	Can not be sampled remotely	Same as above	Same as above	Is redundant when used with neutron probes and suction lysimeters	Same as above	Same as above

*See Section V 3 4 2

Table V 5-1 Conceptual Quantitative Limits for the Quality Assurance/Quality Control Objectives in the Final Engineered Cover and Vadose Zone Monitoring Systems, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Data Quality Objective	Parameter	Instruments	Quantitation Limit
Accuracy	Volumetric Water Content	TDR FDC	2% 2%
	Standard Count	NPAT	2%
	NBS Standards	MET Station	1%
	Lab Standard Recovery	Lysimeter Sampling	+/-10%
Precision	Replicate Measurement	TDR FDC NPAT MET Station	2% 2% 2% 1%
	Lab Replicate	Lysimeter Sampling	<20%
Representativeness	Duplicate Field Measurement	TDR FDC NPAT MET Station	2% 2% 2% 1%
	Laboratory Blank	Lysimeter Sampling	<10%
Completeness	Completion (%)	TDR FDC NPAT MET Station Lysimeter Sampling	>90% >90% >90% >90% >90%*
Comparability	Professional Judgement	TDR FDC NPAT MET Station Lysimeter Sampling	N/A** N/A N/A N/A N/A

* when soil water tension is less than 60 centibars
** N/A = not applicable

Table V 5-2 Proposed Frequency of Sampling for the Final Engineered Cover and Vadose Zone Monitoring Systems, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Monitoring Technology	Frequency of measurement (years after facility installation)			
	0-3	3-10	10-30	30+
MET	**Daily**	**Daily**	**Daily**	**TBD**
TDR	**Daily**	**Daily**	**Daily**	**TBD**
FDC	**Weekly**, unless triggered by TDR rise then daily	**Monthly**, unless triggered by FDC rise then daily	**Monthly**, unless triggered by FDC rise then daily	**No measurement** unless triggered by MET/TDR
NPAT	**Monthly**	**Quarterly**, unless triggered by a rise in NPAT or FDC then monthly	**Semiannually** unless triggered by a rise in NPAT or FDC then monthly	**No measurement** unless triggered sequentially by MET/TDR and FDC
PLS	**Quarterly** or when triggered by water table rise or rise in NPAT or adjacent FDC	**4 times per year** based on previous 3-year MET and well data, or only when triggered by NPAT or adjacent FDC if pore liquid samples are NS	**No measurement** unless triggered by rise in NPAT, adjacent FDC or water table rise	**No measurement** unless triggered sequentially by MET/TDR, FDC, and NPAT, or water table rise

MET = meteorological instrumentation
TDR = time domain reflectometry
NPAT = neutron probe access tube
FDC = frequency domain capacitance probes
PLS = pore liquid samplers
NS = no sample obtainable due to high negative pore pressures
TBD = to be determined

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Acenaphthene		X	8100	200
			8270	10
Acenaphthylene		X	8100	200
			8270	10
Acetone		X	8240	100
Acetophenone		X	8270	10
Acetonitrile, Methyl cyanide		X	8015	100
2-Acetylaminofluorene, 2-AAF		X	8270	10
Acrolein		X	8030	5
			8240	5
Acrylonitrile		X	8030	5
			8240	5
Aldrin		X	8080	0 05
			8270	10
Allyl chloride		X	8010	5
			8240	100
4-Aminobiphenyl		X	8270	10
Aniline		X	8270	10
Anthracene		X	8100	200
			8270	10
Antimony		X	6010	300
			7040	2,000
			7041	30
Aramite		X	8270	10
Arsenic		X	6010	500
			7060	10
			7061	20
Barium	X	X	7080	1,000
			6010	20
Benzene		X	8020	2
			8240	5
Benzo[a]anthracene, Benzanthracene	X	X	8100	200
			8270	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Benzo[b]fluoranthene	X	X	8100 8270	200 10
Benzo[k]fluoranthene	X	X	8100 8270	200 10
Benzo[ghi]perylene		X	8100 8270	200 10
Benzo[a]pyrene	X	X	8100 8270	200 10
Benzyl alcohol		X	8270	20
Beryllium	X	X	6010 7090 7091	3 50 2
alpha-BHC		X	8080 8250	0 05 10
beta-BHC		X	8080 8250	0 05 40
delta-BHC		X	8080 8250	0 1 30
gamma-BHC, Lindane		X	8080 8250	0 05 10
Bis(2-chloroethoxy)methane		X	8270	10
Bis(2-chloroethyl)ether		X	8270	10
Bis(2-chloro-1-methylethyl) ether, 2,2-Dichlorodiisopropyl ether		X	8010 8270	100 10
Bis(2-ethylhexyl) phthalate	X	X	8060 8270	20 10
Bromodichloromethane		X	8010 8240	1 5
Bromoform, Tribromomethane		X	8010 8240	2 5
4-Bromophenyl phenyl ether		X	8270	10
Butyl benzyl phthalate, Benzyl butyl phthalate		X	8060 8270	5 10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Cadmium	X	X	6010	40
			7130	50
			7131	1
Carbon disulfide		X	8240	5
Carbon tetrachloride		X	8010	1
			8240	5
Chlordane		X	8080	0 1
			8250	10
p-Chloroaniline		X	8270	20
Chlorobenzene		X	8010	2
			8020	2
			8240	5
Chlorobenzilate		X	8270	10
p-Chloro-m-cresol		X	8040	5
			8270	20
Chloroethane, Ethyl chloride	X	X	8010	5
			8240	10
Chloroform		X	8010	0 5
			8240	5
2-Chloronaphthalene		X	8120	10
			8270	10
2-Chlorophenol		X	8040	5
			8270	10
4-Chlorophenyl phenyl ether		X	8270	10
Chloroprene		X	8010	50
			8240	5
Chromium	X	X	6010	70
			7190	500
			7191	10
Chrysene	X	X	8100	200
			8270	10
Cobalt		X	6010	70
			7200	500
			7201	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Copper		X	6010	60
			7210	200
m-Cresol		X	8270	10
o-Cresol		X	8270	10
p-Cresol		X	8270	10
Cyanide		X	9010	40
2,4-D, 2,4-Dichlorophenoxyacetic acid		X	8150	10
4,4'DDD		X	8080	0 1
			8270	10
4,4' DDE		X	8080	0 05
			8270	10
4,4' DDT		X	8080	0 1
			8270	10
Diallate		X	8270	10
Dibenz[a,h]anthracene		X	8100	200
			8270	10
Dibenzofuran		X	8270	10
Dibromochloromethane, Chlorodibromomethane		X	8010	1
			8240	5
1,2-Dibromo-3-chloropropane, DBCP		X	8010	100
			8240	5
			8270	10
1,2-Dibromoethane, Ethylene dibromide		X	8010	10
			8240	5
Di-n-butyl phthalate		X	8060	5
			8270	10
o-Dichlorobenzene		X	8010	2
			8020	5
			8120	10
			8270	10
m-Dichlorobenzene		X	8010	5
			8020	5
			8120	10
			8270	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
p-Dichlorobenzene, 1,4-Dichlorobenzene	X	X	8010 8020 8120 8270	2 5 15 10
3,3'-Dichlorobenzidine		X	8270	20
trans-1,4-Dichloro-2-butene		X	8240	5
Dichlorodifluoromethane		X	8010 8240	10 5
1,1-Dichloroethane		X	8010 8240	1 5
1,2-Dichloroethane, Ethylene dichloride		X	8010 8240	0 5 5
1,1-Dichloroethylene, Vinylidene chloride		X	8010 8240	1 5
trans-1,2-Dichloroethylene		X	8010 8240	1 5
2,4-Dichlorophenol		X	8040 8270	5 10
2,6-Dichlorophenol		X	8270	10
1,2-Dichloropropane	X	X	8010 8240	0 5 5
cis-1,3-Dichloropropene		X	8010 8240	20 5
trans-1,3-Dichloropropene		X	8010 8240	5 5
Dieldrin		X	8080 8270	0 05 10
Diethyl phthalate		X	8060 8270	5 10
O,O-Diethyl O-2-pyrazinyl phosphorothioate, Thionazin		X	8270	10
Dimethoate		X	8270	10
p-(Dimethylamino)azobenzene		X	8270	10
7,12-Dimethylbenz[a]anthracene		X	8270	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
3,3'-Dimethylbenzidine		X	8270	10
alpha, alpha-Dimethylphenethylamine		X	8270	10
2,4-Dimethylphenol		X	8040 8270	5 10
Dimethyl phthalate		X	8060 8270	5 10
m-Dinitrobenzene		X	8270	10
4,6-Dinitro-o-cresol		X	8040 8270	150 50
2,4-Dinitrophenol		X	8040 8270	150 50
2,4-Dinitrotoluene		X	8090 8270	0 2 10
2,6-Dinitrotoluene	X	X	8090 8270	0 1 10
Dinoseb, DNBP, 2-sec-Butyl-4,6-dinitrophenol		X	8150 8270	1 10
Di-n-octyl phthalate		X	8060 8270	30 10
1,4-Dioxane		X	8015	150
Diphenylamine		X	8270	10
Disulfoton		X	8140 8270	2 10
Endosulfan I		X	8080 8250	0 1 10
Endosulfan II		X	8080	0 05
Endosulfan sulfate		X	8080 8270	0 5 10
Endrin		X	8080 8250	0 1 10
Endrin aldehyde		X	8080 8270	0 2 10
Ethylbenzene		X	8020 8240	2 5

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Ethyl methacrylate		X	8015 8240 8270	10 5 10
Ethyl methanesulfonate		X	8270	10
Famphur		X	8270	10
Fluoranthene		X	8100 8270	200 10
Fluorene		X	8100 8270	200 10
Heptachlor		X	8080 8270	0 05 10
Heptachlor epoxide		X	8080 8270	1 10
Hexachlorobenzene	X	X	8120 8270	0 5 10
Hexachlorobutadiene		X	8120 8270	5 10
Hexachlorocyclopentadiene		X	8120 8270	5 10
Hexachloroethane		X	8120 8270	0 5 10
Hexachlorophene		X	8270	10
Hexachloropropene		X	8270	10
2-Hexanone	X	X	8240	50
Indeno(1,2,3-cd)pyrene	X	X	8100 8270	200 10
Isobutyl alcohol		X	8015	50
Isodrin		X	8270	10
Isophorone		X	8090 8270	60 10
Isosafrole		X	8270	10
Kepone		X	8270	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Lead		X	6010 7420 7421	40 1,000 10
Mercury	X	X	7470	2
Methacrylonitrile		X	8015 8240	5 5
Methapyrilene		X	8270	10
Methoxychlor		X	8080 8270	2 10
Methyl bromide, Bromomethane		X	8010 8240	20 10
Methyl chloride, Chloromethane		X	8010 8240	1 10
3-Methylcholanthrene		X	8270	10
Methylene bromide, Dibromomethane		X	8010 8240	15 5
Methylene chloride, Dichloromethane		X	8010 8240	5 5
Methyl ethyl ketone, MEK		X	8015 8240	10 100
Methyl iodide, Iodomethane		X	8010 8240	40 5
Methyl methacrylate		X	8015 8240	2 5
Methyl methanesulfonate		X	8270	10
2-Methylnaphthalene		X	8270	10
Methyl parathion, Parathion methyl		X	8140 8270	0 5 10
4-Methyl-2-pentanone, Methyl isobutyl ketone		X	8015 8240	5 50
Naphthalene		X	8100 8270	200 10
1,4-Naphthoquinone		X	8270	10
1-Naphthylamine		X	8270	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
2-Naphthylamine		X	8270	10
Nickel	X	X	6010 7520	50 400
o-Nitroaniline		X	8270	50
m-Nitroaniline		X	8270	50
p-Nitroaniline		X	8270	50
Nitrobenzene		X	8090 8270	40 10
o-Nitrophenol		X	8040 8270	5 10
p-Nitrophenol		X	8040 8270	10 50
4-Nitroquinoline 1-oxide		X	8270	10
N-Nitrosodi-n-butylamine		X	8270	10
N-Nitrosodiethylamine		X	8270	10
N-Nitrosodimethylamine		X	8270	10
N-Nitrosodiphenylamine		X	8270	10
N-Nitrosodipropylamine, Di-n-propylnitrosamine	X	X	8270	10
N-Nitrosomethylethylamine		X	8270	10
N-Nitrosomorpholine		X	8270	10
N-Nitrosopiperidine		X	8270	10
N-Nitrosopyrrolidine		X	8270	10
5-Nitro-o-toluidine		X	8270	10
Parathion		X	8270	10
Polychlorinated biphenyls, PCBs	X[4]	X	8080 8250	50 100
Polychlorinated dibenzo-p-dioxins, PCDDs		X	8280	0 01
Polychlorinated dibenzofurans, PCDFs		X	8280	0 01
Pentachlorobenzene		X	8270	10
Pentachloroethane		X	8240 8270	5 10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Pentachloronitrobenzene		X	8270	10
Pentachlorophenol	X	X	8040 8270	5 50
Phenacetin		X	8270	10
Phenanthrene	X	X	8100 8270	200 10
Phenol		X	8040 8270	1 10
p-Phenylenediamine		X	8270	10
Phorate		X	8140 8270	2 10
2-Picoline		X	8240 8270	5 10
Pronamide		X	8270	10
Propionitrile, Ethyl cyanide		X	8015 8240	60 5
Pyrene		X	8100 8270	200 10
Pyridine		X	8240 8270	5 10
Safrole		X	8270	10
Selenium		X	6010 7740 7741	750 20 20
Silver		X	6010 7760	70 100
Silvex, 2,4,5-TP		X	8150	2
Styrene		X	8020 8240	1 5
Sulfide		X	9030	10,000
2,4,5-T, 2,4,5-Trichlorophenoxyacetic acid		X	8150	2
2,3,7,8-TCDD, 2,3,7,8-Tetrachlorodibenzo-p-dioxin		X	8280	0 005

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
1,2,4,5-Tetrachlorobenzene		X	8270	10
1,1,1,2-Tetrachloroethane		X	8010 8240	5 5
1,1,2,2-Tetrachloroethane		X	8010 8240	0 5 5
Tetrachloroethylene, Perchloroethylene, Tetrachloroethene		X	8010 8240	0 5 5
2,3,4,6-Tetrachlorophenol		X	8270	10
Tetraethyl dithiopyrophosphate, Sulfotepp		X	8270	10
Thallium		X	6010 7840 7841	400 1,000 10
Tin		X	7870	8,000
Toluene		X	8020 8240	2 5
o-Toluidine		X	8270	10
Toxaphene		X	8080 8250	2 10
1,2,4-Trichlorobenzene		X	8270	10
1,1,1-Trichloroethane, Methylchloroform	X	X	8240	5
1,1,2-Trichloroethane		X	8010 8240	0 2 5
Trichloroethylene, Trichloroethene		X	8010 8240	1 5
Trichlorofluoromethane		X	8010 8240	10 5
2,4,5-Trichlorophenol		X	8270	10
2,4,6-Trichlorophenol		X	8040 8270	5 10
1,2,3-Trichloropropane		X	8010 8240	10 5
O,O,O-Triethyl phosphorothioate		X	8270	10
sym-Trinitrobenzene		X	8270	10

Table V 5-3 Potential Analytical Parameters for Post-Closure Ground Water Monitoring and Pore Liquid Monitoring, OU4 Solar Evaporation Ponds, Rocky Flats Environmental Technology Site, Golden, Colorado

Compound	Contaminants of Concern[1]	Part 264[2] App IX	Suggested Analytical Methods	PQL[3] (ug/L)
Vanadium		X	6010	80
			7910	2,000
			7911	40
Vinyl acetate		X	8240	5
Vinyl chloride		X	8010	2
			8240	10
Xylene (total)		X	8020	5
			8240	5
Zinc		X	6010	20
			7950	50
Americium-241	X			
Plutonium-239/240	X			
Tritium	X			
Uranium-235	X			

1 Contaminant of concern for OU4 soils Data collected July 1987 to May 1993
2 Groundwater monitoring list, Appendix IX, RCRA Part 264
3 Practical quantitation limits for groundwater samples in micrograms per liter
4 Arochlor-1254 is the only PCB compound listed as a contaminant of concern

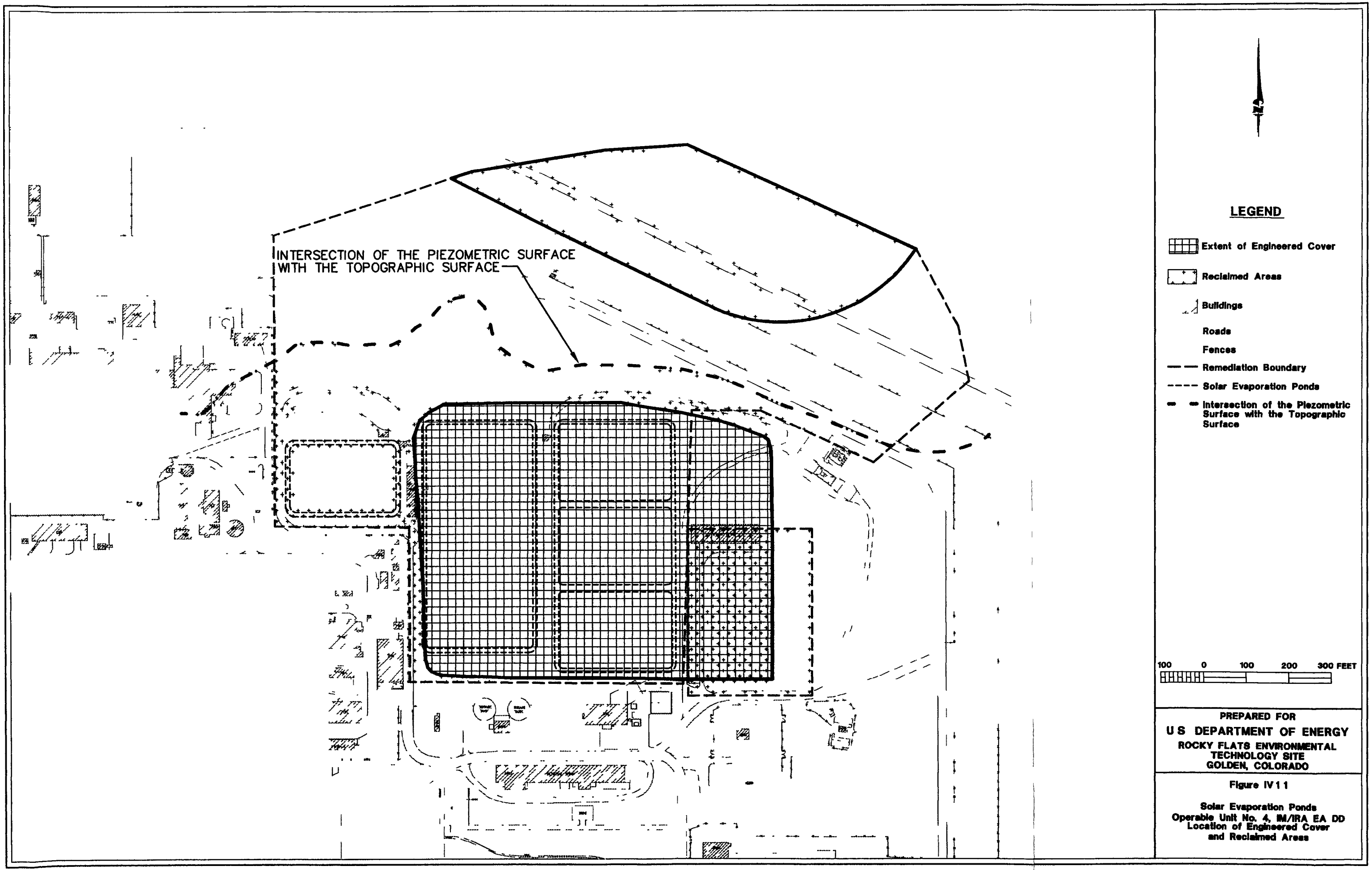
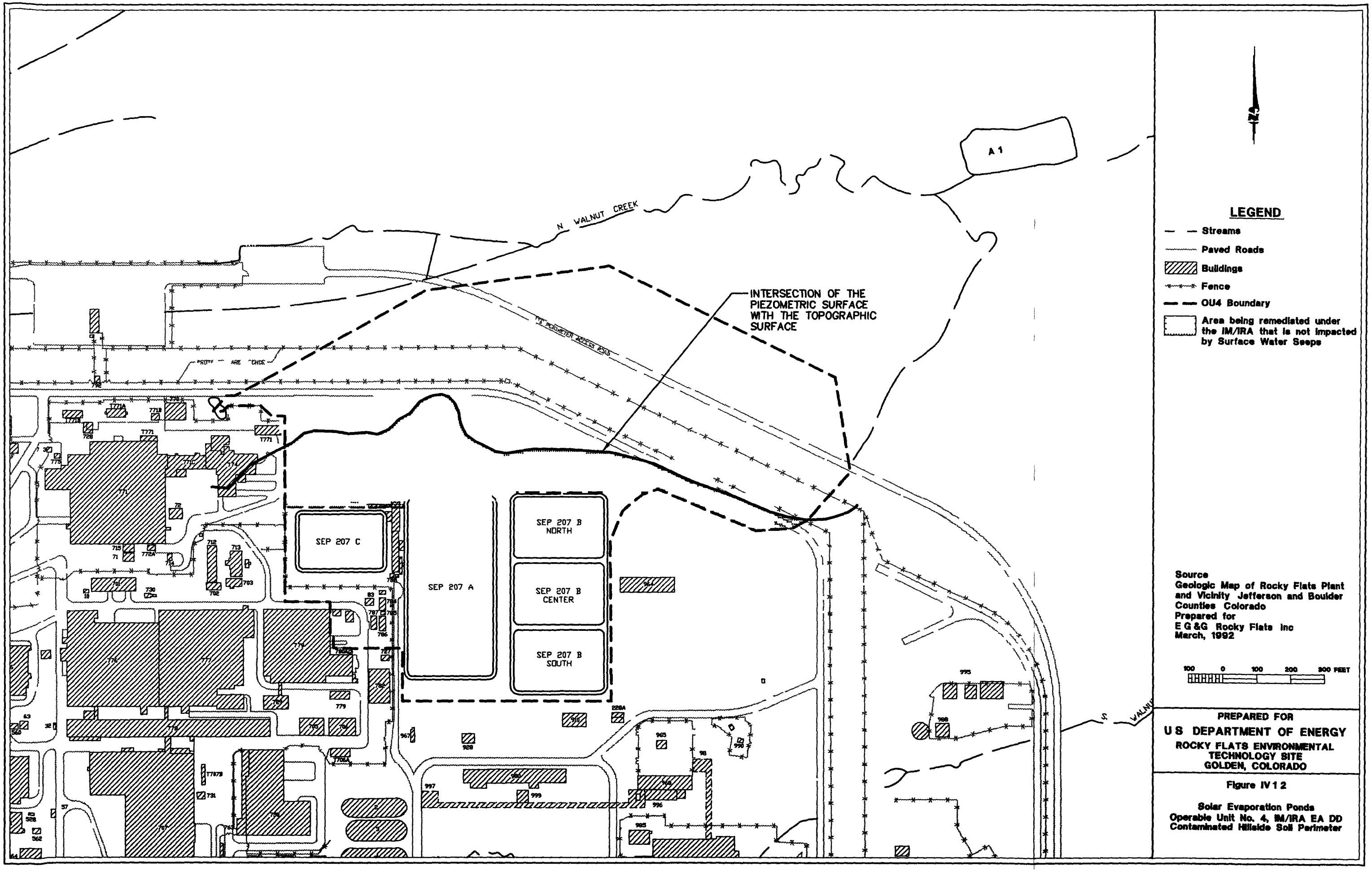


Figure IV 1 1

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Location of Engineered Cover
and Reclaimed Areas


N WALNUT CREEK
INTERSECTION OF THE PIEZOMETRIC SURFACE WITH THE TOPOGRAPHIC SURFACE
A 1
SEP 207 C
SEP 207 A
SEP 207 B NORTH
SEP 207 B CENTER
SEP 207 B SOUTH
LEGEND
Streams
Paved Roads
Buildings
Fence
OU4 Boundary
Area being remediated under the IM/IRA that is not impacted by Surface Water Seeps
Source
Geologic Map of Rocky Flats Plant and Vicinity Jefferson and Boulder Counties Colorado
Prepared for
E G &G Rocky Flats Inc
March, 1992
100 0 100 200 300 FEET
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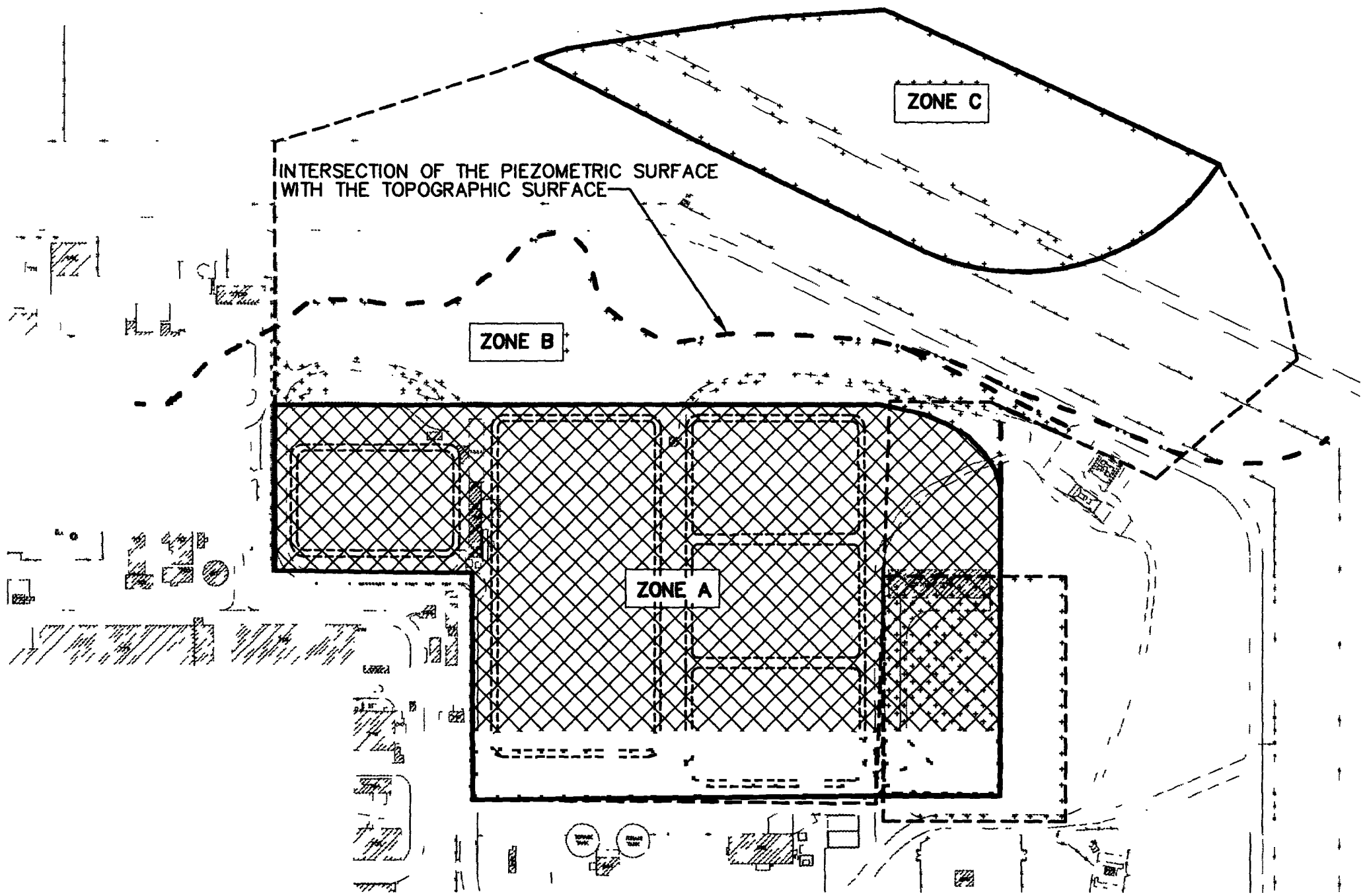
GOLDEN, COLORADO
Figure IV 1 2
Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Contaminated Hillside Soil Perimeter



LEGEND

- Zone A Excavated to Mean of the Seasonal High Water Table Elevation
- Zones B and C 6 Surficial Soil Excavation
- Buildings
- Roads
- Remediation Boundary
- Solar Evaporation Ponds
- Intersection of the Piezometric Surface with the Topographic Surface

100 0 100 200 300 FEET

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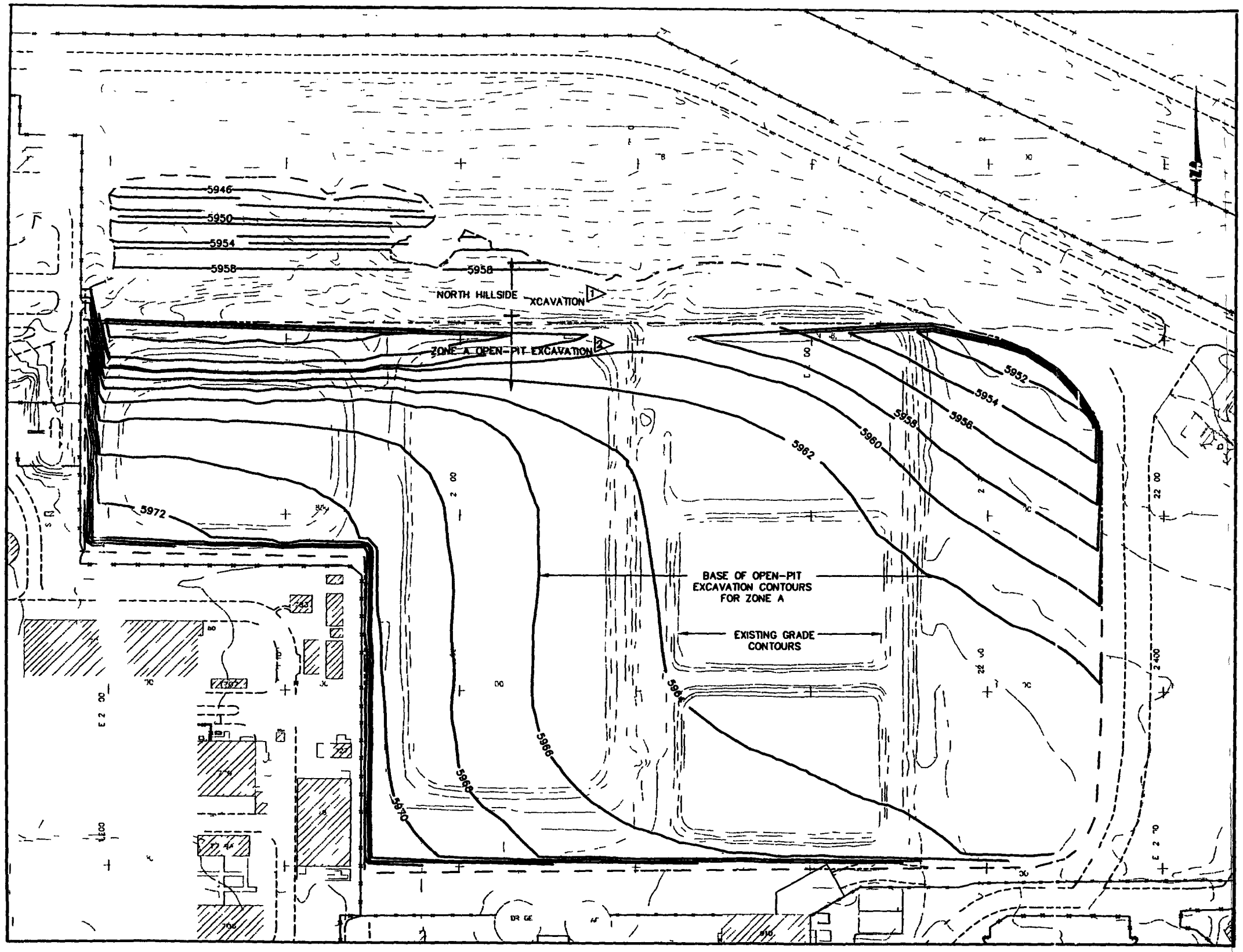
GOLDEN, COLORADO

Figure IV 3-1

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Zones of Soil Excavation



LEGEND

- EXISTING FENCE
- EXCAVATION BOUNDARY (ZONE A)
- EXISTING CONTOURS
- EXCAVATION CONTOURS
- ROADWAYS

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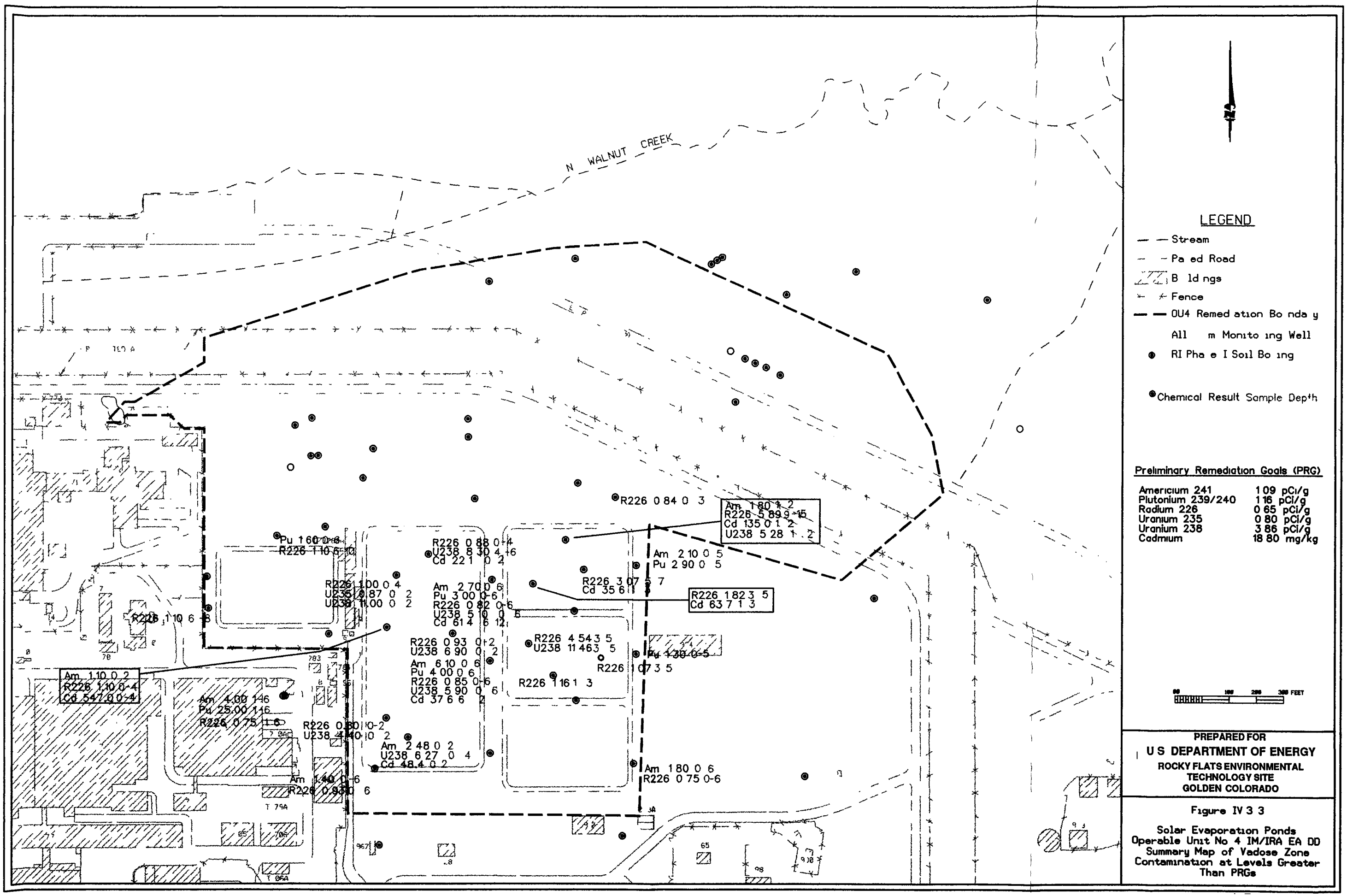
GOLDEN, COLORADO

Figure IV 3-2

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Excavation Plan


N WALNUT CREEK
LEGEND
Stream
Paved Road
Buildings
Fence
OU4 Remediation Boundary
All m Monitoring Well
RI Phase I Soil Boring
Chemical Result Sample Depth
Preliminary Remediation Goals (PRG)
Americium 241 1 09 pCi/g
Plutonium 239/240 1 16 pCi/g
Radium 226 0 65 pCi/g
Uranium 235 0 80 pCi/g
Uranium 238 3 86 pCi/g
Cadmium 18 80 mg/kg
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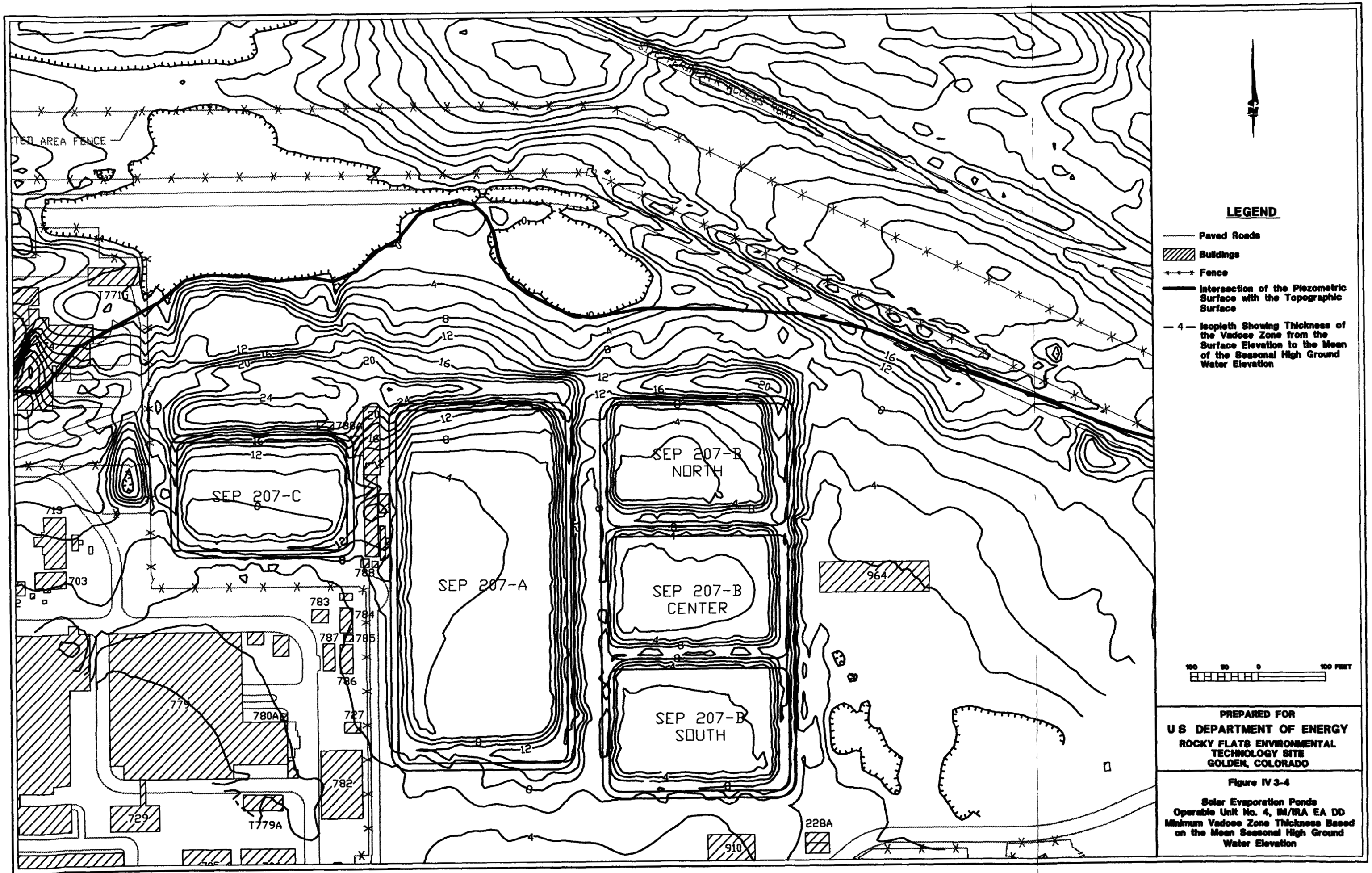
GOLDEN COLORADO
Figure IV 3 3
Solar Evaporation Ponds
Operable Unit No 4 IM/IRA EA DD
Summary Map of Vadose Zone Contamination at Levels Greater Than PRGs



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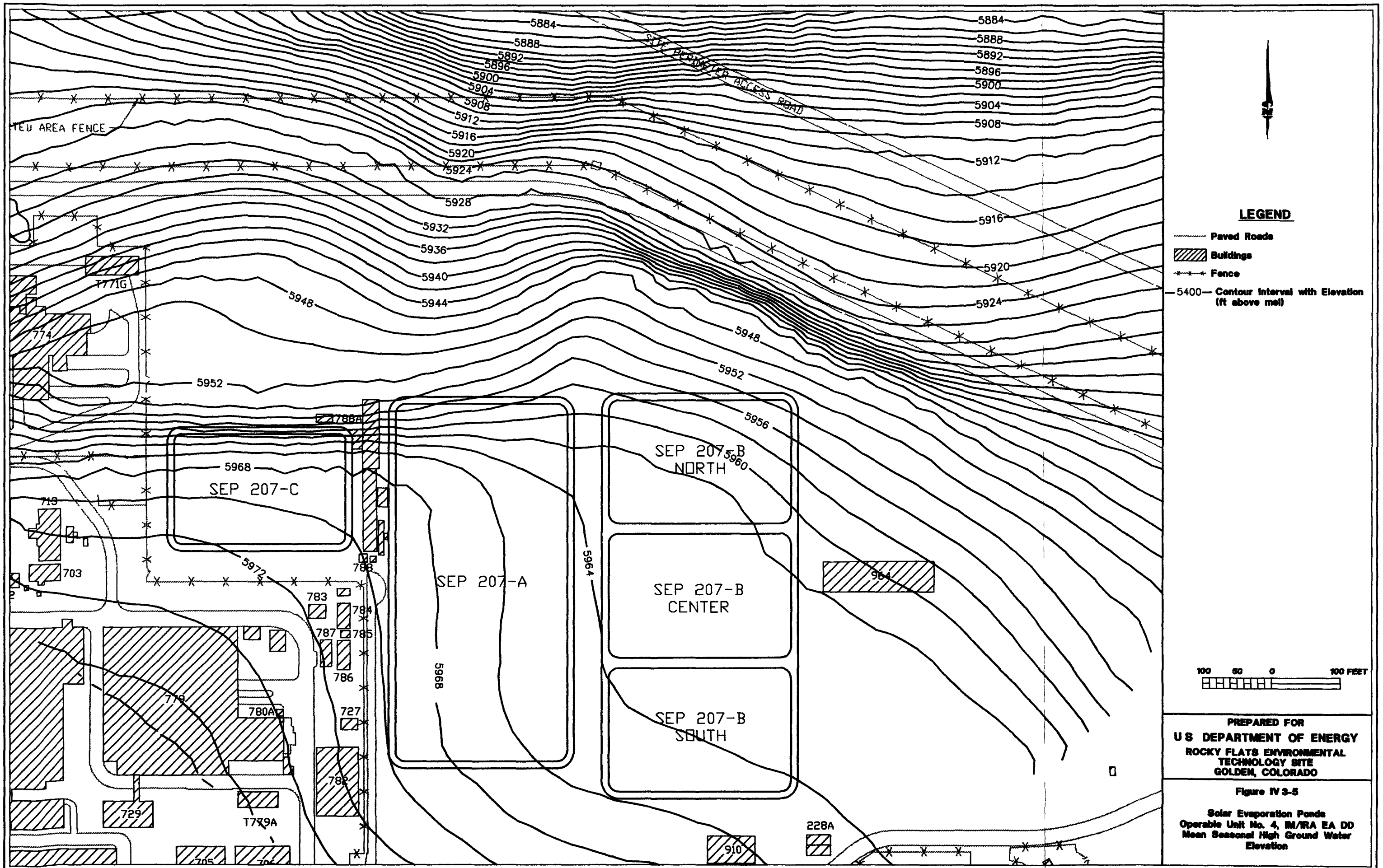
GOLDEN, COLORADO

Figure IV 3-4

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Minimum Vadose Zone Thickness Based on the Mean Seasonal High Ground Water Elevation


5884
5888
5892
5896
5900
5904
5908
5912
5916
5920
5924
5928
5932
5936
5940
5944
5948
5952
5956
5960
5964
5968
5972
SITE PERIMETER ACCESS ROAD
TED AREA FENCE
T771G
774
788A
SEP 207-C
713
703
788
783
784
787
785
786
779
780A
727
782
729
T779A
705
706
SEP 207-A
SEP 207-B NORTH
SEP 207-B CENTER
SEP 207-B SOUTH
964
910
228A
LEGEND
Paved Roads
Buildings
Fence
5400 Contour Interval with Elevation (ft above msl)
100 50 0 100 FEET
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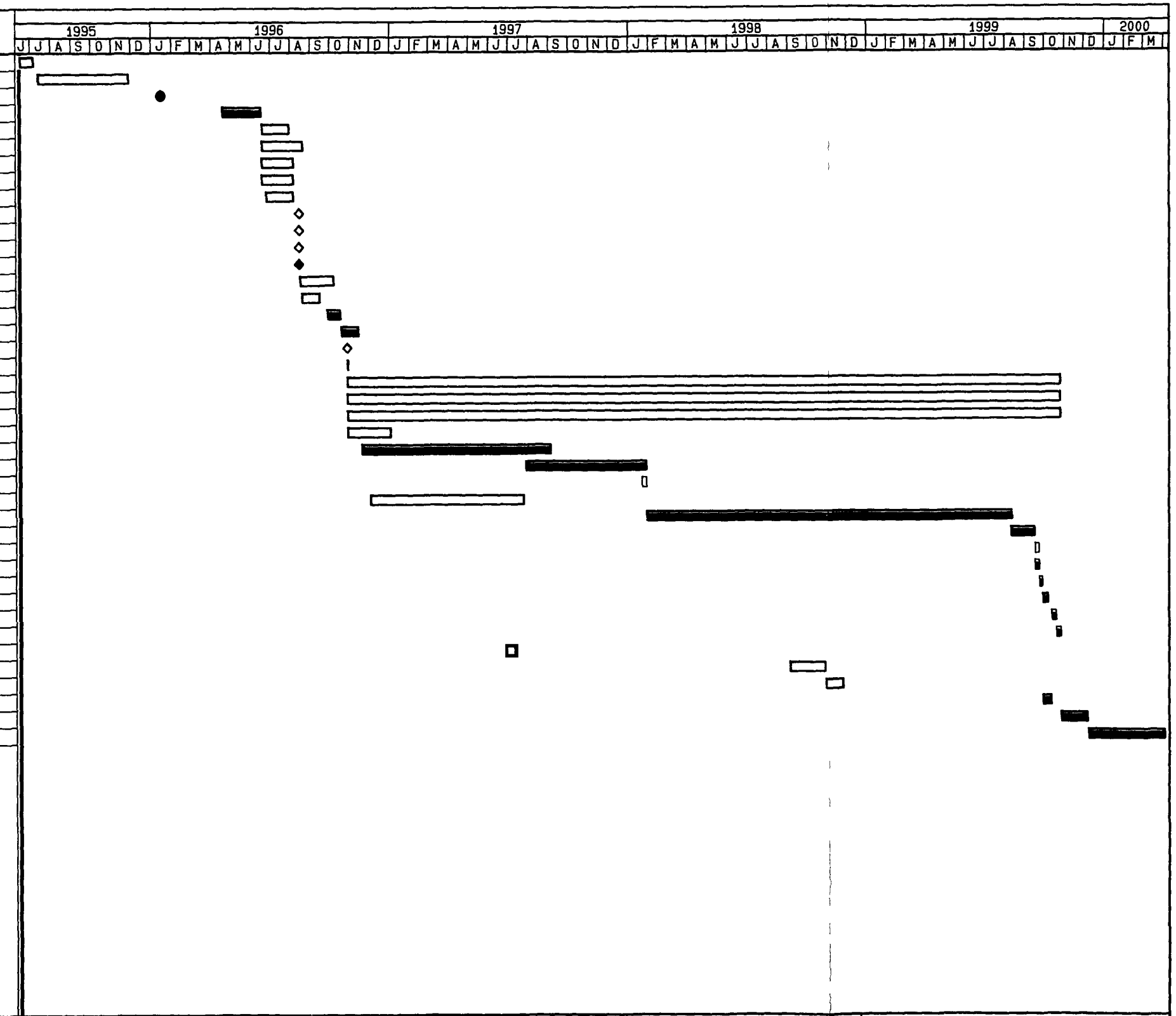
GOLDEN, COLORADO
Figure IV 3-5
Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Mean Seasonal High Ground Water Elevation

ACTIVITY ID	ACTIVITY DESCRIPTION	EARLY START	EARLY FINISH	ORIG DUR
000	GEOTECHNICAL ANALYSES	15JUN95	6JUL95	15
005	COMPLETE TITLE II DESIGN	13JUL95	28NOV95	97
010	PROJECT APPROVAL		15JAN96	0
015	PROPOSAL	18APR96	17JUN96	42
020	EVALUATION	18JUN96	30JUL96	30
025	WASTE DISPOSAL PLAN	18JUN96	20AUG96	45
030	EXCAVATION PERMIT	18JUN96	6AUG96	35
035	SECURITY PLAN	18JUN96	6AUG96	35
048	NEGOTIATIONS	25JUN96	6AUG96	30
040	788 D & D		14AUG96	0
046	964 D & D		14AUG96	0
047	EARLY WORK PACKAGE		14AUG96	0
060	AWARD CONTRACT	15AUG96		0
065	SITE SPECIFIC H & S PLAN	16AUG96	7OCT96	36
055	JOB SAFETY ANALYSIS	19AUG96	16SEP96	20
050	TRAINING	27SEP96	17OCT96	15
070	MOBILIZATION	18OCT96	14NOV96	20
075	START CONSTRUCTION	28OCT96		0
100	BASELINE RADIOLOGICAL/HAZARDOUS SURVEY	28OCT96	29OCT96	2
140	PROJECT & CONSTRUCTION MANAGEMENT	28OCT96	26OCT99	771
150	CLEAN UP & LABOR SUPPORT	28OCT96	26OCT99	771
400	MONITOR JOBSITE (HEALTH & SAFETY)	28OCT96	26OCT99	771
7000	SURFICIAL SOILS REMOVAL	28OCT96	2JAN97	45
8000	POND LINER PREPARATION	19NOV96	4SEP97	202
9000	MIX/PLACE WASTE	28JUL97	28JAN98	128
9500	CONCRETE ENTOMBMENT	22JAN98	28JAN98	5
10000	UTILITIES	2DEC96	25JUL97	165
11000	INSTALL FINAL ENGINEERED COVER	29JAN98	12AUG99	401
12000	FINAL FILLS & SUBGRADES	10AUG99	16SEP99	28
12500	EROSION PROTECTION	17SEP99	22SEP99	4
13000	REMOVE & DECONTAMINATE STAGING AREA	17SEP99	23SEP99	5
15000	FINAL SITE SURVEY	24SEP99	28SEP99	3
15500	SEED	29SEP99	7OCT99	7
16000	FINAL SITE PREPARATION	13OCT99	19OCT99	5
17000	DEMOBILIZATION (CONSTRUCTION COMPLETION)	20OCT99	26OCT99	5
A096	INSTALL GROUND WATER MONITORING WELLS	27JUN97	11JUL97	10
A090	CAP MONITORING SYSTEM	4SEP98	29OCT98	40
A095	CONDUIT AND CONNECTIONS	30OCT98	26NOV98	20
A100	SLOPE STABILITY	29SEP99	12OCT99	10
A150	SETTLEMENT MONUMENT INSTALLATION	27OCT99	7DEC99	30
A200	POST CLOSURE AND SYSTEM START UP	8DEC99	3APR00	84



Pl t D t 23JAN95
D t D t 15JUN95
Pr j t Start 7JUN94
Pr j t Fi i h 3APR00

( ) Prima Sy t ms, In

Acti ity Bar/Early Dat s
Critical Acti ity
Pr gress Bar
Mil ton /Flag Acti ity

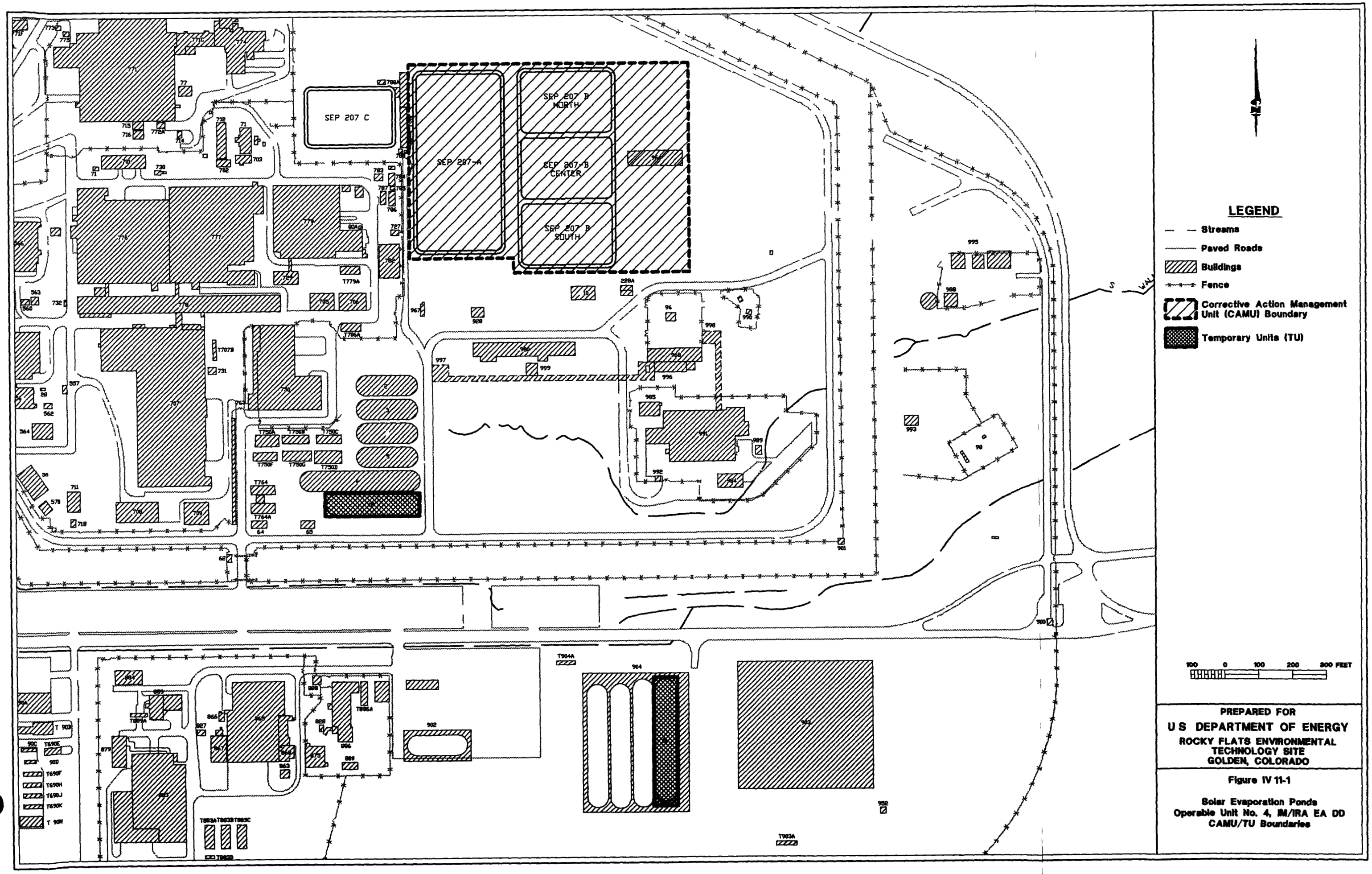
0109

FIGURE IV-6 1 OU4 IM/IRA
SUMMARY LEVEL
PRELIMINARY SCHEDULE

She t i of i

PROJECT SCHEDULE

Date	Re ision	Checked	Appro ed


SEP 207 C
SEP 207-A
SEP 207 B NORTH
SEP 207-B CENTER
SEP 207 B SOUTH
LEGEND
Streams
Paved Roads
Buildings
Fence
Corrective Action Management Unit (CAMU) Boundary
Temporary Units (TU)
100 0 100 200 300 FEET
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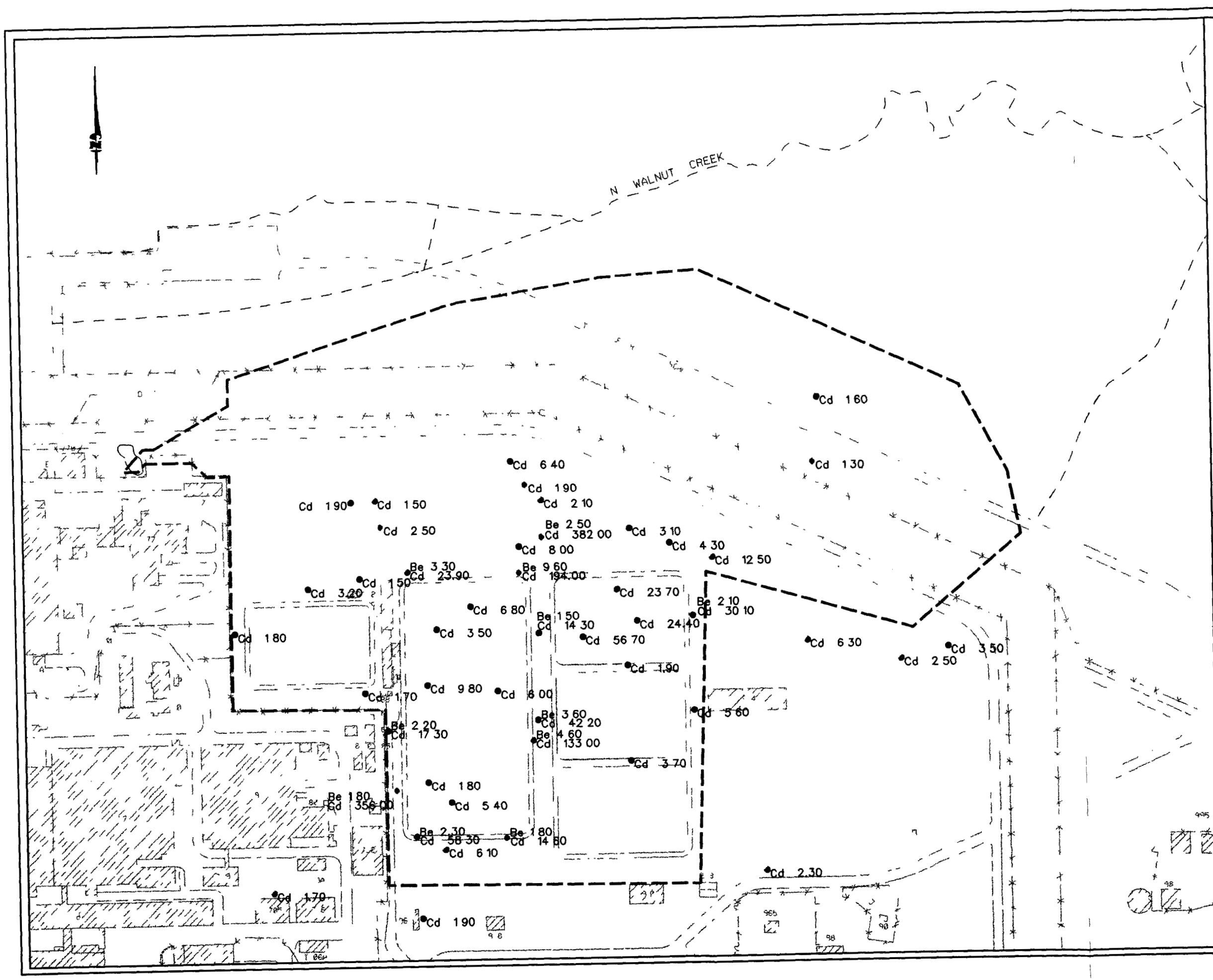
GOLDEN, COLORADO
Figure IV 11-1
Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
CAMU/TU Boundaries



LEGEND

- Streams
- Pa d Roads
- Building
- Fence
- OU4 Remed at n Bo nda y
- All m Mon to ng W ll
- RI Pha e I So l Bo ing
- Random Su f c al So l Location
- D c ete Su f c l So l Location

• Chemical Result

Preliminary Remediation Goals (PRG)

Beryllium	0 92 mg/kg
Cadmium	0 64 mg/kg

100 100 200 300 FEET

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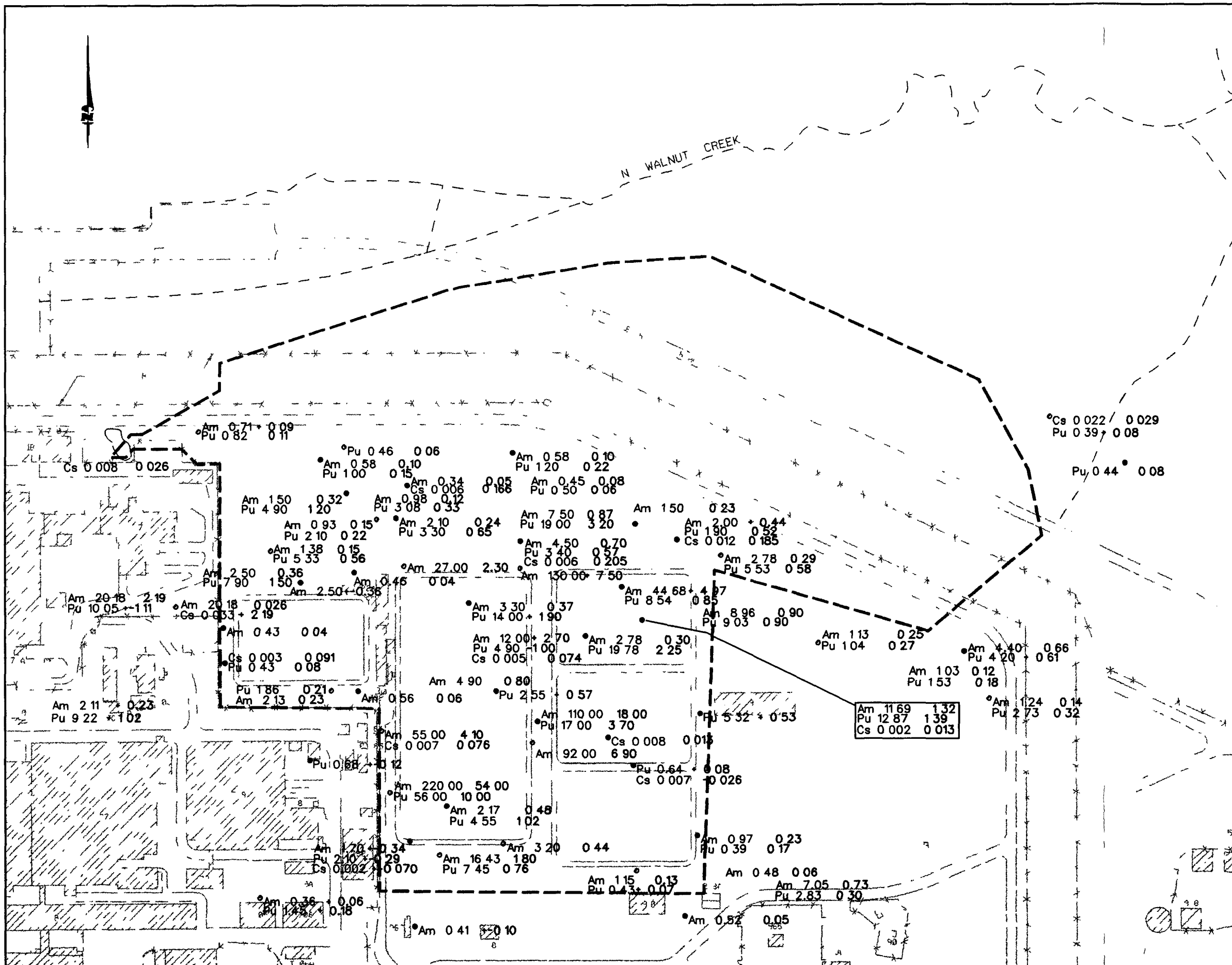
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GOLDEN COLORADO

Appendix IV C 1

Solar E aporation Ponds
Operable Unit No 4 IM/IRA EA DD
Summary Map of Surficial Soil Contamination at Levels G eater Than PRGs



LEGEND

- Streams
- P ed Road
- B ld ng
- Fence
- OU4 Remed at n Bo nda y
- All m Mon to ng Well
- RI Ph e I S l Bo ng
- Random S f c al So l Lo at on
- Disc te Su f c al So l Location

• Chemical Result err

Preliminary Remediation Goals (PRG)

Americium 241	0 27 pCi/g
Plutonium 239/240	0 38 pCi/g
Cesium 134	0 001 pCi/g

100 100 200 300 FEET

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GOLDEN COLORADO

Appendix IV C 2

Solar Evaporation Ponds,
Operable Unit No 4 IM/IRA EA DD
Summary Map of Surficial Soil Contamination at Levels Greater Than PRGs

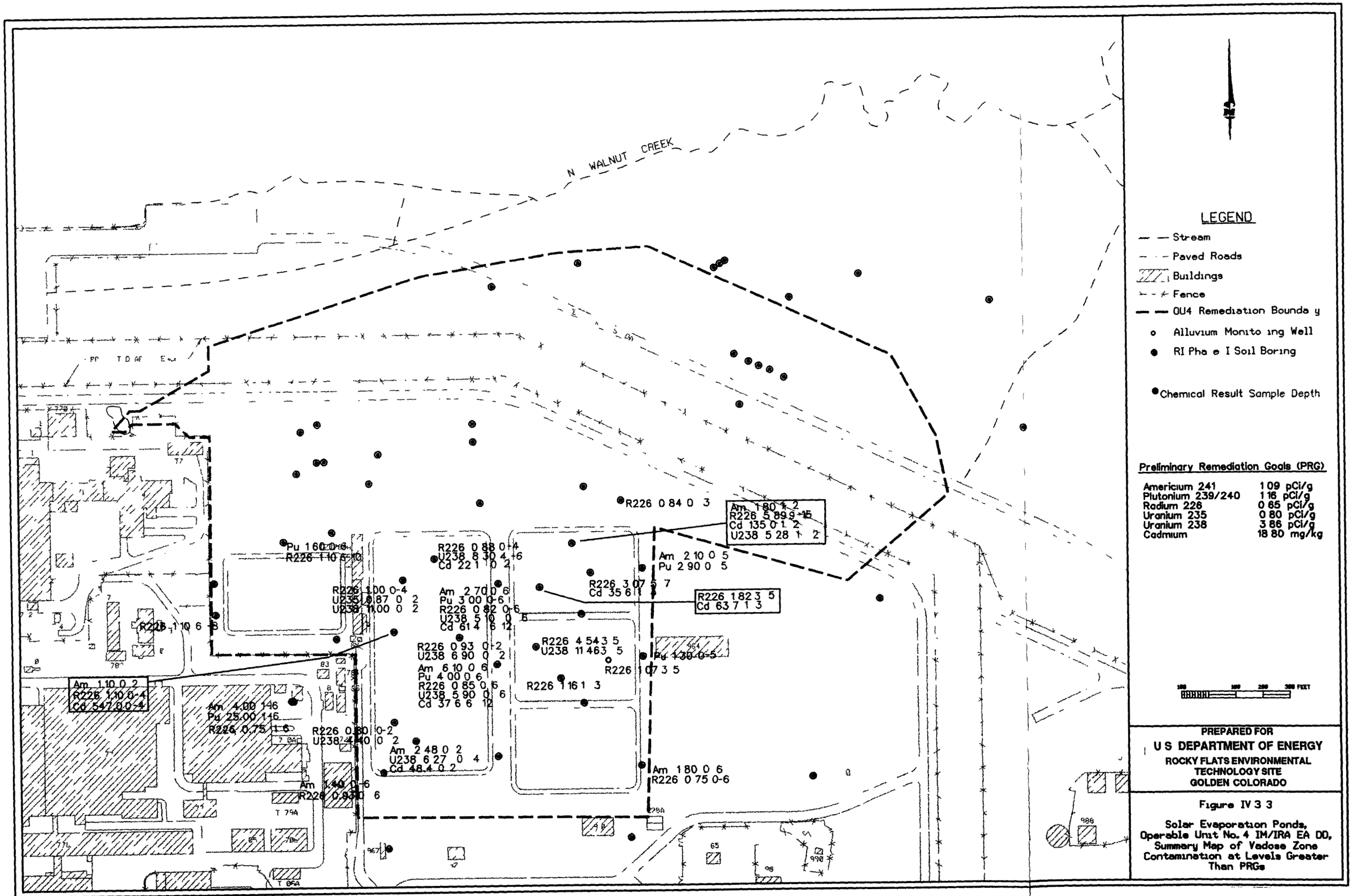
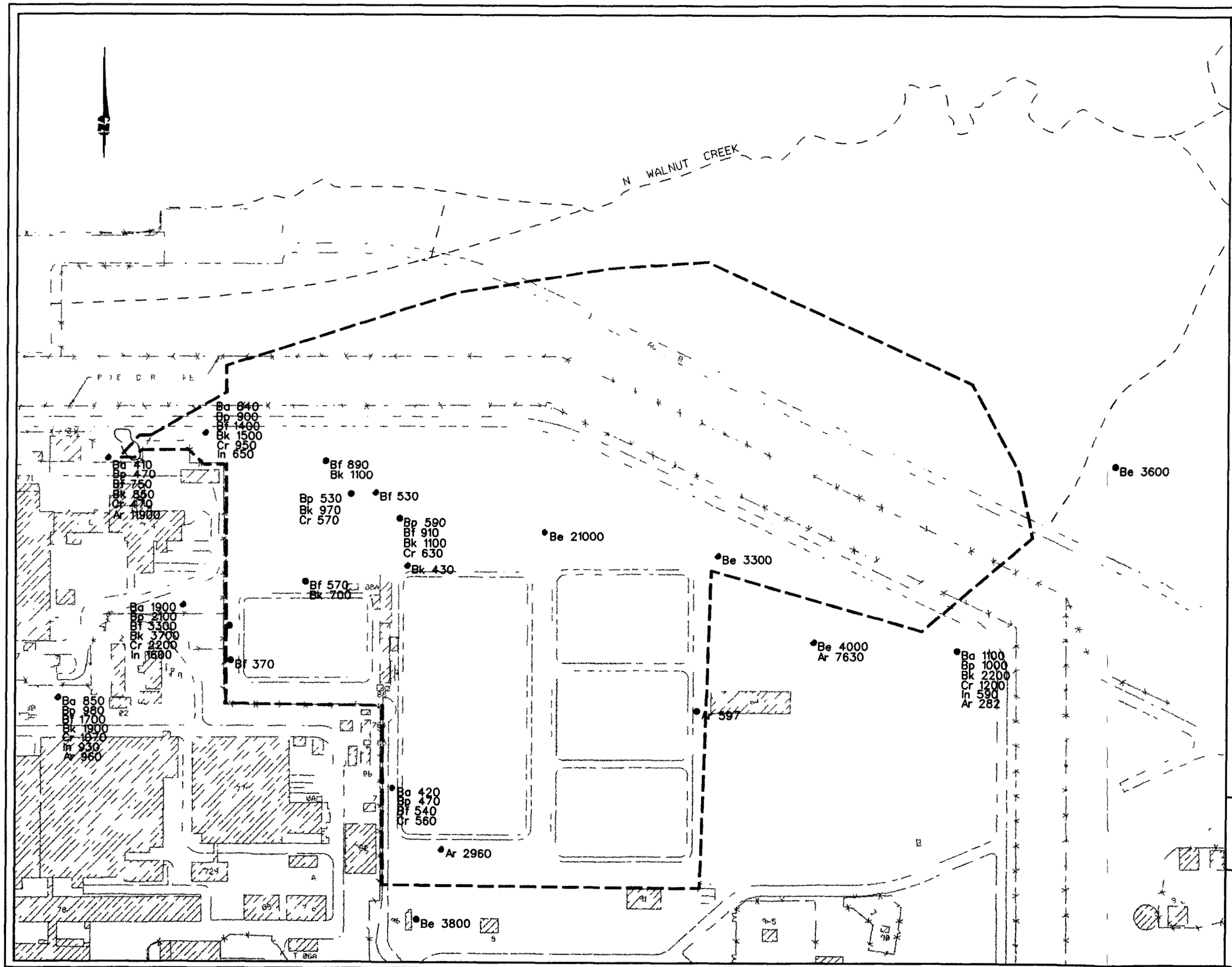


Figure IV 3 3

Solar Evaporation Ponds, Operable Unit No. 4 IM/IRA EA DD, Summary Map of Vadose Zone Contamination at Levels Greater Than PRGs


N WALNUT CREEK
Ba 840
Bp 900
Bf 1400
Bk 1500
Cr 950
In 650
Ba 410
Bp 470
Bf 750
Bk 850
Cr 470
Ar 11900
Bf 890
Bk 1100
Bp 530
Bk 970
Cr 570
Bf 530
Bp 590
Bf 910
Bk 1100
Cr 630
Bk 430
Be 21000
Be 3300
Be 3600
Bf 570
Bk 700
Ba 1900
Bp 2100
Bf 3300
Bk 3700
Cr 2200
In 1600
Bf 370
Be 4000
Ar 7630
Ba 1100
Bp 1000
Bk 2200
Cr 1200
In 590
Ar 282
Ba 850
Bp 980
Bf 1700
Bk 1900
Cr 1070
In 930
Ar 960
Ar 597
Ba 420
Bp 470
Bf 540
Cr 560
Ar 2960
Be 3800
LEGEND
Stream
Paved Road
Buildings
Fence
OU4 Boundary
All Alluvium Monitoring Well
RI Phase I Soil Boring
Random Surficial Soil Location
Chemical Result
CONTAMINANTS OF CONCERN
PRG
B Benzo(a)anthracene 7.4 ug/kg
Bp Benzo(a)pyrene 0.74 ug/kg
Bf Benzo(b)fluoranthene 7.4 g/kg
Bk Benzo(k)fluoranthene 74.02 ug/kg
B Bis(2-ethylhexyl)phthalate 2686 g/kg
C Chrysene 137.39 ug/kg
I Indeno(1,2,3-cd)pyrene 7.4 ug/kg
Ar Aroclor 1254 11.87 g/kg
100 0 200 300 FEET
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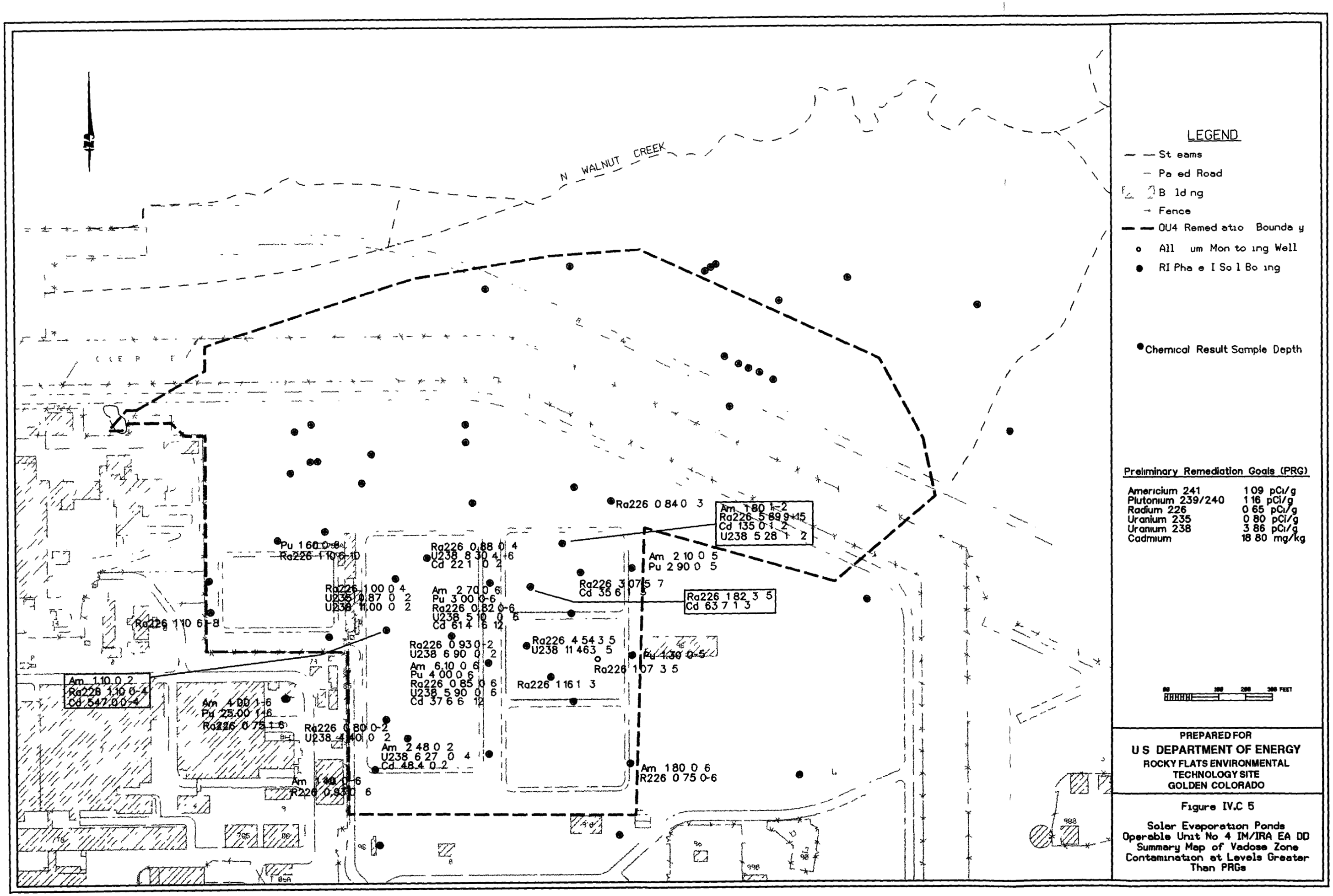
GOLDEN COLORADO
Appendix IV C 4
Solar Evaporation Ponds, Operable Unit No 4 IM/IRA EA DD
Summary Map of Surficial Soil Contamination at Levels Greater Than PRGs


N WALNUT CREEK
LEGEND
St eams
Pa ed Road
B ld ng
Fence
OU4 Remed ati o Bounda y
All um Mon to ing Well
RI Pha e I So l Bo ing
Chemical Result Sample Depth
Preliminary Remediation Goals (PRG)
Americium 241 1 09 pCi/g
Plutonium 239/240 1 16 pCi/g
Radium 226 0 65 pCi/g
Uranium 235 0 80 pCi/g
Uranium 238 3 86 pCi/g
Cadmium 18 80 mg/kg
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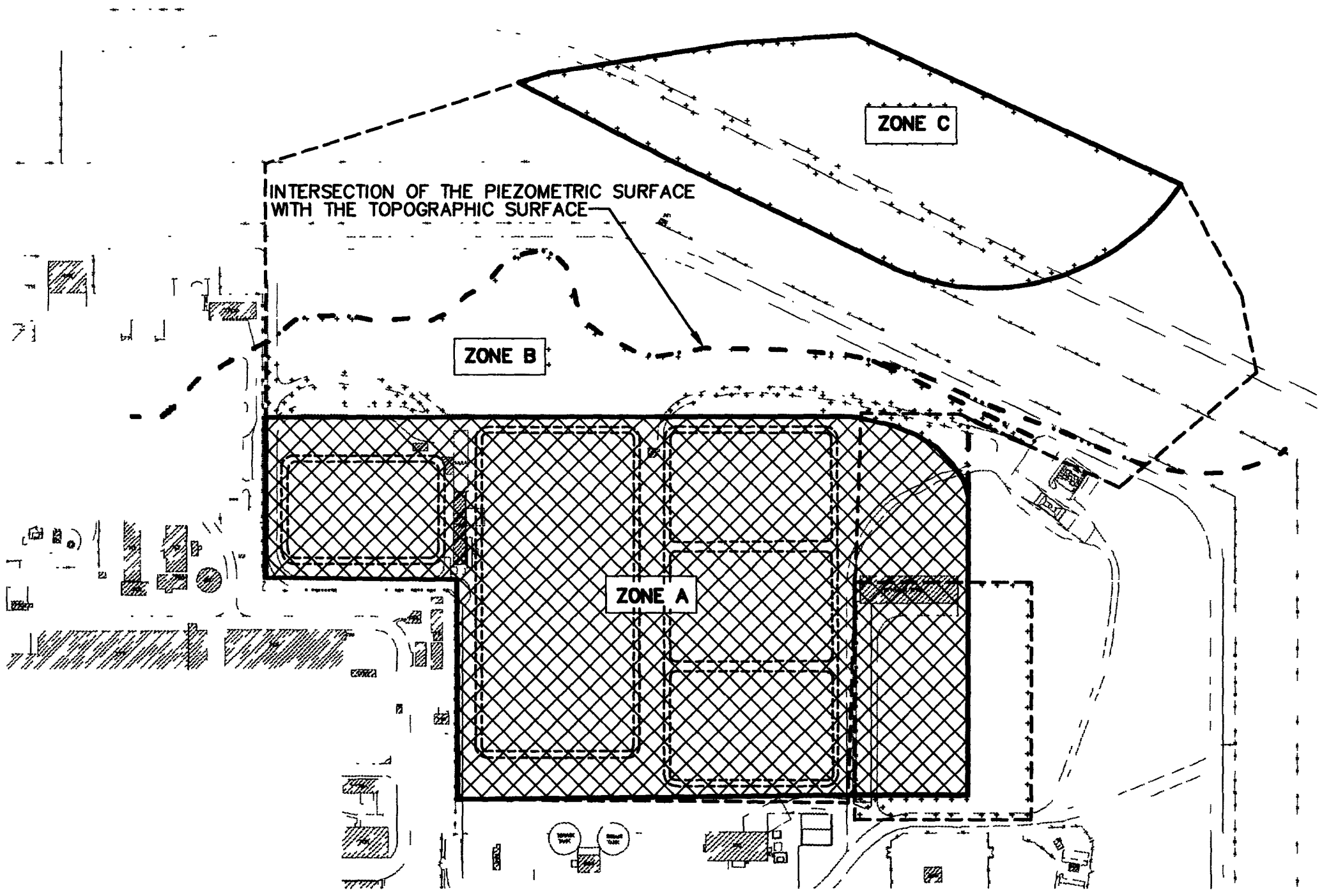
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN COLORADO
Am 1 80 1-2
Ra226 5 89 9-15
Cd 135 0 1 2
U238 5 28 1 2
Ra226 0 84 0 3
Am 2 10 0 5
Pu 2 90 0 5
Ra226 3 07 5 7
Cd 35 6 1 5
Ra226 1 82 3 5
Cd 63 7 1 3
Pu 160 0-8
Ra226 1 10 6-10
Ra226 0 88 0 4
U238 8 30 4 6
Cd 22 1 0 2
Ra226 1 00 0 4
U235 0 87 0 2
U238 11 00 0 2
Am 2 70 0 6
Pu 3 00 0-6
Ra226 0 82 0-6
U238 5 10 0 6
Cd 61 4 6 12
Ra226 1 10 6-8
Ra226 0 93 0-2
U238 6 90 0 2
Am 6 10 0 6
Pu 4 00 0 6
Ra226 0 85 0 6
U238 5 90 0 6
Cd 37 6 6 12
Ra226 4 54 3 5
U238 11 463 5
Ra226 1 07 3 5
Pu 1 30 0-5
Ra226 1 16 1 3
Am 1 10 0 2
Ra226 1 10 0-4
Cd 547 0 0-4
Am 4 00 1 6
Pu 25 00 1 6
Ra226 0 75 1 6
Ra226 0 80 0-2
U238 4 40 0 2
Am 2 48 0 2
U238 6 27 0 4
Cd 48 4 0 2
Am 1 80 0 6
R226 0 75 0-6
Figure IV.C 5
Solar Evaporation Ponds
Operable Unit No 4 IM/IRA EA DD
Summary Map of Vadose Zone
Contamination at Levels Greater
Than PRGs



N

LEGEND

- Zone A Excavated to Mean of the Seasonal High Water Table Elevation
- Zones B and C 6 Surficial Soil Excavation
- Buildings
- Roads
- Remediation Boundary
- Solar Evaporation Ponds
- Intersection of the Piezometric Surface with the Topographic Surface

100 0 100 200 300 FEET

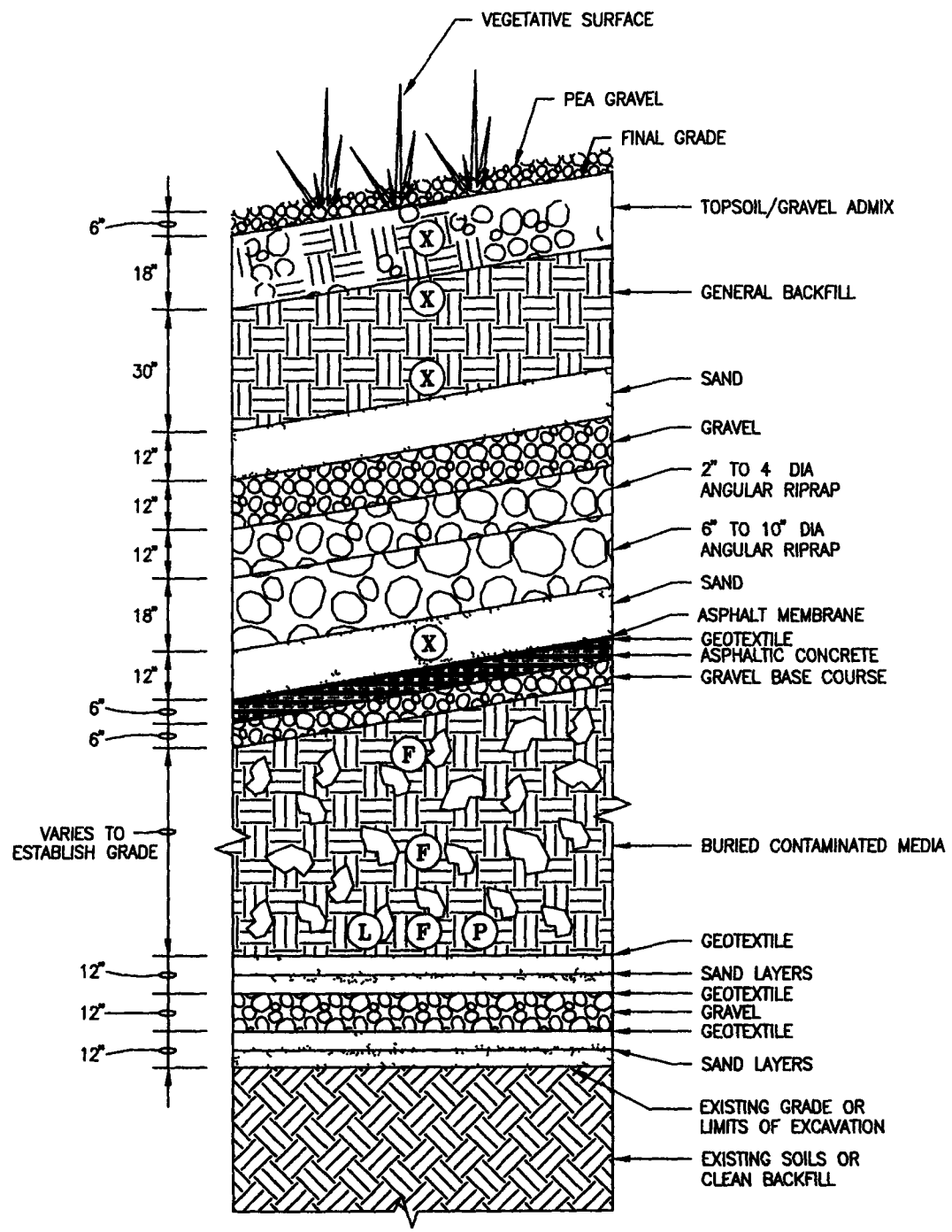
PREPARED FOR

U S DEPARTMENT OF ENERGY

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO

Figure IV G 1

Solar Evaporation Ponds
Operable Unit No. 4, IM/IRA EA DD
Zones of Soil Excavation



FINAL ENGINEERED COVER SECTION

CONCEPTUAL DESIGN

PART	QUAN	DESCRIPTION	MATERIAL

NOTES

1) SENSORS NOT SHOWN TO SCALE.

LEGEND

X	INDIVIDUAL TDR WAVEGUIDES
F	FDC SENSOR (ARRAY)
L	PRESSURE VACUUM LYSIMETER
P	NEUTRON PROBE ACCESS TUBE

REV	DESCRIPTION	DATE	DWN	CHK	APP	CLASS	JOB NO.
B	UPDATES TO CAP DESIGN	01/28/95					
A	ORIGINAL ISSUE						R30503.0

KEYWORDS: COVER, 2. DESIGN, 3. ENGINEERED, 4. COVER, 5. SECTION, BLDG./FACILITY: OU-4 SOLAR POND, AREA/AREA: 207A,207B PLUG, SWD CODE/CGL NO.

DESIGNED	CULLEN	01/28/95
DRAWN	WAGNER	01/28/95
CHECKED	GROBERSON	01/28/95
APPROVED		
ENGINEERED	HANSEN	01/28/95

SCALE: AS NOTED

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN,COLORADO

ROCKY FLATS
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GOLDEN, COLORADO 80402

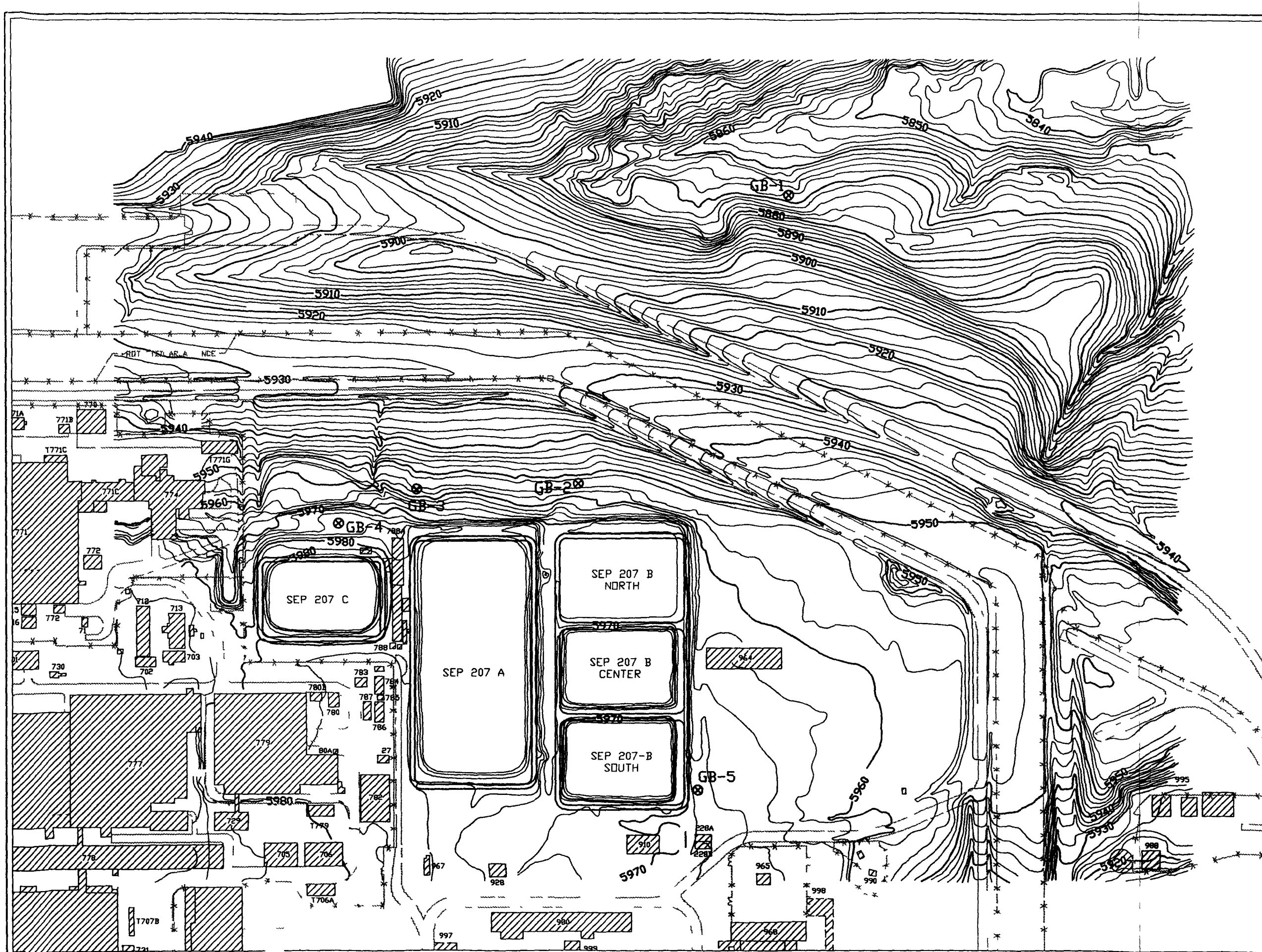
SOLAR EVAPORATION PONDS, OPERABLE UNIT NO. 4 (OU-4), IA

CROSS-SECTIONAL DETAIL OF FINAL ENGINEERED COVER SHOWING POSITION OF TDR WAVEGUIDES

SIZE	DRAWING NUMBER	REVISION	SHEET
B	51045-150	B	1 of 1

FILENAME = FGV4-1.DWG PLOT SCALE 1 100

COMPUTER-GENERATED NO MANUAL CHANGES ALLOWED



LEGEND

- Streams
- Paved Roads
- Buildings
- Fence
- ⊗ Proposed Boring Location

100 0 100 200 300 FEET

PREPARED FOR

US DEPARTMENT OF ENERGY

ROCKY FLATS PLANT
GOLDEN, COLORADO

Figure 1

Solar Evaporation Ponds
Operable Unit No 4 IM/IRA EA DD
Geotechnical Sampling
Locations